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FINANCE AND CLIMATE RESILIENCE:
EVIDENCE FROM THE LONG 1950S US DROUGHT

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ABSTRACT

We study how the availability of credit shaped adaptation to the long 1950s US drought. We find that investment in irrigation increased substantially more in drought-exposed areas with access to bank finance. The spillover effects of farmers' ability to adapt to the drought through financing, thus preserving agricultural livelihoods, also lead to the greater survival of retail and manufacturing businesses. Overall, areas with greater access to financing suffered significantly less population decline, both in the short-and long term. Thus, enhancing access to finance can enable communities to adapt to large adverse climatic shocks, and limit migration.

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As mitigation efforts lag, the world heats up, and climate volatility increases, the issue of climate adaptation becomes important. What factors can help a population adapt to adverse climate shocks? Can these factors affect long range outcomes? To answer these questions, we examine the long 1950s US drought, the second most severe drought to affect the US at the time (after the "Dustbowl" during the Great Depression). Despite its prolonged effect, the drought was not a persistent change in weather. Rainfall patterns in the areas most severely affected were not qualitatively different from unaffected areas before the drought, and by the 1960s, familiar weather patterns returned. Prima facie, there was a case for people to adapt to the weather shock rather than migrate permanently. Our focus is on whether access to bank finance facilitated adaptation, and influenced long run demographic shifts.

Emigration is the obvious response of a population to a prolonged drought if the population cannot adapt, even if the shock is not permanent (see, for example, Bohra-Mishra, Oppenheimer et al. (2014), Hornbeck (2012, 2022), and Long and Siu (2016)). Adaptation, for example through irrigation or a move to hardier crops, can weather-proof livelihoods and stave off the need to emigrate. Adaptation can even promote immigration, typically of younger, able bodied migrants from other drought-hit areas that do not adapt. Adaptation often entails the adoption of new technologies and capital investment and is obviously supported by the greater availability of financing.

We find that access to finance shaped the demographic impact of the drought, both in the short-run and over a generation. For a county at the 10th percentile of the log of per capita loans in 1950—one measure of ex-ante credit availability—drought exposure is associated with a 6 percentage point decline in population growth between 1950-1960 (p-value=0.01) relative to if the county was not exposed to the drought. But for a county at the median level of per capita credit availability, drought exposure is associated with only a 1.5 percentage point decline (p-value=0.42). The direct association of finance with population growth is modest.

In an "event study" of decadal changes in population, we find little difference in long run population growth between the 1950s drought hit counties and non-drought-hit counties in the period 1930-1950. However, after the drought hit in the 1950s, drought exposure is associated with a 5.2 percentage point decline in population growth over 1960-80 in the areas at the 10th percentile of credit availability, while there is no association between drought exposure and population growth in areas at the 90th percentile of credit availability. Probing more deeply into the sources of demographic change, we find that areas with low credit availability lose younger workers as livelihoods dwindle, which in turn reduces birth rates and increases death rates over time. Another contributor to population decline is lower in-migration.

We next use data on lending to measure the credit supply response to the drought. If low levels of ex ante credit per capita reflect frictions in lending such as the inadequate capacity of banks to do due diligence, limited trust in potential borrowers or their lack of fungible collateral, or the lack of capital in local banks, then the drought might exacerbate credit supply constraints in low credit-availability areas and shrink lending relative to high credit-availability areas. If, however, a low level of credit per capita simply reflects low demand, then the drought could well magnify lending in low credit per capita areas relative to other areas.

We find that bank lending increased sharply in response to the drought in areas with greater ex-ante credit availability. The time variation in the data also show that this relative surge in lending in drought-exposed areas with greater credit availability reflects a specific credit supply response to drought-related credit demand, as there is no similar pattern in the data in the decade before the drought. In keeping with this supply response, we also document a large shift in the composition of banks' assets towards loans in response to drought-related credit demand.

Of course, ex ante per capita bank credit can proxy for a variety of other factors than credit supply, including local income and wealth, all of which could influence the economic adjustment to an adverse shock. To address concerns about identification, we use two strategies.

Our first approach uses the fact that state borders significantly hampered lending during the sample period (see, for example, Ramcharan and Rajan (2015)). Bank branching networks did not extend across borders, nor was collateral registration or information readily accessible to potential lenders on the other side of the border. Because of these lending frictions at state borders, it was relatively hard for migrants with existing banking relationships to access credit in a new destination across the state border than within the state border.

So if our proxies for local credit availability indeed proxy for credit, we should find that there is more emigration from a town with low credit availability when there are nearby in-state towns with high credit availability than when there are nearby out-of-state towns with high credit availability. If however credit availability in 1950 proxies for income, wealth, local economic diversification, or some other latent factor, then state borders should be largely irrelevant in shaping the impact of the drought. We find that high credit availability in nearby in-state towns reduces population growth in towns with low credit availability, but we find no such effect for towns with high credit availability, or if credit availability is high in nearby out-of-state towns.

Regulations determining the organization of banks (unit or branch banks) could also change their ability to lend amid distress. This forms the basis for our second approach to identification. Studies find that, if anything, branch banking states were underbanked relative to unit banking states in terms of access to banking offices over the period of our study (see Horvitz and Shull (1964), Jacobs (1965), Pakonen (1969)). However, an extensive literature also documents the lower ability of unit banks to survive distress during the Depression (see Calomiris (2000), Michener (2005), and Wheelock (1995)).

Given that the drought was also a time of distress, banks in states that mandated unit banking would likely be more hard pressed to expand credit in response to the drought than banks in states that allowed some form of branching: Unit banks in drought-hit areas would have a much greater concentration of impaired loans than the typically more-diversified branch banks, which would likely have some part of its branching network outside drought-affected areas. Greater loan losses would thus hurt unit bank capital and constrain unit bank lending more. Branch banks would also likely be able to draw deposits from unimpaired areas to lend into drought-hit areas, something a unit bank located in a drought-exposed area would not be able to do. Using bank-level data, we verify that loan growth in counties on the unit banking side of a state border is significantly lower than credit growth in typically similar counties on the branch banking side of the same border during the drought. We use lower regulation-induced credit supply to establish greater confidence about causality below.

Perhaps the most important form of adaptation investment was investment in irrigation (Leonard and Libecap 2019, Cooley and Smith 2022). And center pivot irrigation systems, first patented in 1952, rapidly became an important technology that allowed farmers to irrigate using groundwater and boosted agricultural production in arid areas beginning in the 1950s.[1] We show that ex-ante credit availability helped foster this transition to ground water irrigation in drought exposed counties, but not in unit banking states, where these unit banks had less capacity to lend into distress.

[1] In drought affected Nebraska, the number of such systems increased from about a dozen in 1952 to around 10,000 by 1954--https://www.smithsonianmag.com/innovation/how-center-pivot-irrigation-brought-dust-bowl-back-to-life-180970243/--accessed on 7/26/2022 and Opie, Miller and Archer (2018).

Specifically, we focus on irrigation wells, using high frequency data on the usage of about 106,000 water wells between 1950 and 1970 across the US. We thereby draw a direct line between drought exposure, credit access, and the shift towards ground water irrigation-based agriculture. On average, the depth of the underlying aquifer is measured in each well—the source of ground-water irrigation-based agriculture—every 80 days. We find that aquifer discharge increased sharply in drought exposed areas with access to finance relative to drought exposed areas with aquifers but less access to finance (suggesting investment in deeper and more wells in the former areas). But within one year after normal rainfall returned, these differences in aquifer discharge vanish, connecting access to finance, the timing of the drought, and adaptation through ground-water mining. We obtain a similar result at the extensive margin, showing that the number of new wells increased more in drought exposed counties with credit access. We also find that plentiful ex ante credit availability had no significant effect on water depth levels or number of wells in unit banking states, which is consistent with adaptation investment being inhibited in those states by the distress-related lack of ex post credit.

Another form of adaptation is a shift to more drought tolerant crops in drought affected counties. Sorghum is one such well-known drought resistant grain and in the 1950s drought years, sorghum production across the US expanded significantly, rising from 12 to 27 million planted acres between 1952 and 1957 (Abdel-Ghany, Ullah et al. 2020). We find that among drought exposed counties, sorghum production expanded significantly more in counties with high credit availability. By helping the agricultural economy better survive the drought, adaptation can shape the pattern of production and ownership. For instance, easier credit access can allow marginal farms to survive. Indeed, we find that tenant farming, which is most fragile because of the lack of land collateral among tenant farmers, fell significantly in drought-hit areas with low credit availability relative to those areas with high credit availability.

These effects can also spill over into the local economy. Better adapted and productive farmers can support local demand, preserving the non-tradeable sector relative to counties where demand collapsed. Low credit availability may, of course, also prevent establishments from borrowing to survive in the face of low demand. We find the number of retail establishments declines significantly in drought-hit counties with low credit availability, and the effect persists long after the drought ends.

This paper builds on a rich literature that uses droughts and other climate shocks to evaluate predictions from economic models (Ramcharan 2007). Hornbeck (2012) examines soil erosion during the Dust Bowl, and its effects on migration. Hornbeck does ask whether access to finance (as proxied for by the number of banks in 1928) allows more soil-eroded counties to adjust their mix of agricultural activities faster, and finds mixed results – consistent with the limited results he finds on adaptation. He does not examine the relationship between access to finance and migration. Turning to papers that focus more directly on credit supply, Cortes and Strahan (2017) study how multi-market banks respond to a variety of natural disasters, and find they increase lending in affected areas, but reduce lending to unaffected areas, especially ones peripheral to the bank's core locations. Cortes (2014) examines the rebuilding process after a natural disaster, and finds that areas with a one standard deviation more local deposits experience between 1 to 2% less employment loss for young and small firms. Morse (2011) finds that in areas served by payday lenders, poor residents face fewer foreclosures following natural disasters. Berg and Schrader (2012) use volcanic eruptions in Ecuador as an exogenous shock to credit demand, and find those firms with stronger bank relationships have more access to credit. Taken together, these papers suggest access to credit helps areas affected by natural disasters to cope better.

Like Hornbeck (2012), our paper focuses on a climatic event with long term implications for the viability of a key economic activity (agriculture) in the area. Our outcome measure, population growth over the short and long run, reflects the failure to preserve livelihoods or create new ones – a central concern for climate adaptation. In contrast, many of the aforementioned papers focus on the actual damage by disasters to the local area and its repair, not on whether the long run viability of existing livelihoods is fundamentally altered. So in those papers, credit (for rebuilding or repair), investment, or short term unemployment are the appropriate outcome measures given the nature of the shocks. For us, they are only intermediate measures, which help us understand how adaptation takes place.

Perhaps most closely related is Albert, Bustos, and Ponticelli (2023), who examine the effects of changes in climate in Brazil on capital and labor reallocation in affected areas. While they examine short term annual shocks (where finance helps producers weather low cash flows and consumers to smooth consumption) and long term shocks over decades (where capital and labor reallocation are warranted), unlike us they do not focus on non-persistent shocks over the medium term where adaptation investment is critical. Albert et al. (2023) find that financial integration helps local communities in the face of short term shocks but hurts them when shocks are more permanent, as capital flees all sectors, not just agriculture. In contrast, we find that the local availability of finance helps adaptation investment, and limits population loss.

Given the growing concern that mitigation efforts will be insufficient to prevent climatic catastrophes from increasing in frequency and impact, adaptation becomes important for policy. Our findings then suggest that one way to help poor countries, which are most deeply affected by climate change (in part because they are so dependent on agriculture), is to improve their people's access to finance, especially when physical adaptation is possible within the local community. A related finding in our work is that this can help limit the extent of climate-induced migration, especially to parts of the world that are unprepared to absorb migrants. Also, while financial regulators need to calibrate carefully the possible risks to the banking system from climate-related losses, which would suggest less lending to climate sensitive areas and sectors, this needs to be set against the benefits of credit access in facilitating adaptation and innovation.

Section 1 of this paper develops the main hypothesis and describes the data, while Section 2 presents the basic results. Section 3 focuses on identification; Section 4 studies adaptation investment in irrigation in greater detail, and presents evidence that the availability of finance was important. We examine other forms of adaptation investment in section 5, and well as other intermediate outcomes such as the spillover effects to the retail sector. We conclude in section 6.

1. Hypothesis and Data

1.1. Droughts as adverse shocks

Technically, droughts are prolonged exogenous interruptions in rainfall that can disrupt agricultural production and broader economic activity. An empirical setting using droughts is thus a useful laboratory to study the role of access to credit in shaping an economy's long run adjustment to an adverse shock.

To this end, we focus on the "1950s" drought, which began in the late 1940s (as early as 1947 in some areas) and lasted through 1957 in many areas. This drought was the second most severe drought of the 20th century after the "Dustbowl" of the 1930s (July 1928-May 1942), and remains the third most severe drought to affect the continental US since 1895—the 2012 drought became the most severe drought since 1895 (Heim 2017). Unlike the Dustbowl, which occurred during the Depression, the 1950s drought did not occur at a time of general economic distress, and so we can tease out the specific effects of the drought without the broader confounding factors of a depression. Moreover, unlike more recent droughts, enough time has passed since the 1950s drought to examine its longer run consequences. Also, farm output accounted for much more economic activity in 1950 than in 2012 (farm output was 10.4% of US GDP in 1950, with a significantly greater presence in interior rural areas, and only 2.4% in 2012). Our results can thus help inform discussions of how large-scale climatic disruption might affect modern developing economies, which typically have large agricultural sectors.

Figure A1.1 in the Internet Appendix (IA) shows the time series intensity of droughts, plotting the percent of the continental US land area classified as in drought from 1900-2014. In terms of land area affected, the Dustbowl is only slightly larger than the 1950s drought; the peak coverage of the Dustbowl was 64.5% of the US land area versus 60.9% for the 1950s drought. IA Figure A1.2 shows the spatial variation in drought intensity across the continental US for both the Dustbowl and 1950s droughts. There is only a modest spatial overlap between the two drought episodes. While the Dustbowl mainly affected the upper-Midwest and plain states, the 1950s drought was particularly severe in the southern regions of the United States. In Texas, for example, the 1950s was the most arid period in the modern era.

In this paper, we use county-level SPI indices from the National Oceanic and Atmospheric Administration (NOAA) that use a 9 month time scale to measure the percent of a county's land area that is in exceptional drought, defined as "exceptional and widespread crop/pasture losses" and "shortages of water in reservoirs, streams and wells creating water emergencies". [2] These data are available monthly from 1895 through the current period. The main drought metric used in the analysis is the average percent of a county's land area in exceptional drought over the period 1950-1960. We focus on the decade of the 1950s as much of our data are for the decadal end points, and the drought began and ended in slightly different years across counties. Specifically, if on average 20 percent of a county's land area was in drought over the 1950s, then

[2] The Standardized Precipitation Index (SPI) is a widely used indicator of drought (Guttman 1999). It is a probability-based measure of drought based on the deviation of precipitation over a particular time period from its historical distribution. The SPI is thus comparable across space, and can be measured at different time scales. For example, an SPI that measures precipitation deviations from its historical mean at a 3 month frequency measures soil moisture conditions, while SPI indices based on a longer time scale, such as the 9 month deviation in precipitation from its historical average, captures more chronic drought conditions that impact soil moisture, as well as ground water and reservoir storage.

this variable would equal 20. IA Table A1.1 reports summary statistics for this measure for the nine standard geographic Census regions.

Panel A of Figure 1 shows that from 1895-1949, drought conditions were very similar among counties that subsequently become affected by the 1950s drought compared to those that were less affected. The solid line in panel A plots the monthly time series of the mean percent of land area in extreme drought between 1895-1949 for the sample of counties that subsequently became exposed to the 1950s drought (for the 1950s drought, we focus on top quartile exposure, which we will describe shortly). The dashed line in panel A plots the monthly time series of the mean percent of land area in extreme drought between 1895-1949 for the subsample of counties outside the top-quartile of exposure to the 1950s drought. Panel A shows that these two series tended to move together in the 636 months before the onset of the 1950s drought, with the exception of some months during the Dust Bowl period. During this 1895-1949 period, the coefficient from a simple bivariate regression of the mean percent of the land area in extreme drought among counties not subsequently exposed to the 1950s drought on the mean percent in those that eventually had top-quartile exposure to the 1950s drought is 0.95 (p-value<0.00).

Panel B of Figure 1 repeats this exercise for the period 1950-1960. Naturally during this period, the mean percent of the land area in extreme drought among the sample of top quartile drought exposed counties diverges sharply from the non-drought exposed counties. And the coefficient from the simple monthly bivariate regression drops to 0.21 (p-value<0.00). Next, Panel C plots these two time series over the 1960-1980 period. The previously non-drought sample is now somewhat more arid than the 1950s drought exposed counties in the early 1960s, but there is substantial co-movement once again. The bivariate regression coefficient is 0.90 during this 1960-1980 period (p-value<0.00). In sum, counties in the sample had very similar drought conditions in the decades before 1950; during the 1950s some counties became exposed to extreme drought conditions; while after the 1950s, the counties in our sample again experienced similar aridity.[3]

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[3] A simple difference-in-difference (DiD) framework formalizes this graphical evidence. This DiD framework uses a county-year panel from the 993 counties in the sample with banking data, averaging the monthly data on the percent of land area in extreme drought up to the year-level for each county. In this panel, a treated county is one that experienced top-quartile exposure to the drought in the 1950s (1950-1960). The DiD estimator computes the difference in the mean percent of a county's land in area in extreme drought during the 1950s drought for those counties with top quartile drought exposure compared to those counties outside the top-quartile and relative to other years in the sample. The DiD estimate suggests that the percent of land area in extreme drought is 5.93 (p-

This evidence suggests the 1950s drought, despite its prolonged effect, was not a persistent change in weather patterns. By the 1960s, familiar weather patterns returned. While doing nothing may be the appropriate response to a short drought, and migration may be the optimal response to a permanent change in weather conditions (at least for some share of those dependent on agriculture), prima facie, there seems to be a case for people to adapt to a prolonged drought if they can, rather than migrate permanently – this avoids the costs of liquidating property, buying property afresh, and re-establishing organizational capital and social ties. The loss in social ties for emigrants and of community health for those left behind, as well as adjustment costs for receiving communities, are additional reasons to favor in-place adaptation over migration. Of course, if the local labor market is tighter and wages higher when workers emigrate, some segments of the population, for example workers that stay behind, can benefit (see, for example, Jayachandran (2006)). So we cannot claim the absence of emigration is universally wellbeing enhancing, only that it is likely to help many.

Less clear is when one would expect a response through adaptation or migration, given the uncertainty about the duration of the change in weather patterns. Migration could be driven by income stress, and could occur early in a drought if farmers and businesses in the local area have limited resources to make payrolls. Adaptation investment such as in irrigation facilities may occur quickly if this is likely to be beneficial regardless of the drought. But given the irreversibility of these investments, and the possibility that their benefits might be small in non-drought states of the world, adaptation might be delayed until the farmer becomes more certain of a change in weather patterns.

1.2. Hypothesis

Adaptation may require a locality's farms, businesses, and individuals to invest in working capital, irrigation, hardier crops, machines, or livelihood support. All this entails credit.

Survival and Adaptation

An adverse shock that reduces cash flows and collateral values also reduces an enterprise's borrowing capacity, especially in the presence of financial frictions that prevent the full present

value<0.00) percent higher in these top quartile counties during the 1950s (also over 1950-1960) relative to otherwise. We get a similar estimate when using the over-3000 US counties.

value of an investment from being pledged to financiers.[4] At the same time, the adverse shock may itself require more spending by enterprises for their own survival. For instance, farms may need key inputs like new seeds and fertilizers to keep production going. Farmers with little revenues may also need to borrow to pay workers and put food on the table for their own families. Spending that helps farms survive is likely to have high private and social returns, especially if it preserves human and organizational capital. Farm failures were indeed of great importance during the 1950s Drought. Texas lost nearly 100,000 farms and ranches over the 1950s, exceeding those of the Dust Bowl years.

An adverse shock such as a persistent drought may also increase the return from adaptation investments, for instance from irrigation or sowing drought-hardy crops. Furthermore, to the extent that production has to be curtailed during investment because key inputs to production are unavailable (for example, because farmer labor is devoted to supervising the investment, or land cannot be planted as irrigation pumps are being installed), a time of low productivity may imply a low opportunity cost in terms of lost production and hence greater effective returns to investment (Aghion, Angeletos, Banerjee, and Manova 2010).

Indeed the need to invest to adapt, coupled with the lower opportunity cost of investment, may allow farmers in drought-hit areas with better credit access to *leapfrog* technologically. For instance, farmers with the financing capacity to afford both the installation and working capital costs might be expected to adapt to the drought by installing irrigation equipment, especially the then newly developed center pivot irrigation system, even before areas with no drought.[5]

Land use and Number of farms

Farmers could increase farmed acreage to compensate for lower yields, and to better use fixed investments in irrigation. Access to credit would again facilitate such investment, which would be seen in an increase in aggregate farm acreage. Because small marginal farms (especially tenant farmers, who did not have enough wealth to own their farms and therefore would have little pledgeable collateral) would also be able to survive in areas with easier access to credit, the number of surviving farms should also be higher in such areas.

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[4] See, for example, Hart and Moore (1994) or Kiyotaki and Moore (1997) and Bernanke and Gertler (1989), and Bernanke, Gertler, Gilchrist et al. 1999). Richer formulations of this insight that incorporate lender balance sheet dynamics and asset prices including Gertler and Kiyotaki (2011), He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014), Gertler and Kiyotaki (2015).

[5] See, for example, Matsuyama (2007) and Aghion and Howitt (2008).

Spillovers

Investment, facilitated by easier access to credit, could also result in sectoral and geographic spillovers. Specifically, the survival and continuing presence of marginal farmers as well as the expansion of large farm production in drought-stricken areas with access to credit could result in more jobs and preserved livelihoods. These could create stronger demand for goods sold by retail and other non-traded local businesses, preserving jobs in those sectors also. More jobs in areas with credit access could then draw migrants from neighboring drought-hit areas with limited credit access. So areas with credit access may have caused negative spillovers for areas without credit access, especially if credit is hard to obtain at a distance. Finally, the shrinkage of jobs in agriculture would have added to local labor supply, while net out-migration would have reduced it. There might thus have been spillovers even to businesses not wholly dependent on local demand, such as manufacturing.

1.3 Credit Data

Even today, small business bank lending is an intensely local business, and agricultural lending more so.[6] Given that communications technology was even less well developed in the 1950s, lending depended on the availability of credit within the town or county in which the farm or business was located. While agricultural production occurs in rural areas, incorporated towns were the predominant centers of finance in most counties during this period. We thus first collect data on the balance sheets of all banks headquartered in a stratified random sample of about 1,300 towns across the US in end-1929, 1939, 1950 and 1960—the towns are shown in IA Figure A1.3 for the 1950 snapshot of the panel. Note that the number of banks vary in each period of the panel, so that we have 5,621 banks in 1929; 2,985 banks in 1939; 2,896 banks in 1950 and 3,027 banks in 1960. For each bank, we collected basic information on the value of loans, assets, deposits, capital, and other balance sheet variables.

For much of the analysis, we aggregate the bank-level data up to the county-level to construct standard measures of credit availability in a county just before the drought. Our main measure of credit availability is the log of loans per capita in a county in 1950. Later, when we focus on

[6] Petersen and Rajan (2002) find that the mean distance between small businesses and their bank lender was 16 miles in the 1970s (median 2 miles), and this had increased with the advent of information technology to 68 miles in the early 1990s (median 5 miles). In 2000, Granja, Leuz, and Rajan (2022) find that the average distance between bank and borrower for all loans is around 200 miles, and the median for all loans is still around 5 miles. The mean distance between borrower and lending branch for agricultural loans is only around 50 miles at this time – so agricultural loans are even more local.

agricultural investment, we proxy for credit availability to agriculture with loans per farm or loans per acre of farmed land. All these proxies should be higher in areas where banks have historically been better able to overcome information and other frictions in order to establish credit relationships, and thus would have a greater capacity to accommodate a drought-related increase in the demand for bank finance.

IA Figure A1.4 shows that loans per capita in the county is strongly positively correlated with the number of banks per 10,000 people in the county—another standard proxy for de facto credit availability. Table 1 Panel A summarizes these standard ex-ante credit availability measures in 1950. At the county level, the mean loans per capita is about $115 or about $1,400 in 2022 dollars, and on average, there are about 7 banks per 10,000 people in the county. Towns are geographically much smaller than counties, and these credit availability measures tend to be higher when measured at this more granular level. Because there are a number of small towns in the sample, the variability in loans per capita and the number of banks per 10,000 people also tend to be higher at the town-level. Panel B shows that the three main county-level measures of credit—loans per capita; loans per farm; loans per farm acreage are all highly positively correlated—note that one county does not have data on both acres and farms, and drops out of this sample.

We focus on local banks because they were an important source of farm credit during this period, especially for working capital and equipment financing (Herder 1970).[7] IA Table A1.2 shows that banks accounted for about 28 percent of all credit flowing into the farming sector in 1950. Banks specialized in working capital and equipment financing loans, accounting for about 40 percent of such loans. Merchants and dealers, such as captive financiers, provided most of the remaining financing for these non-real estate loans. In the case of real-estate loans, banks supplied only about 16.8 percent of mortgage credit in 1950, with life insurance companies and other institutions doing the bulk of mortgage financing. Thus, the potential supply of bank finance is likely to be more useful for farmers investing to adapt to the drought than for land

[7] See the narrative evidence at https://livinghistoryfarm.org/farminginthe40s/money_12.html. For example “"They just probably knew me," he says. "Knew my dad and so forth... [Now] you put down what you want to do, what your costs for different fertilizer, seed and so forth, irrigation. You go through that every year with the bank … and try to see what the bottom line is going to look like at the end of the year. So, they play a part in the role of most farmers."

purchases. To the extent, however, that banks monitor on behalf of more passive lenders (e.g., Diamond (1997)), the availability of bank credit should influence all forms of credit.

1.4. Economic and Demographic Data

Adverse productivity shocks like droughts have non-linear effects on agricultural production and local economic activity. A drought of moderate intensity for example makes existing capital—livestock and trees—less productive; it can diminish milk production or harvests, temporarily reducing cash-flow among farms and local businesses. But a more severe drought can destroy the underlying "physical" capital on the farm—killing livestock and trees and causing soil erosion—leading to an increase in demand for both working capital and investment finance in order for farms to survive, replace physical capital, and make adaptive investments.

Therefore, our main measure of extreme drought in the paper will be an indicator variable that equals 1 if a county is in the top quartile of drought exposure between 1950 and 1960. Since drought exposure measures the percent of a county that is in extreme drought stress averaged over the period 1950-1960 (see earlier), this indicator proxies for how widespread and prolonged stress is in a county. For the town-level analysis, we use the same county-level drought indicator.

The specific timing and intensity of droughts reflect exogenous geophysical forces—in this case a change in the jet stream (Nace and Pluhowski 1965). But it is possible that ex-ante credit availability, as well as key economic and demographic factors might systemically differ between drought-affected counties and the other counties in the sample. Notably, the drought was particularly severe in some of the big sunbelt states like Georgia, Texas and Oklahoma. And in 1950, these states were relatively less populated, as the post-war demographic shift towards the sunbelt states was still nascent. Indeed, among counties with top quartile drought exposure, the mean of the log population in 1950 was 10.12, while the mean for counties outside the top-quartile was 10.58—a mean difference that is economically small but statistically significant at the 1 percent level. In all our specifications we control for the log population in 1950 and the county's land area.

Table 2 considers a comprehensive series of "balance tests", regressing a range of the most salient potential ex-ante confounders, all observed circa 1950 on the top-quartile drought indicator variable based on drought conditions between 1950 and 1960. These tests check whether counties that subsequently became exposed to the drought were ex-ante different than the other counties in the sample. Panel A of Table 2 includes only state-fixed effects, while Panel

B also controls for the log of a county's population in 1950; Panel C of Table 2 drops the state-fixed effects.

Table 2 show that the ex-ante structure of the local banking system; median income; the structure and productivity of agriculture; and the broader local economy were all ex-ante similar between top-quartile drought exposed counties and the other counties in the sample. Specifically, loans per capita, the number of banks per capita, and the value of deposits per capita, all observed in 1950, were indistinguishable across the two samples. Likewise, the capacity for ex-ante self-insurance, as proxied by the log of median income in 1950; along with the mean farm size; the number of farms; the productivity of farmland and the share of irrigated farmland were all similar between top-quartile drought exposed counties and the other counties. The per capita number of retail establishments circa 1950 is also similar across both types of counties, but there is a small difference in the per capita number of manufacturing establishments; this difference vanishes once we control for state fixed effects and the log population in 1950—these are in the baseline set of controls for our subsequent tests.

That top quartile drought exposed counties and the other counties in the sample are similar on a range of pre-drought dimensions is consistent with the fact that the 1950s drought emerged from geophysical forces that did not "select" on ex-ante local economic and demographic factors. It also echoes the evidence in Figure 1 which shows that apart from the 1950s, both sets of counties experience similar aridity patterns. Taken together, this evidence implies that any pre-existing differences between counties that eventually had top-quartile exposure to the 1950s drought and other counties in the sample are likely to be slight.

2. Basic results on drought exposure and the impact of credit

In what follows, we will first establish the correlations between drought and population growth, and the mediating effect of credit. We will look for pre-trends that might indicate that differences in drought-hit counties were not just due to the drought. Net emigration of able-bodied young workers should have had counterpart effects in immigration, births, and deaths, which we examine. Finally, we will show that credit did indeed grow in areas with higher ex ante credit availability over the time of the drought, relative to areas with low ex ante credit availability. After establishing all this, we will turn in the next section to evidence of the causal effect of the availability of credit on demographic outcomes and credit growth.

2.1 Demographic Outcomes—County-Level Evidence

In Table 3 we study the interaction between access to finance and drought exposure on population growth at the county-level between 1950 and 1960. The baseline specification interacts county *i's* drought exposure, D_i, with the county's log per capita loans in 1950, C_i:

$$(3) \qquad \Delta population_i = \beta_0 + \beta_1 D_i + \beta_2 C_i + \beta_3 D_i * C_i + \beta_4 X_i + \beta_4 D_i * X_i + e_i$$

where β_3 measures the role of credit in mediating the impact of the drought. If, for example, emigration is weaker and immigration stronger in drought exposed counties in which the local population can obtain significant additional bank credit to adapt to the shock, then $\beta_3 > 0$. The baseline specification also allows per capita loans to vary with other factors, X_i, such as a county's pre-existing population, and also allows the drought's impact to vary with X_i.

To show simply that the 1950s drought exposure affected demographic outcomes, column 1 of Table 3 estimates the direct impact of the drought on population at the county-level, with state fixed effects also included as explanatory variables. The sample consists of all US counties with available drought intensity data. The drought measure is the continuous SPI based measure of the mean percent of a county's land area affected by extreme drought over 1950-1960. The point estimate on drought intensity is statistically significant (p-value=0.03) and economically large—the binscatter plot in panel A of IA Figure A1.5 displays the relationship estimated in column 1. The point estimate implies that moving from a county at the 10^{th} to 90^{th} percentile of drought intensity is associated with a decline in the county's population growth of about 3.6 percentage points between 1950-1960; the absolute value of this magnitude equals the mean population growth over the period or about 0.16 standard deviations.

We have hand-collected bank lending data for about 1,300 towns and cities across 993 counties, and column 2 of Table 3 restricts the sample to these counties. The implied effect of the drought on population growth is similar to the full sample. Moving from a county at the 10^{th} percentile of drought intensity to one at the 90^{th} percentile is associated with a decline in the county's population growth of about 5.2 percentage points between 1950-1960.

Column 3 allows the impact of the drought on population growth to vary depending on the county's quartile of drought exposure. The bottom quartile—those counties least exposed to drought conditions over the 1950s—is the base category. The evidence suggests that the effects of 2nd and 3rd quartile exposure on population growth, while negative, are not statistically different from exposure at the base-level. However, top quartile exposure is associated with a 6.6 percentage point reduction in population growth.

In order to more easily exposit the evidence, in what follows, we use the top quartile drought indicator as the main measure of drought exposure. Column 4 provides preliminary evidence that access to bank credit might moderate the impact of severe drought exposure on population growth. We include an interaction of top quartile exposure indicator with the log of per capita bank credit in the county in 1950, and also include each of these variables directly.

However, a concern with the log of per capita bank credit as a proxy for credit access is that this variable could vary mechanically with the population or physical area of the county. For example, a small county might have a large per capita stock of loans on account of a few large borrowers. At the same time, because of its small size, the county might also have a much less spatially- and sectorally- diversified economy. Because it is unlikely to be able to absorb surplus farm labor, a small county would be particularly susceptible to a severe drought. To exclude these forms of mechanical bias, we also include linearly in column 4 the log of population in 1950 and the log area of the county as well as the interaction between these variables and the top quartile drought indicator. This is the baseline specification henceforth**.**

The estimates in column 4 of Table 3 suggest that bank credit access attenuates the economic impact of adverse productivity shocks. Holding constant the population of the county in 1950, the estimates in column 4 show that for a county at the 10th percentile of the log of per capita loans in 1950, top quartile drought exposure is associated with a 6.0 percentage point decline in population growth relative to counties outside the top quartile exposure (p-value=0.01). But for a county at the median level of the per capita credit distribution, top quartile drought exposure is associated with only a 1.5 percentage point decline, which itself is not different from zero (p-value=0.41). Going forward, we will report the marginal impact of top-quartile drought exposure for the 10th, 50th and 90th percentiles of the credit distribution. The associated p-value measure the likelihood that a particular marginal effect is different from zero. Unless otherwise noted, these marginal effects are always evaluated at the mean of population and any other covariate that is also interacted with the drought indicator variable. What will matter for the tests is the sign of the coefficient and whether it is different from zero at one of the extremes of credit availability, as well as the change in estimated coefficients across the distribution of credit availability, and not which extreme is significantly different.

Using the point estimates in column 4, Figure 2 uses a binscatter plot to illustrate the predicted relationship between the change in population growth, 1950-1960, and the log loans per capita in 1950, separately for those counties with top quartile drought exposure and those without such exposure. Consistent with the reported marginal effects which show that loans per capita attenuates the economic impact of the drought, Figure 2 shows that ex-ante credit is positively associated with predicted population growth only in drought exposed counties. Among non-drought exposed counties, ex-ante credit appears unrelated to predicted population growth.

Next, counties differ in size, and column 5 addresses heteroscedasticity by using weighted least squares based on county population in 1950 for the baseline sample of counties. The point estimates are slightly larger, and we use the more conservative unweighted approach in the subsequent analysis.

Loans per capita can proxy for myriad salient factors. To partially address this concern, in column 6, we interact the drought indicator variable with the mean rainfall in the county; the standard deviation of rainfall; mean snow fall; the standard deviation of snowfall; the log of county area; the log of median income in the county in 1950; the share of rural population in 1950; and indicator for whether the county's centroid is west of the 98th meridian, and the log population in 1950. The regression also includes log deposits per capita in 1950 to better control for the self-insurance capacity of local farmers through their existing savings. All variables are also linearly included. The regression in column 6 thus allows the marginal impact of top-quartile drought exposure to depend simultaneously on 10 different factors. Because of multicollinearity, the direct effect of the drought is no longer significant, but despite the large number of controls, the marginal impact of credit availability remains economically similar to the baseline effect.[8]

Column 7 next examine whether diversification, as well as past droughts might affect these results. The availability of credit can for example affect the diversification of the broader local economy, as well as within the agricultural sector itself. In turn, diversification can be an important mediating mechanism through which credit might shape the impact of the drought. As

[8] The weather variables are averages over the 20th century. The point estimates for these additional controls are available upon request.

a first pass to address these concerns, we create two diversification measures. The first measure is a Herfindahl Hirshman Index (HHI) based on male employment across 13 sectors in the 1950 Census.[9] Intuitively, smaller HHI values mean that employment would be more evenly spread across these 13 sectors, suggesting that the local economy might be more diversified. The second measure of diversification is focused on the agricultural sector itself, and is a HHI based on the market value of 13 types of broad agricultural goods produced in the county in 1950.[10] In this case, a smaller HHI would suggest a more diversified local agricultural economy.

Column 7 adds these two HHI measures to the baseline set of controls. In addition, column 7 also includes a county's past drought conditions (1895-1926), as well as an indicator for whether the county is west of the 98th meridian. The supply of local surface water for agriculture is greater in counties east of the 98th meridian, and in part this geographic fact led to different settlement densities and water rights practices across the US, which in turn could affect these results (Libecap and Dinar 2022). Note that all controls appear linearly and interacted with the drought exposure indicator. The marginal impact of loans per capita on mediating the impact of the drought remains qualitatively similar.[11]

2.2. Demographic Outcomes—County Panel

The drought was an unexpected prolonged adverse shock, so a longer term panel analysis can allow us to absorb potentially important confounding factors like the era's rapid technological change or secular trends in urbanization. A longer term panel can also illustrate both pre and post drought dynamics, as the onset of drought conditions varied. We therefore create a town-decade panel of log population from 1930-1980, and use a difference-in-difference (DiD) research design that controls for state specific trends using state by year fixed effects. We begin with the event study plot in Figure 3 Panel A, which allows the impact of drought exposure on population to vary over time. Figure 3 Panel A is normalized so that the base year is 1950—the first decadal observation point before the onset of the drought in most places.

[9] The sectors are: professional/technical; farmers (managers); proprietors (managers); clerical; sales; craftsmen; machine operators; household workers; non-domestic service workers; family farm labor; unskilled non-farm labor; and unknown occupations.
[10] The 13 market values are: cream and milk; live calves; cattle; other dairy products; florist products; forest and horticultural crops; fruit and nut crops; hogs and pigs; nursery and greenhouse products; trees and shrubs; poultry; sheep; vegetable crops.
[11] Interestingly, in both cases these diversification variables do not mediate the impact of drought exposure on population growth.

Consistent with the cross-section evidence, Figure 3 Panel A shows that the population in 1960 is about 5.2 percent lower in drought exposed towns relative to the 1950 base year. By 1970, this effect more than doubles, so that the population among drought exposed towns is now on average about 12.7 percent lower. The negative impact of the drought is also highly persistent at the town-level, so that by 1980, the population in drought exposed towns is now 25.5 percent lower on average compared to if these towns were never exposed to the drought. Together, these point estimates suggests that the average population decline after 1950 among drought exposed towns is -14.4 percent (p-value<0.00). Panel A also suggests that there was no pre-trend, as population levels in 1930 or 1940 did not significantly differ from the 1950 baseline among drought exposed towns. If anything, the average pre-1950 point estimate is positive at 1.7 percent (p-value=0.44), and the resulting difference-in-difference point estimate is -15.05 (p-value<0.00).

Panel B of Figure 3 repeats the event study analysis using a county-level population panel, also observed over the period 1930-1980. A similar pattern emerges at the county-level, though as before, the impact of drought exposure is smaller at the county-level. For example, the population in 1960 is about 4.5 percent lower in drought exposed counties relative to the 1950 base year. This effect doubles to around 9.4 percent in 1970, but then population losses slow during the 1970s at this more spatially aggregated level, so that the population in 1980 is about 11.7 percent lower on average than otherwise among drought exposed counties.

Building on these event studies, Table 4 next examines the importance of ex-ante finance in mitigating the impact of the drought using a standard DiD framework. To this end, the analysis interacts the "post-1950 indicator *drought exposure" variable with the county's 1950 log per capita credit; all lower order interaction terms are include along with state by year fixed effects. At the 10^{th} percentile of loans per capita, drought exposure suggests a 16.6 percent decline in population over the 1960-1980 period relative to the previous decades. But as in the cross-section, at the 90^{th} percentile of loans per capita, the average effect of the drought is only -5.7 percent, which is not significant (p-value=0.29). In results available upon request, we have included the full suite of controls from column 6 of Table 3, both linearly and interacted with drought exposure; we obtain very similar marginal effects of ex-ante credit.

To address any residual endogeneity concern that loans per capita in 1950 might reflect the early onset of the drought in some counties, column 2 uses instead loans per capita circa 1940 to proxy for local credit constraints. The impact of credit on mediating the effects of the drought using this earlier proxy is similar to the 1950 estimates in column 1. At the 10th percentile of credit, drought exposure suggests a 12.82 percent demographic decline over 1960-1980. But at the 90th percentile, this effect shrinks to -6.4 percent, which as before is not significant (p-value=0.22). In sum, the panel evidence suggests that drought-related population losses accelerated through the 1950s and 1960s, with ex-ante credit availability mediating losses.

2.2. Demographic Outcomes—Migration and Fertility

This divergence in long run demographic outcomes can arise from permanent net migration away from drought exposed counties with limited access to credit, and migration's contribution to fertility (and reduced fertility) in the host location (sending location). Fertility among the remaining population can decline, for example if the remaining population are older and past the child-bearing age, or are less able to afford children because of their diminished economic circumstances. In Table IA A1.3, we find evidence consistent with these various pathways in the county-level cross-section. In column 1, for example, top quartile drought exposure is associated with a 1.67 percentage point decline in the percent of domestic immigrants into a county (p-value=0.04) in 1960 for a county at the 10th percentile of the log of per capita loans in 1950. But at the median of the ex-ante credit availability distribution, the negative impact of the drought becomes much smaller and statistically insignificant.

IA Table A1.3 also shows that the number of per capita live births in the county in 1960 among drought exposed counties with limited credit fell significantly and remained much lower even in 1980. Top quartile drought exposure is associated with a 3 percentage point drop in the number of live births in 1960 for a county at the 10th percentile of the log of per capita loans in 1950 (p-value=0.03). But at the median of the ex-ante credit availability distribution, the negative impact of the drought is again small and insignificant. By 1980, births per capita is about 2.8 percent higher in 1980 among drought exposed counties at the 90th percentile of the credit distribution, and this impact is different from zero (p-value=0.05). IA Table A1.3 also shows that deaths per capita are higher in drought exposed counties with low credit, especially over the long run (by 1980) when these effects would become discernible.

We have shown that there is less immigration, fewer births, and higher death rates in counties with high drought exposure and low access to credit. IA Table A1.4 examines the impact of the drought on the median age in counties. The demographic evidence shows that the median age rises significantly in these counties, both in 1960 and in 1980. We repeat the analysis of Table 3 for town population growth. It is in IA Table A3.1. The economic magnitudes are similar to those obtained using county-level data.[12] Unfortunately, we do not have the details of demographic composition in each town and cannot repeat the demographic and age analyses.

2.4. Credit Outcomes—Town-Level Evidence

Towns were the predominant centers of finance in most counties during this period, and affords our analysis more granularity. The key prediction is that if credit availability indeed shaped the demographic impact of the drought, then towns with smaller ex-ante credit constraints should also experience a relatively larger increase in drought-related lending, as in-town banks expand credit supply in order to meet drought-related credit demand. But in towns where ex-ante credit constraints are large, so that lending does not respond to need, bank lending should be much less sensitive to drought-induced need.

Table 5 examines the impact of drought-exposure and ex-ante credit availability on credit and other bank outcomes. The dependent variable in column 1 is the change in town-level bank lending between 1950 and 1960 scaled by total town-level bank assets in 1950. Column 1 shows that drought-exposure is associated with increased bank lending in towns with greater ex-ante credit access. But for towns with low ex-ante credit access, drought-exposure is associated with a sharp relative contraction in loan growth. For a town at the 10th percentile of the per capita bank credit distribution in 1950, drought exposure suggests a 30.6 percentage point decline in lending over the next 10 years (p-value=0.01), but for a town at the 90th percentile of this distribution, the impact of the drought on lending is positive, at 14.5 percent, but not significantly different from zero (p-value=0.27).

The evidence in column 1 might reflect "pre-trends" in bank lending rather than the local banking system's supply response to the drought. That is, the spatial variation in drought-exposure is random, but the decades immediately after WWII was a period of rapid economic growth in the US, and the variation in town-level drought-exposure might coincide with pre-existing trends in credit growth. We have of course already seen at the county-level that ex-ante differences in attributes between top quartile drought exposed counties and others are slight, but

[12] Also, because droughts are spatial shocks, they can induce dependence in the standard errors based on the spatial proximity of towns. To address this concern, we use the procedure described in (Conley 1999) to adjust the standard errors for possible spatial dependence. These results are in Appendix Table A3.2; the main findings are robust to a wide range of distance-based dependence assumptions.

to address this concern directly, column 2 replicates the specification in column 1, but for lending growth between 1940 and 1950—the decade before the drought. The drought indicator variable, along with the interaction term with per capita credit in 1940 are individually and jointly insignificant. The implied magnitudes are also tiny. This finding suggests importantly that the interaction of credit availability with the drought shock, rather than credit availability alone, seems to be associated with different outcomes.

As a further check of the supply response interpretation, the loans to assets ratio in 1960 among in-town banks is the dependent variable in column 3. The coefficient estimates suggest that these results do not reflect a general balance sheet expansion among banks, but a shift in the composition of banks' assets towards loans in response to drought-related credit demand. Also, droughts can affect bank liquidity and capital and both the liquidity and capital channels can also affect loan supply. To check these alternative channels then, column 4 of Table 5 includes the change in deposits in the town between 1950-1960, scaled by assets in 1950, as well as the change in total bank capital over the decade, scaled by assets in 1950. We also include the interaction of these variables with the drought indicator. Neither the marginal estimated impact of drought exposure on lending, nor the point estimate on the loans per capita in 1950 interacted with the drought indicator, change appreciably relative to column 3, which presents the same regressions without these additional controls.

3. Identification

The evidence thus far is consistent with credit availability being associated with less population decline (and thus, indirectly, suggestive of greater adaptation), but as Table A1.5 shows, there are other plausible alternative interpretations. Loans per capita is positively correlated with deposits per capita and median income, and negatively related to the share of rural population and other potentially important variables. We have of course controlled for these possible confounders both in the cross-section and panel contexts, but we now suggest tests that offer greater evidence of the causal effects of credit availability, and help distinguish between these alternative interpretations.

3.1 Bank credit supply at the border

Until the deregulatory waves of the 1980s, interstate branching was largely prohibited. To the extent that a migrating borrower had to stay near their bank's network of branches—in those states that allowed bank branches--in order to avail of the bank's knowledge about them and obtain additional credit, this would limit migratory options.

It was also difficult to lend across state borders. Concerned about the illiquidity of real estate collateral, states severely restricted the types of mortgage-related transactions that their banks could engage in across state lines, imposing limits for example on the types of properties that could be used as collateral, aggregate limits on out-of-state exposures, as well as more general limits on the size and duration of the mortgage portfolio (Weldon 1910; Barnett 1911). Perhaps most difficult was registering and seizing collateral across state lines (The Bankers Encyclopedia 1920). Until the enactment of the Uniform Commercial Code in most states starting in the late 1950s (see Braucher (1958)), collateral registration and foreclosure laws and practices differed across states, making it difficult for an out-of-state lender to establish the priority of their claim, as well as to seize collateral that had been pledged to them. Nearby in-state lenders with lawyers admitted to the state bar could more easily assess claims and imminent distress, as well as seize collateral, resulting in lower losses given default relative to equidistant banks that lend across state lines. As a result, bank credit across state lines was significantly attenuated relative to bank credit within state (Rajan and Ramcharan (2015)).

If credit markets are extremely local, credit availability in even proximate towns or counties should not matter for credit conditions in the local market. However, to the extent that their original bank's network of branches (and correspondent banks) extends to nearby locales, borrowers might still be able to migrate and obtain fresh credit in their new location from local lenders there. These lenders would get to know the borrower's credit history from the network, and if in-state, would be able to handle the borrower's past loans and collateral pledges, including livestock and other farm assets, even while lending against new assets. So we would expect that if better prospects elsewhere drives outmigration, in-state locations with strong credit availability would be particularly attractive if credit were an important factor, while equidistant out-of-state locations with strong credit availability would not.

By contrast, if per capita bank credit in 1950 proxies for income, local economic diversification or some other latent factor, then state borders should be largely irrelevant. For instance, if per capita credit proxies for income or non-agricultural sources of employment, then people in drought affected towns seeking better economic opportunities could just as easily migrate to higher income nearby towns in-state, or to equidistant higher income towns across the state border.[13] The estimated coefficient of per capita bank credit in 1950 computed over nearby towns and interacted with drought exposure, should be similar whether in state or out of state.

To implement these border tests, for each town in the sample we locate all towns within a 200 mile radius and in the same state, and then compute the mean per capita credit among these nearby towns in 1950, excluding credit in the reference town itself. Similarly, we locate all towns within the same radius of the reference town, but across the state border and compute the mean per capita credit among that subsample of towns. The baseline estimation includes these two additional variables linearly, as well as interacted with the top quartile drought exposure indicator variable of the town in question. To exclude mechanical size effects, we also compute separately the total population of the towns in the 200 mile radius, in-state and out-of-state, and interact these variables with the drought indicator as well; we continue to interact the town's population with drought exposure as well.

The dependent variable in column 1 of Table 6 is population growth in a town between 1950 and 1960. The bottom panel of Table 6 reports the marginal effects of drought exposure for in-town; in-state and out-of-state sources of credit. As before, the negative impact of drought exposure is smaller when in-town credit constraints are small. At the 10th percentile of the in-town loans per capita distribution, drought exposure suggests an 8.6 percentage point decline population (p-value=0.04). But at the 90th percentile, drought exposure suggests a 2.2 percentage point increase in population (p-value=0.68). However, consistent with the credit-induced migration hypothesis, the negative impact of drought exposure on a town's population growth is larger when nearby in-state loans per capita is large. At the 90th percentile of loans per capita among in-state banks within a 200 mile radius, drought exposure suggests a 6.8 percentage point drop in local population growth (p-value=0.09).

Importantly, the coefficient on loans per capita among equidistant out-of-state banks is about half the size at the 90th percentile of credit availability and not statistically significant. Because towns are on average closer to their in-state neighbors than their out-of-state neighbors, even within the 200 mile radius, column 2 uses third order polynomials to control both for the average distance between a reference town and its in-state neighbors, and the average distance between a

[13] One could imagine other constraints in seeking employment across state borders – for example, the need to recertify professional qualifications. It is hard, however, to imagine such constraints affected the majority of potential migrants, especially farmers and agricultural labor fleeing the drought.

reference town and its out-of-state neighbors. The point estimates and marginal effects are qualitatively similar. We retain these distance polynomials as controls in what follows.

Nearby in-state centers of bank finance are likely to attract migrants when loans per capita in these towns is large relative to the size of lending capacity in the drought-affected town itself. Column 3 evaluates this prediction using a triple interaction term. This specification interacts drought exposure and in-town per capita credit, as well as in-state per capita credit—all three variables and their cross interaction terms are included as well. The marginal effects, shown in the bottom panel, are consistent with the substitution-cum-migration hypothesis. Consider a drought exposed town at the 10^{th} percentile of loans per capita that is also located next to in-state towns at 10^{th} percentile of loans per capita—both the town and its neighbors have limited bank credit availability. In this case, drought exposure is associated with a 7.8 percentage point drop (p-value=0.11) in population growth in our reference town. Now if the reference town at the 10^{th} percentile of loans per capita is located next to in-state towns at the 90^{th} percentile of loans per capita, then drought exposure suggests an 11.0 percentage point (p-value=0.04) decline in population, presumably as the reference town's population migrates from the drought exposed town with limited credit to nearby in-state towns with more credit. [14]

As with the town-level panel evidence, column 4 of Table 6 shows that an even sharper pattern emerges in the long run. The dependent variable is population growth over 1950-1980. Drought exposure suggests a 5.9 percentage point drop in population for a town at the 10^{th} percentile of in-town per capita credit when in-state loans per capita in nearby towns is at the 10^{th} percentile (p-value=0.52). But when the neighboring in-state towns are at the 90^{th} percentile, population declines by about 30.4 percentage points (p-value=0.03) among drought exposed towns at the 10^{th} percentile of loans per capita, as people migrate to nearby in-state sources of finance. Column 5 Table 6 shows a similar pattern for lending. The dependent variable in column 5 is loan growth, using the change in loans between 1950 and 1960 among banks headquartered in a town, and scaled by total banking assets in 1950 as the dependent variable. As the estimates show, lending collapses in drought exposed towns with relatively high credit constraints that are also located near relatively large in-state centers of bank finance.

[14] Note that regardless of the size of nearby in-state sources of credit, the demographic impact of the drought on towns with small populations and limited in-town sources of credit is generally much more negative.

3.2 Border Differences

Could the in-state and out-of-state differences stem from differences in attributes across a state border rather than the causal effects of credit? In Table A1.6, we restrict the sample to counties whose geographic centroid is located no more than 200 miles from a state border. For 10 key variables, Table A1.6 then shows the mean of these variables separately for counties located on either side of the state border, and reports both the one sided and two sided tests for whether the mean differs across the two samples. For the sample of counties within 200 miles of a state border, mean differences across these 9 variables are relatively tiny and mostly insignificant. For instance, among these border counties, the mean difference in median income on either side of the border is just $27.07, and this difference is insignificant (p-value=0.55). There are however small differences in population—the mean log difference in population is 0.19 (p-value=0.01) for example. However, all specifications already absorb county population.

Finally, in Table IA A1.7, we perform an "intention-to-treat" analysis at the county-level. We have seen that nearby in-state sources of credit help mediate the drought's impact, as people can migrate to nearby in-state areas in search of loans. The approach in Table A1.7 thus computes the total amount of in-state credit within 200 miles of a county, and allows the impact of drought exposure in the county to depend on the overall nearby in-state sources of finance. That is, the relevant measure of credit is broader than just the county. We also allow the impact of drought to depend on loans per capita among equi-distant out-of-state counties. As in the case of towns, plentiful sources of in-state credit tend to reduce population growth among drought exposed counties. There is again no such effect across state lines.

3.3. Bank-Level Analysis: Branching regulations and state borders

We now extend the border approach further, combining bank-level data with differences in branching regulations across states in order to identify a particular lending friction that might mediate a local bank's response to the drought.

In our sample, 8 states were unit banking states (Figure 4), where a bank could have only one office and could not open additional branches. Four states had no specific laws on branching, while 15 states allowed full branching, so that banks were free to open up branches anywhere within the state; the remaining branching states limited branching to either within the same town or county in which the bank was headquartered.

Standard risk-sharing-through-geographic-diversification arguments predict that in drought exposed areas, banks in branching states would be better able to meet loan demand relative to unit banks. On the asset side of the balance sheet, banks in branching states would be less exposed to large losses stemming from concentrated lending in drought exposed areas, preserving their lending capacity relative to unit banks. On the liabilities side of the balance sheet, branching networks can also raise deposits or transfer spare liquidity more easily from non-drought exposed parts of the state to make loans in the drought affected areas. This movement of liquidity within the network to meet the liquidity needs of the local drought exposed population also limits inefficient loan sales and local fire-sales. In contrast, unit banks would have to rely on risk-sharing through their less-reliable correspondent banking relationships, making them less able to lend into the drought compared to banks that have a branch network. Consistent with these observations, a number of papers suggest there was more banking distress in banks in unit banking states during the Depression than in banks in branch banking states (see, for example, Calomiris (2000), Michener (2005), Wheelock (1995)).[15]

There are, of course, reasons why a unit bank, if it stays healthy, might lend more locally after a shock, such as its inability to lend outside the distressed area, unlike a branch bank.[16] So whether unit banks lend more after a shock or less depends on their health conditional on the shock. Comprehensive shocks like the drought, we hypothesize, would more likely impair unit bank health and their lending relative to branch banks, especially if the unit bank has large exposures before the shock. This is why we now test whether crossing the border from a unit banking to a branching state mediates a bank's lending response to the drought. We find this to be the case below, and will use the fact in subsequent analysis.

The baseline analysis in Table 7 uses the 8 unit branching states for which we have bank-level data, along with the states that had laws explicitly allowing some kind of branching—we omit the 5 states that had no explicit regulations on the spatial provision of banking services—see Figure 4. Clearly, because of their differing economic and political histories, branching and unit

[15] Unit banks have especially struggled in agricultural areas. Writing after the twin banking and agricultural crises of the 1920s, (Cartinhour 1931) observes: "The appalling mortality record of the small unit banks located in purely agricultural territory has been revealed elsewhere. In the main the wholesale colossal number of small bank failures can probably be charged to the unit system itself. The banks have limited capital, little or no credit with correspondent banks, with no affiliated bank to lean upon and with no diversity loans—when there occurs a shortage or failure of crops…"

[16] Conversely, banks might be more discriminating in their use of funds in branching states, rebalancing lending away from risky drought exposed areas towards less drought exposed parts of the state (Commission 1935).

banking states differed in 1950 on a number of dimensions. To reduce the impact of unobserved heterogeneity, we restrict the baseline analysis to banks located in counties with a centroid no further than 200 miles from a branching-unit banking state border. These restrictions create a sample of banks separated by branching regulations along 21 state borders.

The dependent variable in Table 7 is the change in lending at the bank-level between 1950 and 1960, scaled by bank assets in 1950. The specification uses an indicator variable equal to 1 if a bank is located on the branching side of a state border, and 0 if the bank is on the unit bank side. We interact this branching variable with the top quartile drought indicator variable, including the drought indicator directly as well. To help absorb unobserved heterogeneity, all specifications include a county's distance from the particular state border. There is little variation in this variable as it is bounded at 200 miles. There is however much more variation in a county's distance along a particular state border—such as along the GA-FL or NE-SD borders; this distance varies between 0—a county at the beginning of the border between a branching and unit banking state—to 528 miles—a county at end of the same border between the two states, such as Colorado and Utah. Because the variation in distance along the state border can proxy for geographic and other differences, following (Holmes 1998) the baseline specification includes this variable up to a third order polynomial. To absorb further unobserved heterogeneity at the border, all regressions also include border fixed effects.

In addition to the border and distance controls, we also allow the drought's impact on bank lending to vary depending on the log of the county's median income in 1950; the rural population share in the county; as well as the mean farm size in the county along with the county's population. The specification also includes the log of the town's population in which the bank is headquartered. Finally, we cluster standard errors at the bank-level.

The evidence in Table 7 suggests that unit bank lending was less resilient to the drought. From column 1, for two banks of similar size, capital and liquidity, and located in counties with similar median income, population, and farm sizes, the marginal impact of the drought on lending growth at a unit bank is -4.6 percentage points (p-value=0.09). But crossing the border into a branching state, drought exposure is not associated with a significant decline in lending—the point estimate is small -2.6 and insignificant (p-value=0.23). In addition to allowing the impact of the drought to depend on county-level observables, column 2 further controls for bank-level heterogeneity, by allowing the impact of the drought on bank loan growth to depend on the bank's asset size; capital to asset ratio; deposits to asset ratio and loans to asset ratio—all measured in 1950. After absorbing bank-level differences, the loan supply response between unit and branching banks widens. The marginal impact of the drought on lending growth at a unit bank in column 2 is -5.2 percentage points (p-value=0.05), but only -0.005 (p-value=0.79) in a branch banking state. We will use this finding shortly.

3.4. Summary

In sum, we have seen evidence that drought exposed towns and counties suffer significant emigration and demographic decline when credit availability is limited, creating long-run divergence. This result remains qualitatively similar when including a large number of potentially confounding variables. We have also seen evidence that the adverse effects of drought exposure on demographic decline are particularly strong when both lending capacity within a town is limited and the lending capacity of neighboring in-state towns is relatively large. This is not the case for neighboring out-of-state towns. There is also evidence that banks in states that permit branching are more able to lend into the drought than banks in states that permit only unit banks. More generally, the evidence suggests that bank finance helps local economies adapt to large scale environmental shocks.

4. Adaptation through irrigation

We have seen how ex-ante credit availability affects credit usage during the drought, and also population growth. The mediating link between the two is adaptation investment, which we now focus on. We examine irrigation, widely perceived to be the "premier" adaptation margin to drought (Saarinen 1966). And during our sample period, the center-pivot system was the breakthrough innovation that allowed farmers to access groundwater in order to adapt to drought conditions. For example, irrigated acreage in Kansas grew from 250,000 acres in 1940 to about 1,000,000 acres by 1959 largely on account of the adoption of these center-pivot systems. This adaptation margin entails both significant upfront capital investments—reliable gasoline and diesel engines as well as drilling technologies adapted from the oil-industry—and higher operating expenses—fuel and ongoing maintenance costs. Access to finance is thus widely believed to have shaped this adaptation margin (Wiener, Pulwarty and Ware 2016).

In order to measure the importance of ex-ante credit in enabling the shift to irrigated farming in drought areas, we use relatively high-frequency data on well-depths taken from approximately

106,000 wells. This approach builds on the fact that there is increased aquifer depletion in drought exposed areas when credit is used to finance a shift to ground-water irrigation, which will in turn increase the depth of wells in the county—the distance from the surface to the water-level in the well. However, in drought exposed areas with aquifers but limited access to finance, the inability to finance adaptation and the overall decline in agriculture will create less aquifer discharge, resulting in shallower well-depths.

The United States Geological Survey began collecting data on the water depth of these 106,000 wells in 1950.[17] On average each of these wells was sampled every 80 days during our 1950-1970 sample period. Over the period 1950-1970, the summary statistics show that wells in drought exposed counties during the drought period (1950-1957) were about 30.75 feet deeper than wells not exposed to drought conditions (p-value<0.00). The mean well depth over the sample period was 57.6 feet with a standard deviation of 71.1 feet.

The US government did not observe well-depths before 1950 and we cannot formally test for differences in pre-drought trends across these counties. But the event study analysis in Figure 5 strikingly illustrates the well-depth dynamics across these counties, helping to connect causally the timing of drought exposure, credit and the shift towards ground-water irrigation. The data are observed at the well-depth-observation date level and constitute an unbalanced panel over the sample period 1950-1970 that produce about 740,178 well-depth observations. This well-level panel structure allow us to include county fixed effects (because whether a county is in drought varies over time), absorbing local geographic and other time-invariant factors, such as the size of underlying aquifer. Also, because we are focused on agricultural investment, the more appropriate measures of credit availability are loans per farm or loans per acre of farmed land—both are highly positively correlated with each other and with loans per capita (Table 1). In what follows, we present only the loans per acre results in the interest of concision, but obtain similar results with loans per farm.

For each year of drought, the event-study figure plots the average difference in well depth in counties at the 90th percentile of loans per acre to those at the 10th percentile (Figure 5). This average difference is allowed to vary by year from 1950 through 1965—the first seven years of

[17] The data are obtained from https://waterservices.usgs.gov/rest/GW-Levels-Service.html. An overview of water monitoring and well-depth observations in the United States can be found here: https://cida.usgs.gov/ngwmn/doc/ngwmn_framework_report_july2013.pdf

the drought in the sample period—1950-1957—and the seven years immediately after the drought ends—1958-1965. Using loans per acre as the measure of ex-ante credit access, well depth is on average about 45 feet deeper from 1950 to 1956—the peak drought years—in wells located in counties at the 90th percentile of bank finance relative to those at the 10th percentile. But once the drought ends circa 1957 and the rains recharge the aquifers, this gap shrinks rapidly to around zero, becoming insignificant by 1958.

The timing in the event study analysis points to credit as a key factor in the irrigation response to the drought, and column 1 of Table 8 examines the average impact of drought exposure and bank credit access on well depth using a difference-in-difference design. The specification includes an indicator variable that equals 1 if a well is located in a county-year pair that is in drought and 0 otherwise. We interact the county-year drought indicator variable with the 1950 loans per acre. This interaction term measures whether the average effect of drought exposure on well depth varies with credit availability in the county. The sample period remains 1950-1970.

From column 1, the coefficient on the interaction term between the time-varying drought exposure variable and loans per acre in 1950 is positive and significant—well depths are deeper in drought exposed counties with more ex-ante credit access. For a county at the 10th percentile of the loans per acre variable, top quartile drought exposure implies a -9.95 feet decrease in the average well-depth in the county, as agriculture declined along with water usage. But for a county at the 90th percentile of loans per farm, well depth increases by 23.9 feet—a difference of about 34 feet from well depths for counties at the 10th percentile.

To identify better the role of credit in shaping the irrigation response, column 2 relies on the previous bank-level result showing that unit banks were less able to increase credit in response to the drought. The basic rationale behind this test is that because unit banks were less able to offer credit, loans per acre should matter less for shaping well-depth among drought affected counties in unit banking states.

Of course, in any such test, it is important that the unit banking indicator, through bank distress, be a good proxy for ex post credit availability. This assumes there are no other systematic differences between unit and branch banking states that can affect borrower investment. Studies find that, if anything, branch banking states were underbanked relative to unit banking states in terms of access to banking offices over the period of our study (see Horvitz and Shull (1964), Jacobs (1965), Pakonen (1969)). We also correct for ex ante bank credit availability in what follows. Most important, though, we examine irrigation (and, implicitly, irrigation loans), thus narrowing the borrower to local farmers.

In column 2 we essentially estimate a triple interaction term. The specification allows the marginal impact of drought exposure to depend both on loans per acre, and an indicator variable for whether the county is in a unit-banking state—all lower order terms are included. We then calculate the full marginal effects in unit banking states at different levels of credit availability. Ex-ante credit does not mediate the impact of the drought on well-depths in unit banking states.

Specifically, at the 10th percentile of ex ante credit availability, wells depth is shallower in both drought-affected counties in unit banking states (9 feet, p-value=0.06) and branch banking states (11.5 feet, p-value=0.01) suggesting little financing. But at the 90th percentile of loans per acre, wells are about 23.5 feet deeper (p-value<0.01) in drought-affected counties in branching states suggesting plentiful financing for irrigation investment. In unit-banking states, however, well-depths are largely unchanged when drought affected even in counties with ex ante credit availability at the 90th percentile (-2.67 feet, p-value=0.89), suggesting little incremental financing for investment. So even in areas with high ex ante credit availability, farmers in unit banking states do not appear able to increase well depths, adding support to the view that credit supply was essential for adaptation.

Columns 3 and 4 of Table 8 next examine the impact of credit on irrigation at the extensive margin. The dependent variable is the log number of wells located in a county in each year, resulting in an annual county-level panel from 1950 and 1970. At the 90th percentile of loans per acre for example, the number of wells increased by about 35.5 percent (p-value<0.01) in drought exposed counties. At the 10th percentile of loans per acre, drought exposure is not significantly associated with an increase in the number of wells. And again, in column 4, we interact drought exposure and loans per acre with the unit banking indicator variable. Once again, ex ante credit availability does not help in unit banking states, with the coefficient estimates at all levels of ex ante credit availability being statistically not different from zero.

5. Adaptation and outcomes

5.1. More on adaptation

Having established that access to credit influences adaptation through more, and deeper, irrigation wells, let us turn to outcomes other than demographic change, including irrigated acreage, farm output, adaptation through drought-resistant crops and capital investments, ownership patterns, farm values, and spillover effects to other sectors.

Most immediately, if indeed credit allowed farmers to drill for water in order to adapt to drought conditions, then the acreage of irrigated land in farming should also increase more in drought exposed counties with credit access (see (Evett 2020) for a survey of irrigation on the Great Plains). Column 1 of Table 9 assesses this extensive margin prediction using decadal data from the US Census. The dependent variable is the change in irrigated acres in a county between 1949-1959. The point estimates show that there is a near doubling of irrigated acres in drought exposed counties at the 90th percentile of 1950 loans per acre during this drought decade, and a sharp decline in irrigated acres when these counties are at the 10th percentile of loans per acre.

While irrigation is the premier adaptation margin to droughts, crop choice is also an important dimension of drought adaptation. Access to finance can also help with such adaptation, as adopting new crops typically involves new seeds, new growing techniques, as well as a fair amount of risk. Sorghum is one such well-known drought resistant grain, and is often used to feed livestock instead of less-drought tolerant corn during times of drought (Abdel-Ghany, Ullah et al. 2020). Consistent with crop choice as an important adaptation margin, sorghum production significantly expanded across the US during the drought affected 1950s, rising from 12 to 27 million planted acres between 1952 and 1957 (Lin and Hoffman 1990).[18] To gauge the importance of finance in this adaptation margin, column 2 of Table 9 studies the county-level variation in sorghum production—the change in the number of bushels between 1949 and 1959. Among drought exposed counties at the 10th percentile of the credit availability, there is no significant change in sorghum production over this period. But at the 90th percentile of the credit availability, sorghum production expands by about 23.4 percentage points (p-value=0.07).

Column 3 of Table 9 examines the impact of this shift towards irrigated farming on farm output. The dependent variable in column 3 is log output per farm in 1970. The specification uses a triple interaction term, allowing the impact of drought exposure to vary with loans per acre and the log of irrigated water usage on farms in 1969 (acres-feet); all lower order terms are included as well. Because output per farm can mechanically reflect pre-existing variation in farm

[18] In part, this adaptation was driven by the development of new hybrid sorghum which was suitable for deficit irrigation—irrigation only during the drought sensitive part of a crop's yield cycle—making it profitable for farmers to simultaneously invest in irrigation and shift production towards sorghum (Schertz 1979).

sizes, the specification also interacts mean farm size in 1950 with both the drought exposure variable and water usage variables. We also control for output per farm in 1950 to absorb preexisting level differences in farm productivity.

The marginal effects of drought exposure are in Panel B of Table 9. These marginal effects suggest that the availability of credit combined with the physical capacity to adapt through irrigation helped to mitigate the effects of the drought. Drought exposure in the 1950s is associated with an 8.4 percent increase in output per farm in counties at both the 90th percentiles of credit and irrigation. But without credit or the physical capacity to access ground water, the marginal effects of the drought on output per farm is negative, though imprecisely estimated.

Credit would have also allowed marginal farmers to survive, affecting farm ownership and tenure, as well as the overall number of farms. For example, tenant farmers, without land collateral, are usually the most marginal farmers, heavily dependent on cash flow if credit is unavailable. They are most likely to be able to benefit from greater access to finance during a drought. Table A1.8 thus studies the role of credit availability in mediating the impact of the drought on farm ownership, acreage, and the number of farms. The evidence is suggestive that tenant farming survived to a greater extent in drought affected areas with credit (that is, the share of owned farms was lower), and that the overall acreage devoted to farming increased, while the number of farms declined less, in drought exposed areas with credit availability. In addition to helping the agricultural sector survive the drought, Table A1.9 also suggests that these adaptations led to higher farm values in the long run. In 1978 for example, the average farm value was about 7 percent higher among drought exposed counties at the 90th percentile of loans per acre in 1950.

5.2 Spillovers: Drought, credit and the non-agricultural economy

Unaddressed, the effects of drought can clearly spill over onto other facets of the local economy. Easier access to credit can have both a direct and an indirect effect on the survival of non-tradeable businesses, such as local retail establishments, during the drought. For a given decline in local demand on account of the drought, the non-tradeable sector might access working capital and fulfil its other credit needs in areas with high ex-ante credit availability, helping the sector survive. By helping farmers and other businesses survive, and by limiting population shrinkage, credit can also preserve local demand in the face of the drought, indirectly benefitting the non-tradeable sector.

Table 10 studies the impact of the drought on the non-agricultural economy. Column 1 proxies for the size of the local non-tradeable sector using the log number of retail establishments in the county in 1967. We control for the initial pre-drought size of the retail sector using the log number of retail establishments in 1952—these are the two closest years with the data that are adjacent to the pre and post drought period. All specifications also include the baseline controls. Because our focus is now on the non-agricultural economy, we report marginal effects for loans per acre and loans per capita. Drought exposure is associated with a 9.5 percent decline in the number of retail establishments in 1967 in counties at the 10^{th} percentile of the loans per acre distribution (p-value=0.09). The negative impact of drought exposure on retail growth in areas with limited credit is similar when measured over the 1952-1977 period (column 2), though less precisely estimated.

The demand for manufacturing products is often national or international and is unlikely to be directly affected by the drought. Instead, the drought can affect the manufacturing sector mainly through the availability of credit and labor supply. In areas with limited access to credit, the contraction of the agricultural economy in response to the drought can push labor off farms and increase local labor supply, allowing the local manufacturing sector to expand. However, if low credit availability also constrains investment in the manufacturing sector, then the capacity of the manufacturing sector to absorb surplus farm labor in the short run might also be limited. Then drought-induced net local outmigration could reduce potential labor supply over time, increase manufacturing labor costs, and hurt the manufacturing sector.

Columns 3 and 4 of Table 10 examine the local manufacturing sector. The dependent variable in column 3 is the log number of manufacturing establishments in the county in 1967, and we control for the pre-existing size of the manufacturing base using the log number of manufacturing establishments in 1940. In column 4, the dependent variable is the log number of manufacturing establishments in the county in 1977. The estimates are less precise than the retail case, but continue to suggest that drought exposure and limited credit access had negative spillover effects on the local manufacturing sector. Note that the results are similar, though slightly less precisely estimated, if the dependent variables are expressed as changes instead of log levels.

Taken together, the evidence suggests the outmigration in areas where agriculture could not adapt because of a lack of credit, the associated fall in local demand coupled with the fall in local labor supply, and finally the direct adverse effects of a lack of credit to business for investment, all had adverse effects on local businesses even outside agriculture. These spillovers likely further hurt livelihoods, and further exacerbated long term demographic decline.

6. Conclusion

We collect bank balance sheet data, along with economic and demographic data across US towns and counties, to study how credit availability can interact with climatic shocks to determine long run economic outcomes. We find that exposure to the drought leads to large and persistent declines in population at both the town and county-levels. However, ex-ante credit availability moderates the demographic and economic impact of the drought.

These results are supportive of the importance of the availability of funding for adaptation investment in enabling communities to survive climatic calamities – an issue that rightly concerns poorer countries as they face climate change. To the extent that it helps unaffected communities avoid waves of uncontrolled climate-induced immigration, unaffected communities too have an interest in providing that financing. Indeed, our paper suggests that with adequate financing, and the physical means to adapt, say through groundwater usage, climate-hit communities may even bring forward investment that would otherwise take place with delay, allowing them to build future buffers and even incomes. Conversely, we also find that inequality in access to finance can actually exacerbate outmigration, from finance-poor communities to finance-rich communities.

As we have shown, the Texas drought did not constitute a permanent change in weather conditions, and there was plentiful groundwater available over the course of the drought. Climate change may have a more permanent character, and groundwater resources could be depleted over time. Nevertheless, there could be other ways of adapting, including financing a shift away from agriculture. Broadening access to finance may be really important to ensure the bulk of the change takes place through local adaptation, preserving local communities and relationships, rather than through migration, which entails costs for the communities left behind, for migrants, as well as for receiving communities. At the very least, finance allows more choice, and can be an important aid as we face up to the challenge of climate change.

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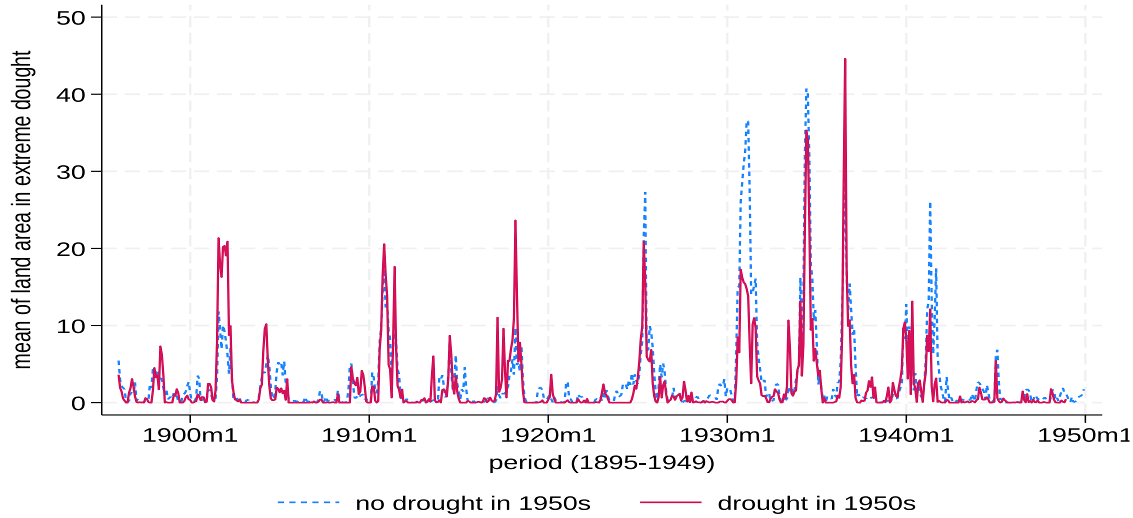
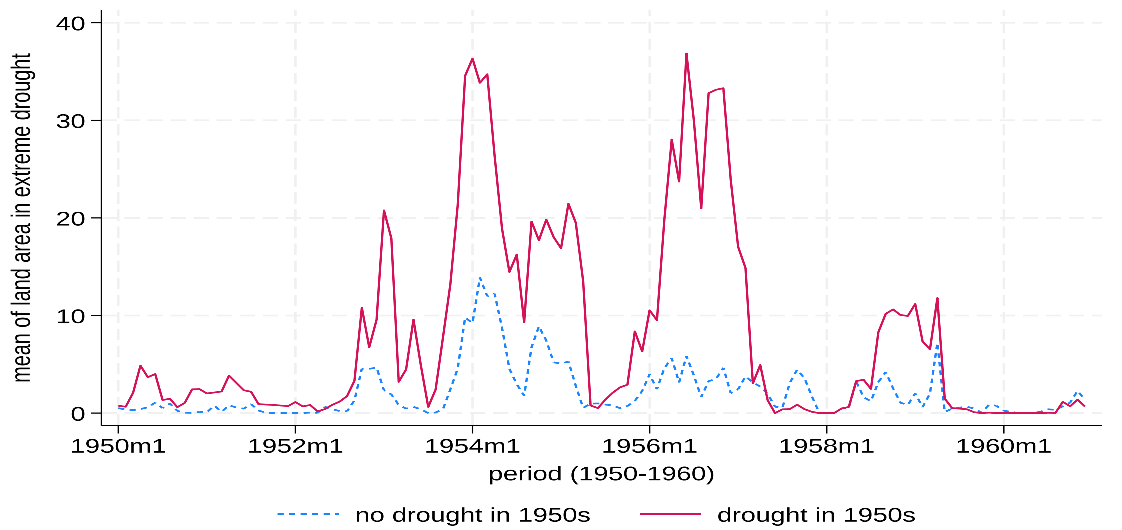
Figures and Tables

Figure 1 The mean monthly percent of land area in extreme drought

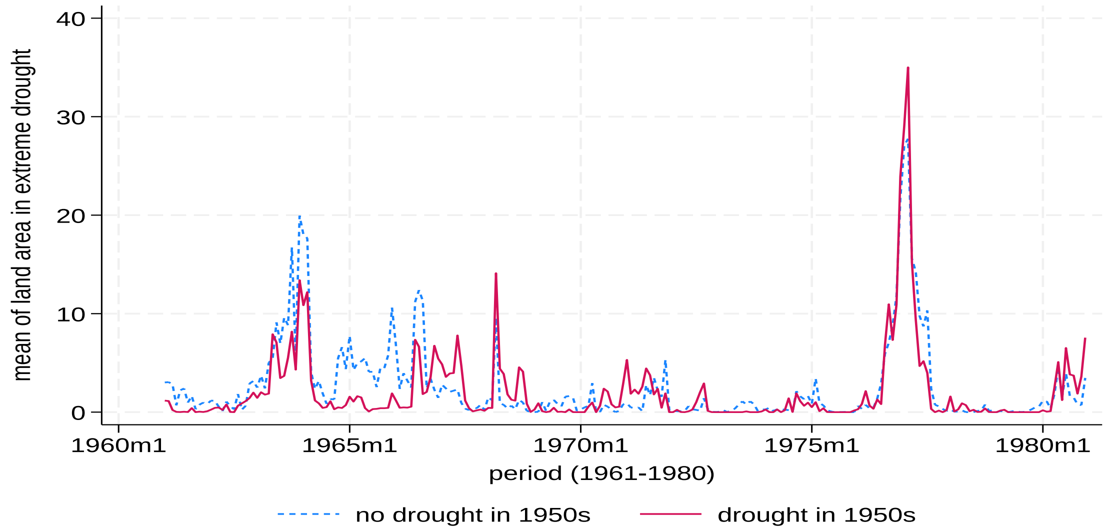
Panel A. 1895-1949



Panel B. 1950-1960

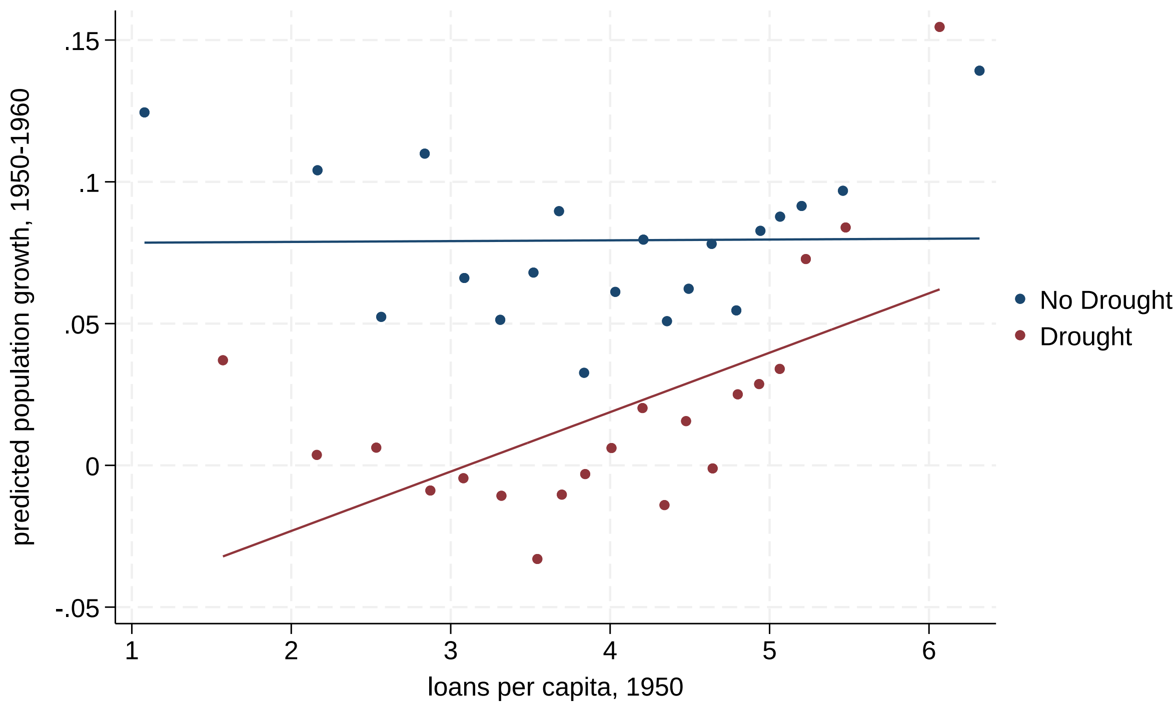


Panel C. 1960-1980



Notes: We use the 993 counties in the sample to compute the mean percent of a county's land area in extreme drought in each year-month observation separately for those counties that were in the top-quartile of drought exposure in 1950-1960, and those counties outside the top-quartile. Panel A plots the two monthly time series for the period before the 1950s drought (1895-1949); Panel B plots the two monthly time series for 1949-1959 (the "1950s drought"; Panel C plots these series for 1960-1980

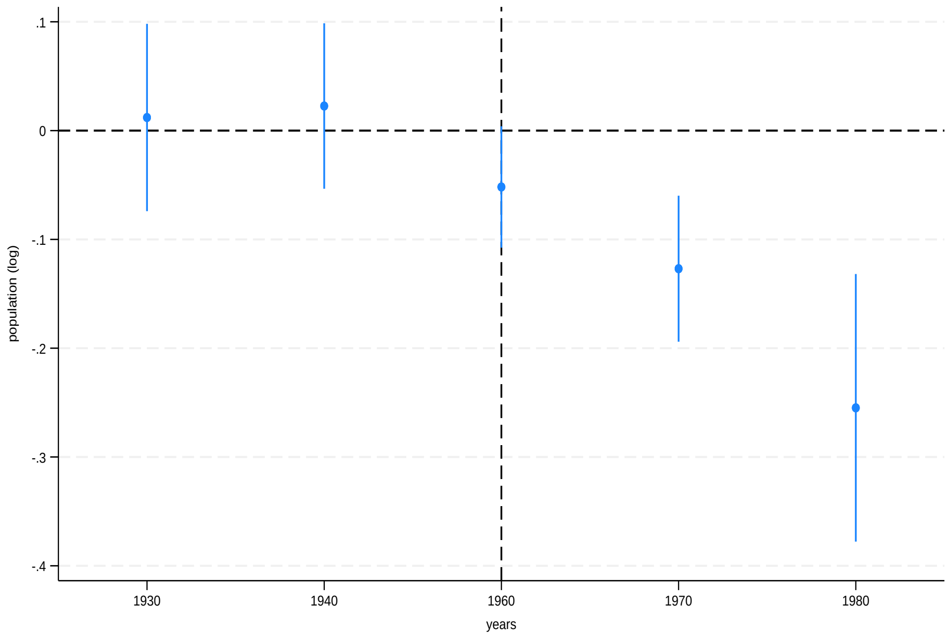
Figure 2 The impact of loans per capita, 1950, log on population growth, 1950-1960, by drought exposure



Notes: Using the model in Table 3, column 4, this figure computes the predicted population growth, 1950-1960, and uses a binned scatterplot to illustrate the relationship between predicted population growth, 1950-1960 and loans per capita, 1950 (log) for non-drought and drought exposed counties (top quartile exposure).

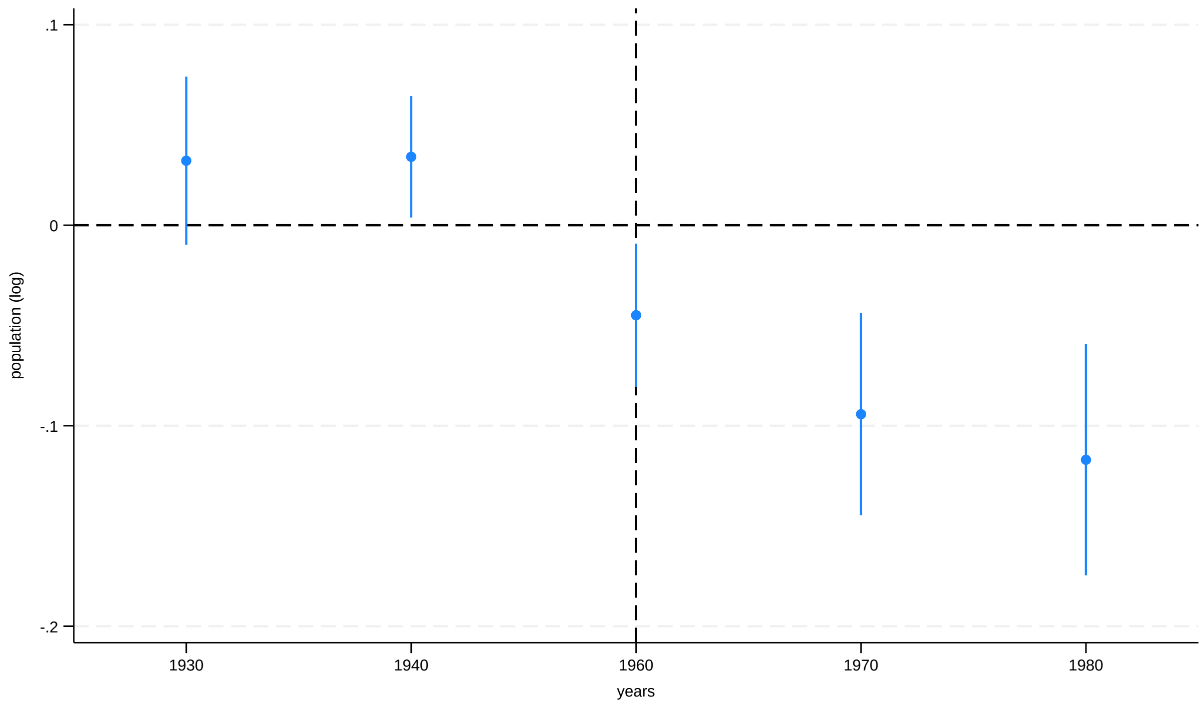
Figure 3 The impact of drought exposure on population, 1930-1980

Panel A. Town-level population



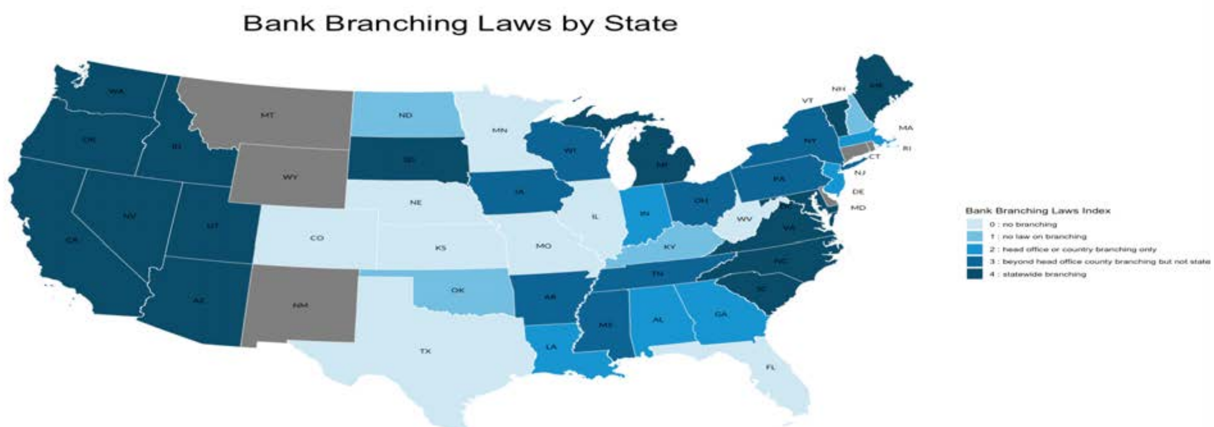
This figure reports the coefficients from an event study analysis. The dependent variable is the log population observed at the town-level each decade from 1930 through 1980. This variable is regressed on an indicator variable that equals 1 if a town was located in a county with top quartile of drought exposure during the 1950s and 0 otherwise. The drought indicator variable is also interacted with year indicator variables for 1930; 1940; 1960; 1970 and 1980. 1950 is the omitted category. The figure reports the point estimates and confidence bands (bars) for these coefficients. The regression also includes state by decade fixed effects, and standard errors are clustered at the state level. The average impact of drought exposure pre 1950 is 0.017 (p-value=0.44) and from 1960-1980 is -0.1445 (p-value<0.00). These differences result in a difference-in-difference point estimate equal to -0.1504 (p-value<0.00).

Panel B. County-level population



This figure reports the coefficients from an event study analysis. The dependent variable is the log population observed at the county-level each decade from 1930 through 1980. This variable is regressed on an indicator variable that equals 1 if a county had top quartile of drought exposure during the 1950s and 0 otherwise. The drought indicator variable is also interacted with year indicator variables for 1930; 1940; 1960; 1970 and 1980. 1950 is the omitted category. The figure reports the point estimates and confidence bands (bars) for these coefficients. The regression also includes state by decade fixed effects, and standard errors are clustered at the state-level. The average impact of drought exposure pre 1950 is 0.0331 (p-value=0.07) and from 1960-1980 is -0.085 (p-value<0.00). These differences result in a difference-in-difference point estimate equal to -0.1185 (p-value<0.00).

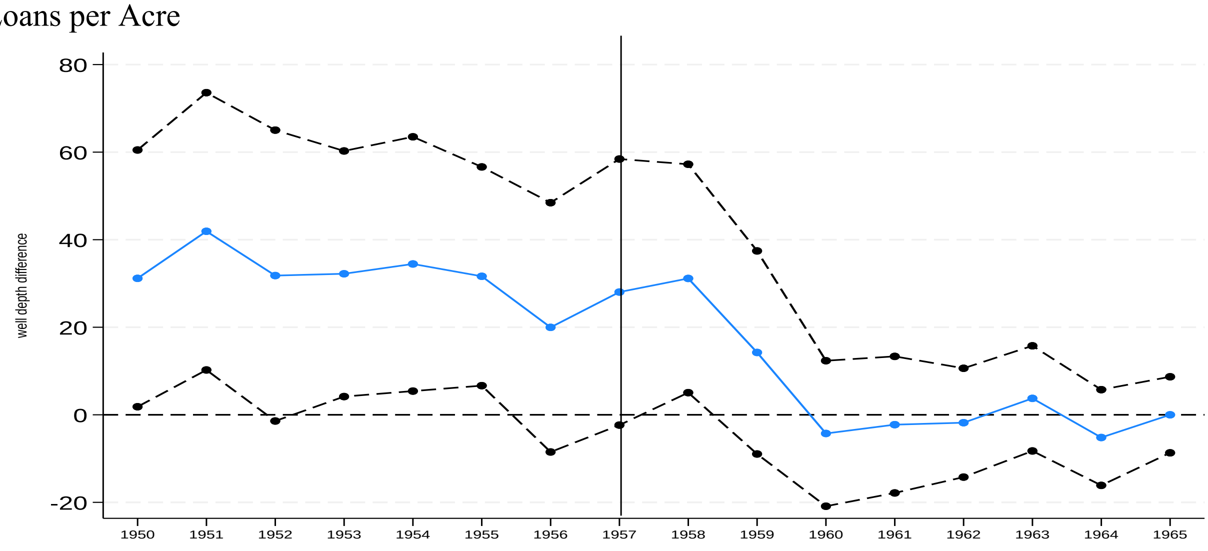
Figure 4 Bank Branching Laws, 1937



Source: https://fraser.stlouisfed.org/title/branch-group-banking-685 Note that we do not have bank-level data for MT, WY and NM.

Figure 5. The difference in well-depth between counties at the 90th and 10th percentiles of credit, 1950-1965

Loans per Acre



This figure plots the coefficients—solid line—along with the 95% confidence bands—dashed lines—for the average difference in well depth in each year between a county at the 90th percentile of bank credit (loans per acre) and a county at the 10th percentile of bank credit. The regression includes county and year fixed effects and standard errors are clustered at the county-level. The sample period is 1950-1970, the dependent variable is well depth (in feet) observed on a given date, and the dataset consists of an unbalanced panel of about 106,000 wells. The drought began at various locations beginning around 1949 and ended around 1957.

Tables

Table 1. Bank credit availability, 1950

Panel A. Summary statistics

	Loans per capita	Number of banks per 10,000 people	Population
	County-level		
Mean	115.04	7.02	85,614
Std.dev	333.72	7.16	259,896
	Town-level		
Mean	615.91	8.16	29,093
Std.dev	2733.98	10.49	159,068

This table reports summary statistics across 1,263 towns in 1950 and among the 993 counties in which these towns are located. The underlying data is hand-collected bank balance sheet information for each bank in the sample of towns—about 3,015 banks in total. Note that overall data collection includes 5,621 banks in 1929; 2,985 banks in 1939; 3,027 banks in 1960 and 4,148 banks in 1970.

Panel B. Correlation

	Loans per capita	Loans per farm
Loans per farm	0.77	
Loans per acre	0.62	0.91

This table reports the correlation coefficient for the three measures of credit availability (N=992). Note that all correlations are significant at the 1 percent level.

Table 2. Ex-Ante Measures at the County-Level (1950) and Drought Exposure (1950-1960)

Panel A. Balance tests with state fixed effects

	(1) log credit per capita, 1950	(2) number of banks per capita, 1950	(3) log deposits per capita, 1950	(4) log median income, 1950	(5) log farm size, 1950
4th quartile drought intensity, 1950-1960	0.0591 (0.113)	0.0920 (0.0638)	-0.0135 (0.0323)	-0.0463 (0.0314)	0.0998 (0.0906)
N	993	993	992	993	985
adj. R^2	0.076	0.292	0.118	0.501	0.610

	(7) share of land in irrigation, 1949	(8) value of farm production per acre, 1950	(9) retail establishments, per capita, 1952	(10) manufacturing establishments per capita, 1949	(11) county area, ln
4th quartile drought intensity, 1950-1960	0.000624 (0.00803)	-0.0810 (0.100)	0.000199 (0.000214)	-0.0000723* (0.0000359)	-0.0167 (0.0309)
N	971	983	992	992	993
adj. R^2	0.413	0.450	0.263	0.341	0.488

Panel B. Balance tests with state fixed effects and log population in 1950

	(1) log credit per capita, 1950	(2) number of banks per capita, 1950	(3) log deposits per capita, 1950	(4) log median income, 1950	(5) log farm size, 1950
4th quartile drought intensity, 1950-1960	0.0699 (0.112)	-0.00571 (0.0489)	0.0258 (0.0360)	-0.00861 (0.0326)	0.0234 (0.0713)
N	993	993	992	993	985
adj. R^2	0.076	0.515	0.180	0.657	0.706

	(6) log number of farms, 1950	(7) share of land in irrigation, 1949	(8) value of farm production per acre, 1950	(9) retail establishments, per capita, 1952	(10) manufacturing establishments per capita, 1949	(11) county area,ln
4th quartile drought intensity, 1950-1960	-0.0276 (0.0670)	0.00199 (0.00774)	-0.000959 (0.0857)	-0.0000944 (0.000176)	-0.0000465 (0.0000404)	-0.0156 (0.0298)
N	986	971	983	992	992	993
adj. R^2	0.324	0.418	0.552	0.404	0.365	0.488

Panel C. Balance tests with log population in 1950

	(1) log credit per capita, 1950	(2) number of banks per capita, 1950	(3) log deposits per capita, 1950	(4) log median income, 1950	(5) log farm size, 1950
4th quartile drought intensity, 1950-1960	0.0446	0.0491	0.0375	-0.0123	0.181
	(0.0796)	(0.0458)	(0.0385)	(0.0457)	(0.149)
N	993	993	992	993	985
adj. R^2	-0.002	0.433	0.067	0.144	0.338

	(6) log number of farms, 1950	(7) share of land in irrigation, 1949	(8) value of farm production per acre, 1950	(9) retail establishments, per capita, 1952	(10) manufacturing establishments per capita, 1949	(11) county area, ln
4th quartile drought intensity, 1950-1960	0.00831	0.00460	0.0689	0.000172	-0.000135***	0.0177
	(0.0836)	(0.00940)	(0.132)	(0.000266)	(0.0000452)	(0.0847)
N	986	971	983	992	992	993
adj. R^2	0.069	-0.000	0.221	0.143	0.077	0.010

These panels regress a variety of demographic and economic variables—the column headings—(all observed in or pre-1950) on an indicator variable that equals 1 if a county is in the 4th quartile of drought intensity, 1950-1960. Panel A uses only state fixed effects as controls; Panel B includes both state fixed effects and log population in 1950, and Panel C only controls for log population in 1950. Standard errors (in parentheses) are clustered at the state-level: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3 The impact of drought exposure on population growth—county-level evidence

	(1) all counties	(2) in-sample	(3) quartiles	(4) baseline	(5) WLS	(6) controls I	(7) controls II
drought intensity, 1950-1960, SPI continuous measure	-0.00528**	-0.00773*					
	(0.00235)	(0.00430)					
2nd quartile drought intensity, 1950-1960			-0.0133				
			(0.0256)				
3rd quartile drought intensity, 1950-1960			-0.0368				
			(0.0276)				
4th quartile drought intensity, 1950-1960			-0.0661**	-0.644**	-1.148***	1.231	-0.504
			(0.0317)	(0.292)	(0.339)	(0.881)	(0.409)
log loans per capita, 1950				-0.000127	-0.0290**	-0.00378	0.000407
				(0.00592)	(0.0115)	(0.00387)	(0.00540)
4th quartile drought intensity*loans per capita				0.0260*	0.0414**	0.0169*	0.0223*
				(0.0131)	(0.0166)	(0.00980)	(0.0137)
log population, 1950				0.0748***	0.0121	0.0189	0.0614***
				(0.00991)	(0.00886)	(0.0145)	(0.00951)
4th quartile drought intensity*population				0.0191	0.0759***	0.0483**	0.00496
				(0.0135)	(0.0160)	(0.0211)	(0.0233)
log, area				-0.0127	0.0467**	0.00898	-0.0168
				(0.0184)	(0.0175)	(0.0178)	(0.0198)
4th quartile drought intensity*area				0.0440	0.0125	-0.0166	0.0362
				(0.0280)	(0.0413)	(0.0285)	(0.0251)
N	3082	993	993	991	991	989	977
adj. R^2	0.194	0.205	0.206	0.330	0.381	0.463	0.424
The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per capita, 1950, distribution:							
10th percentile				-0.0601	-0.00910	-0.0437	-0.0524
p-val				0.00692	0.772	0.0271	0.0258
50th percentile				-0.0151	0.0627	-0.0143	-0.0140
p-val				0.419	0.0815	0.267	0.396
90th percentile				0.0162	0.113	0.00601	0.0123
p-val				0.588	0.0264	0.755	0.652

Notes: This table examines the impact of drought exposure on the log change in population in the sample of counties. The dependent variable is the log change in population between 1950-1960. All regressions include state fixed effects, and linearly include the log population in 1950 and log county area in 1950, as well as interacted with the top quartile drought indicator variable. Standard errors in parentheses are clustered at the state level * p < 0.10, ** p < 0.05, *** p < 0.01. In column 6, the drought indicator (4th quartile drought intensity, 1950-1960) is interacted with deposits per capita, 1950, the mean rainfall in the county; the standard deviation of rainfall; mean snow fall; the standard deviation of snowfall (all based on 20th century averages); the log of county area; the log of median income in the county in 1950; the share of rural population in 1950; and an indicator for whether the county is located west of the 98th latitude. In column 7, the drought indicator variable is interacted with the mean land area in drought, 1985-1926; the Herfindahl-Hirshman Index (HHI) based on male labor occupations in 1950; the HHI based on farm production values in 1950. See the description of the HHI variables in the main text. The mean of the dependent variable is 0.064 and the standard deviation is 0.21.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4 The impact of drought exposure on county-level log population, 1930-1980

	(1)	(2)
drought exposure	-0.245***	-0.159**
	(0..099)	(0.081)
drought exposure*credit, 1950	0.0369	
	(0.024)	
drought exposure *credit 1940		0.029
		(0.025)
N	5,934	5,550
adj. R^2	0.34	0.35
The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per capita distribution:		
10th percentile	-0.166	-0.128
p-val	0.0000	0.012
50th percentile	-0.102	-0.091
p-val	0.0003	0.000
90th percentile	-0.057	-0.063
p-val	0.223	0.167

Notes: This table examines the impact of drought exposure on the log of population in a decadal panel of 970 counties from 1930-1980—not all 993 counties consistently had population data over the sample period. The dependent variable is the log population observed in each decade. Drought exposure equals 1 from 1960-1980 if a county was in the top-quartile of drought exposure in the 1950s, and 0 otherwise. All regressions include state by decade fixed effects. Column 1 interacts the drought exposure indicator with the log of loans per capita in 1950. Column 2 interacts the drought exposure indicator with the log of loans per capita in 1940. Standard errors in parentheses and are clustered at the state level * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 5. The impact of drought exposure on town-level credit growth

	(1) loan growth, 1950-1960	(2) loan growth, 1940-1950	(3) loans to assets,1960	(4) loans to assets,1960
4th quartile drought intensity, 1950-1960	-1.374* (0.727)	-0.147 (0.110)	-0.299*** (0.0872)	-0.302*** (0.0874)
log loans per capita, 1950	-0.291** (0.118)		0.0321*** (0.00570)	0.0331*** (0.00522)
4th quartile drought intensity*loans per capita 1950	0.221** (0.102)		0.0462*** (0.0107)	0.0458*** (0.0106)
log loans per capita, 1939		-0.0106 (0.00705)		
4th quartile drought intensity*loans per capita, 1939		0.0042 (0.1161)		
N	1309	1290	1230	1230
adj. R^2	0.081	0.043	0.259	0.262
The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per capita distribution:				
10th percentile	-0.306	0.00601	-0.0478	-0.0433
p-val	0.00736	0.699	0.00859	0.0207
50th percentile	-0.0847	0.0105	-0.00235	0.00177
p-val	0.163	0.252	0.800	0.862
90th percentile	0.145	0.0140	0.0455	0.0492
p-val	0.277	0.279	0.000	0.000

This table examines the impact of drought exposure on credit outcomes in the sample of towns. The unit of observation is the town. Loan growth in a town is defined as the change in the stock of loans between two time periods divided by total bank assets in the initial time period in the town. All regressions linearly include log population in the beginning decade, and log population is also interacted with the drought indicator variable; all regressions also include state-fixed effects and standard errors, in parentheses, are clustered at the state-level. Column 4 includes the change in deposits (scaled by assets) and the change in bank capital (scaled by assets) both linearly and interacted with the drought indicator variable. * $p < 0.10$, ** $p < 0.05$, *** $p < 0$.

Table 6. The impact of drought exposure and state borders discontinuities

	(1)	(2)	(3)	(4)	(5)
			Triple interaction term		
	population growth, 1950-1960	population growth, 1950-1960	population growth, 1950-1960	population growth, 1950-1980	loan growth, 1950-1980
4th quartile drought intensity, 1950-1960	-0.0240	-0.190	-1.598	6.996	14.95*
	(0.484)	(0.431)	(2.100)	(6.918)	(8.303)
loans per capita, 1950, log, **in-town**	0.0399**	0.0339**	0.139*	0.247	2.081
	(0.0168)	(0.0148)	(0.0798)	(0.176)	(1.709)
4th quartile drought intensity,#loans per capita, 1950, log, **in-town**	0.0529	0.0617*	0.307	-1.215	-2.454*
	(0.0328)	(0.0313)	(0.365)	(1.230)	(1.419)
loans per capita, 1950, log, **in-state**	-0.0318	-0.0493	0.0641	0.148	2.485
	(0.0214)	(0.0304)	(0.0637)	(0.151)	(2.017)
4th quartile drought intensity,#loans per capita, 1950, log, **in-state**	-0.0640	-0.0656*	0.170	-1.382	-2.917*
	(0.0396)	(0.0356)	(0.342)	(1.222)	(1.534)
loans per capita, 1950, log, **out-of-state**	-0.0179	-0.0202	-0.0222		-0.0980
	(0.0128)	(0.0138)	(0.0136)		(0.0587)
4th quartile drought intensity,# loans per capita, 1950, log, **out-of-state**	-0.0178	-0.0182	-0.0120	-0.0970	0.0881*
	(0.0364)	(0.0359)	(0.0361)	(0.0922)	(0.0471)
4th quartile drought intensity,#**in-town**# **in-state**			-0.0415	0.228	0.444*
			(0.0588)	(0.215)	(0.251)
N	1215	1215	1215	1100	1221
adj. R^2	0.095	0.104	0.103	0.165	0.131
The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles					
In-town log loans per capita:					
10th percentile	-0.0857	-0.0943			
p-val	0.0419	0.0229			
50th percentile	-0.0329	-0.0327			
p-val	0.319	0.339			
90th percentile	0.0218	0.0311			
p-val	0.678	0.557			
In-state loans per capita					
10th percentile	-0.00382	-0.00282			
p-val	0.915	0.937			
50th percentile	-0.0308	-0.0305			
p-val	0.349	0.371			
90th percentile	-0.0677	-0.0683			
p-val	0.091	0.092			

Table 6 cont'd

	Out-of-state loans per capita				
10th percentile	-0.0241	-0.0236			
p-val	0.579	0.596			
50th percentile	-0.0322	-0.0319			
p-val	0.334	0.355			
90th percentile	-0.0397	-0.0395			
p-val	0.183	0.196			
Evaluating the marginal effects of triple interaction terms					
In-town loans per capita at the 10th percentile and **in-state** loans per capita at the 10th percentile					
estimate			-0.0779	-0.0586	0.0826
p-val			0.108	0.523	0.302
In-town loans per capita at the 10th percentile and **in-state** loans per capita at the 90th percentile					
estimate			-0.109	-0.304	-0.677
p-val			0.0416	0.0330	0.0169
In-town loans per capita at the 90th percentile and **in-state** loans per capita at the 10th percentile					
estimate			0.0874	-0.0122	0.00792
p-val			0.260	0.931	0.947
In-town loans per capita at the 90th percentile and **in-state** loans per capita at the 90th percentile					
estimate			-0.0282	0.153	0.148
p-val			0.569	0.448	0.391

This table studies the impact of in-state and out-of-state sources of bank finance on town-level outcomes. "In-state loans per capita, 1950" is the loans per capita computed over towns up to 200 miles from the reference town and located in the same state; it excludes loans per capita in the reference town. The "out-of-state" counterpart is identical except this variable is computed among towns located across state-lines from the reference town. All regressions linearly include the town's population (log), as well as, separately, the sum of the population among nearby towns (in the same distance window) in state, as well as out-of-state. All population variables are interacted with the drought exposure variable. All regressions also include state-fixed effects and standard errors, in parentheses, are clustered at the state-level. ***,**,* denote statistical significance at the 10, 5 and 1 percent respectively. Columns 2-5 controls for the mean distance between a reference town and in-state neighbors using a 3rd order polynomial. These columns also control for the mean distance between a reference town and its out-of-state neighbors using a 3rd order polynomial. Columns 3-5 include a triple interaction term between in-town loans per capita; in-state loans per capita and the drought indicator variable. All subcomponents are also included.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7 Bank branching and the marginal impact of the drought on bank lending—bank-level evidence

	(1) county-level interactions	(2) county and bank-level interactions
	Unit	
All banks	-0.046	-0.052
	(0.09)	(0.05)
	Branching	
	-0.026	-0.005
All banks	(0.23)	(0.79)
N	2,426	2,426
adj. R^2	0.14	0.15

This table reports the marginal effect of top-quartile drought exposure on bank-lending. P-values are in parentheses. The individual bank is the unit of analysis and the dependent variable is a bank's change in loans between 1950 and 1960, scaled by the bank's assets in 1950. This dependent variable is regressed on an indicator variable that equals 1 if the bank is located in a state that allows branching, and 0 otherwise. This branching indicator variable is interacted with an indicator variable that equals 1 if the bank is located in a county with top-quartile drought exposure and 0 otherwise. All variables are linearly included. All specifications include a county's distance from the state border; a 3rd order polynomial of the county's distance along the border; border fixed effects; median income in the county (1950); mean farm size in the county (1950); the rural population share in the county; county population; the log of a bank's assets; the bank's capital to asset ratio; the bank's deposit to asset ratio; and the bank's loans to asset ratio (all observed in 1950). Column 1 interacts the drought indicator variable with the county-level observables. Column 2 interacts the drought indicator variable with all of the bank and county-level controls. Note that the sample includes banks no more than 200 miles from the border between a unit and branching banking state (Figure 4). Standard errors are clustered at the bank-level.

Table 8. Investment and Technological Adaptation: The Case of Irrigation and Unit Banking

	1	2	3	4
	Well-depth		Number of wells	
drought exposure	-7.0319*	-8.4921**	-0.0386	-0.0622
	(4.1176)	(4.3029)	(0.1549)	(0.1934)
drought exposure#loans per acre, 1950	5.1016***	5.2786***	0.0869***	0.0905***
	(1.1226)	(1.1259)	(0.0245)	(0.0269)
drought exposure # unit # loans per acre, 1950		-4.3196		-0.0300
		(3.5768)		(0.0259)
Nobs	740,130	740,130	10,315	10,315
R-squared	0.487	0.488	0.652	0.652
The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles, by branching and unit banking states (columns 2 and 4)				
10th percentile	-9.952	-11.514	-0.093	-0.119
p-value	0.023	0.012	0.578	0.565
10th percentile (unit banking states)		-9.041		-0.100
p-value		0.056		0.609
50th percentile	3.073	1.963	0.108	0.091
pval50	0.440	0.634	0.417	0.591
50th percentile (unit banking states)		-6.593		0.040
p-value		0.408		0.837
90th percentile	23.938	23.552	0.355	0.348
p-value	0.000	0.000	0.005	0.022
90th percentile (unit banking states)		-2.671		0.212
p-value		0.899		0.278

This table studies the impact of drought exposure on irrigation adaptation. The dependent variable in columns 1 and 2 is the depth of an individual well. The data consists of an unbalanced panel of well-depth observations taken between 1950-1970 for about 106,000 wells. The regression includes county and year fixed effects and standard errors are clustered at the county-level. The dependent variable in columns 3 and 4 is the log number of wells in a county in a given year. The data consists of a county-by-year panel observed from 1950-1970. The regression includes county and year fixed effects and standard errors are clustered at the county-level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Unit" equals 1 if a county is in a unit banking state and 0 otherwise.

Table 9. More on Adaptation

	(1)	(2)	(3)
	growth in irrigated acres: 1949-1959	change in sorghum production, 1949-1959	Output per farm, 1970
4th quartile drought intensity, 1950-1960	0.441 (4.492)	-0.288 (0.706)	1.674 (2.853)
4th quartile drought intensity*loans per acre	0.401** (0.150)	0.0288 (0.0322)	0.172* (0.0950)
drought exposure#loans per acre#irrigation water usage			0.003 (0.0021)
N	969	590	968
adj. R^2	0.364	0.506	0.863
Panel B. The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per acre distribution:			
10th percentile	-0.828	0.0426	See panel B for marginal effects
p-val	0.0451	0.594	
50th percentile	0.0689	0.130	
p-val	0.794	0.0373	
90th percentile	1.174	0.234	
p-val	0.00411	0.0744	

Notes: This table studies the impact of drought exposure on county-level growth in irrigated acreage (column 1); growth in sorghum production (column 2) and log output per farm in 1970. All regressions include the log population in 1950 and log area in 1950 both linearly and interacted with the drought indicator variable along with state fixed effects. Column 3 uses a triple interaction term and the marginal effects are reported in Panel B. All regressions also include state fixed effects. Standard errors, in parentheses, are clustered at the state-level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Panel B. The Marginal Effects of Drought Exposure on Output Per Farm

	Output per farm	
Loans per acre	Irrigation water usage	
	10th	90th
10th	-0.014 (0.685)	-0.052 (0.22)
90th	-0.024 (0.54)	0.084 (0.08)_

This table uses the point estimates from column 3 of Table 9 to compute the marginal effects of drought exposure on output per farm at the different points in the distribution of loans per acre, 1950 and irrigation water usage in 1969 (log of acres of feet). The p-values are in parentheses and all covariates are held at their mean levels.

Table 10. Drought, credit and the non-agricultural economy

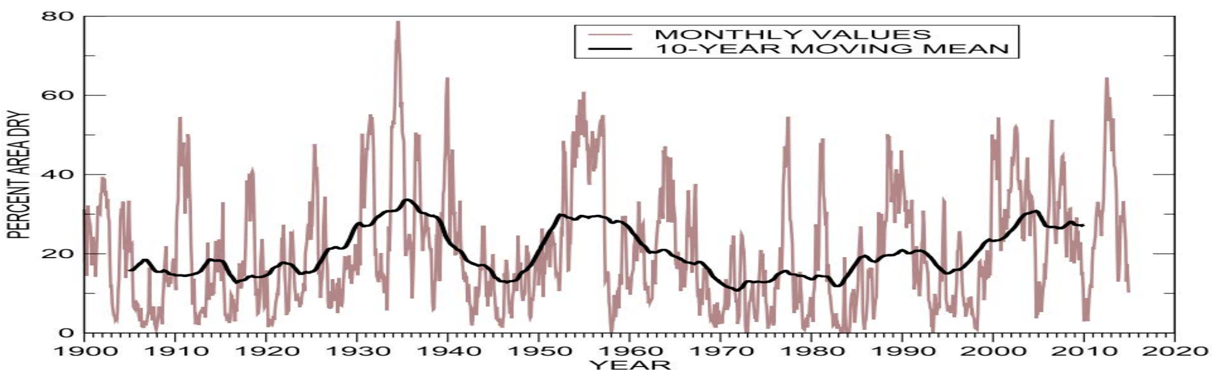
	(1) retail establisments, 1967	(2) retail establisments, 1977	(3) manufacturing establishments, 1963	(4) manufacturing establishments, 1977
4th quartile drought intensity, 1950-1960	-0.664 (0.501)	-0.912* (0.480)	-0.251 (0.619)	-0.326 (0.835)
4th quartile drought intensity*loans per acre	0.0420* (0.0234)	0.0321 (0.0207)	0.0189 (0.0218)	0.0453* (0.0253)
N	977	987	987	987
adj. R^2	0.746	0.942	0.935	0.896
mean	4.431	5.997	3.879	201.4
stdev	0.561	1.184	1.370	860.9
Panel A. The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per acre distribution:				
10th percentile	-0.0949	-0.0747	-0.0771	-0.135
p-val	0.0921	0.141	0.246	0.114
50th percentile	-0.0169	-0.0286	-0.0800	-0.0681
p-val	0.745	0.226	0.0702	0.193
90th percentile	0.0757	0.0265	-0.0834	0.0123
p-val	0.372	0.727	0.235	0.888
Panel B. The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per capita distribution:				
10th percentile	-0.0543	-0.0662	-0.0867	-0.124
p-val	0.328	0.0594	0.163	0.111
50th percentile	-0.0183	-0.0265	-0.0787	-0.0645
p-val	0.717	0.252	0.0702	0.209
90th percentile	0.00629	0.00154	-0.0730	-0.0226
p-val	0.918	0.969	0.143	0.721

Notes: This table studies the impact of drought exposure on county-level measures of retail and manufacturing activity, with log loans per farm as the measure of ex ante credit access. In panel B, we re-estimate all regressions using the log loans per acre as the measure of ex-ante credit access. In Panel C, loans per capita as the measure of ex-ante credit access. All regressions include the log population in 1950 and county area both linearly and interacted with the drought indicator variable; all regressions also include state fixed effects. All regressions include the lag (1950) of the dependent variable. Standard errors, in parentheses, are clustered at the state-level. ***,**,* denote statistical significance at the 10, 5 and 1 percent respectively.

Internet Appendix

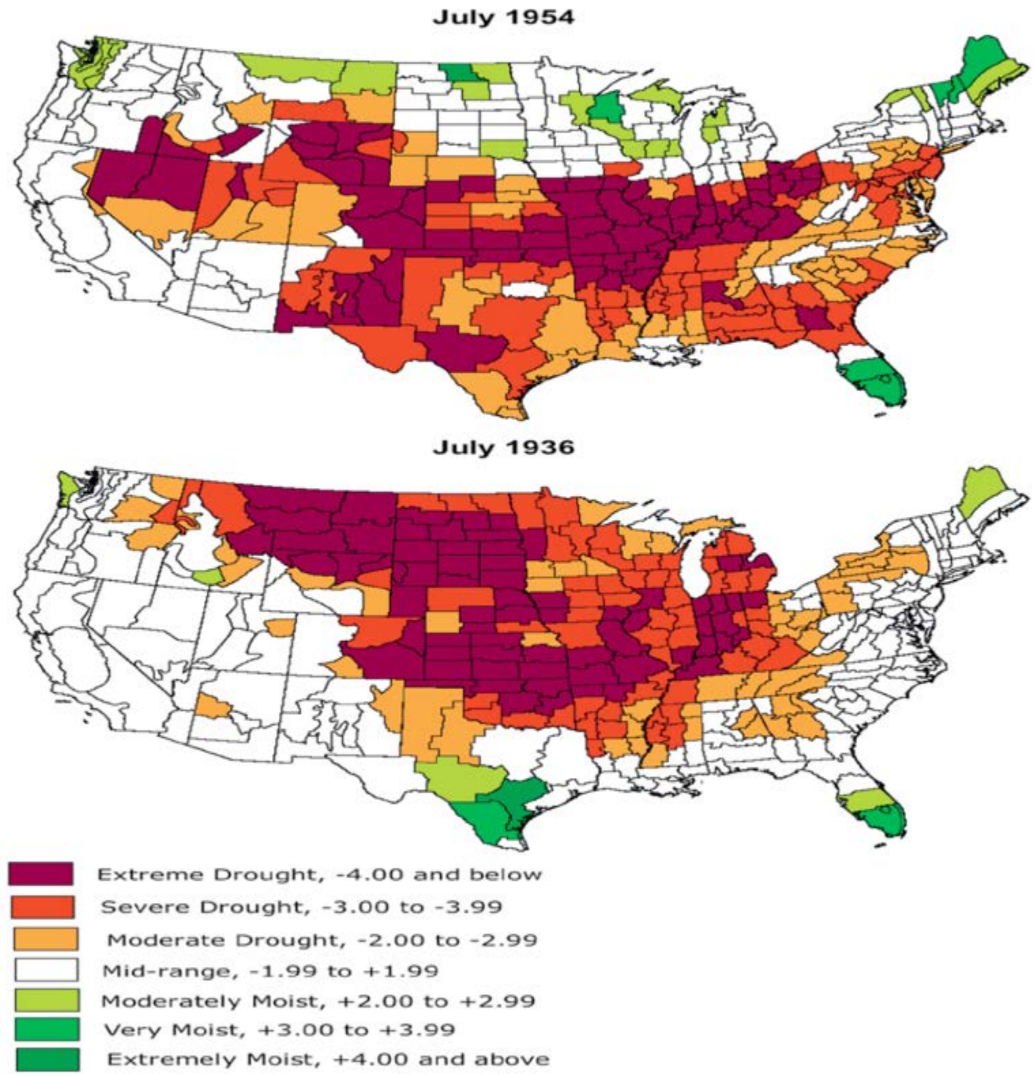
Appendix A1. Supplementary Figures and Tables

Figure A1.1 Drought in the continental United States, 1900-2014



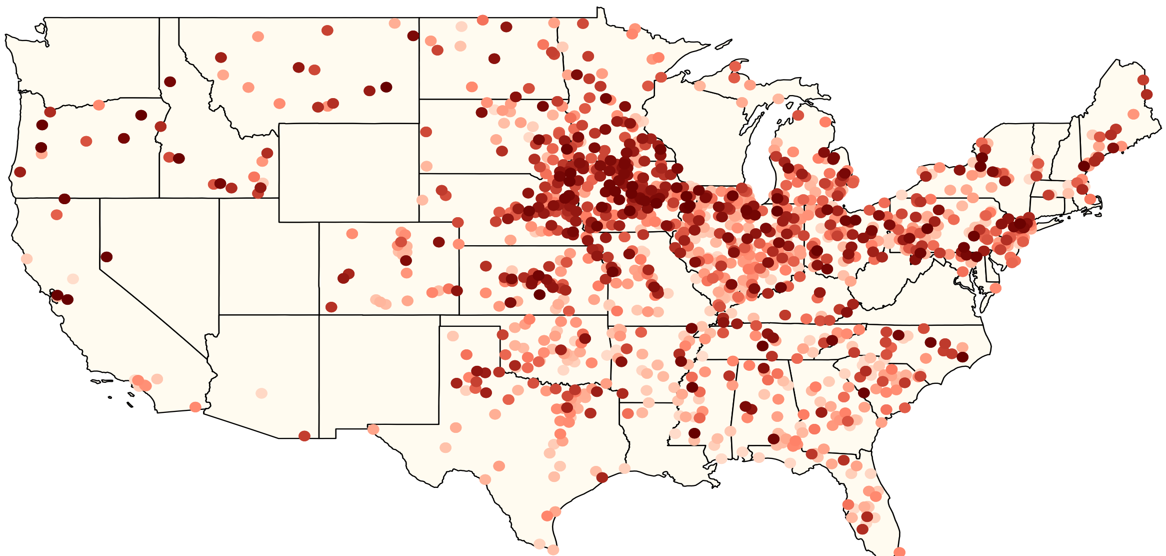
This figure shows the percent area of the continental US experiencing moderate to extreme drought (Palmer Drought Severity Index<-2.00) conditions, Jan 1900-Dec 2014. The black line is the 10 year moving average—see (Heim 2017). The Palmer Drought Severity Index (PDSI) is a single index that uses the water balance for a particular area—precipitation, evapotranspiration, runoff and soil moisture—to calculate local drought intensity. See https://climatedataguide.ucar.edu/climate-data/standardized-precipitation-index-spi for a short description of drought measures.

Figure A1.2 The "Dustbowl" and the 1950s drought



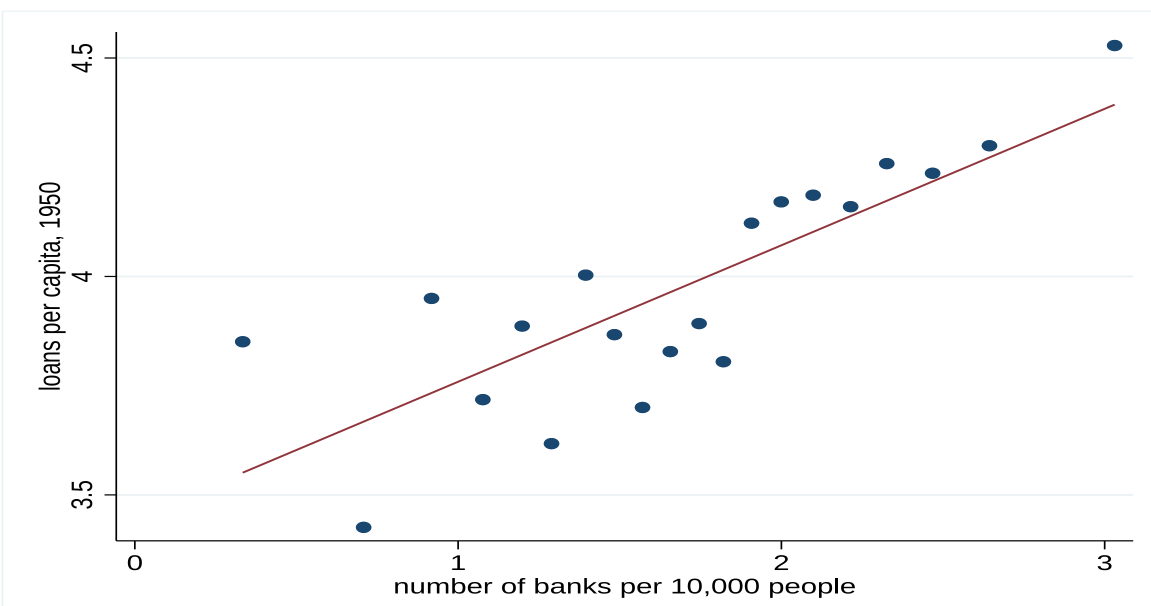
Notes: This figure plots drought intensity using the Palmer Drought Severity Index—see (Heim 2017).

Figure A1.3 Towns in the Sample



Notes: This figure shows the spatial distribution of the towns in the sample with bank-level data.

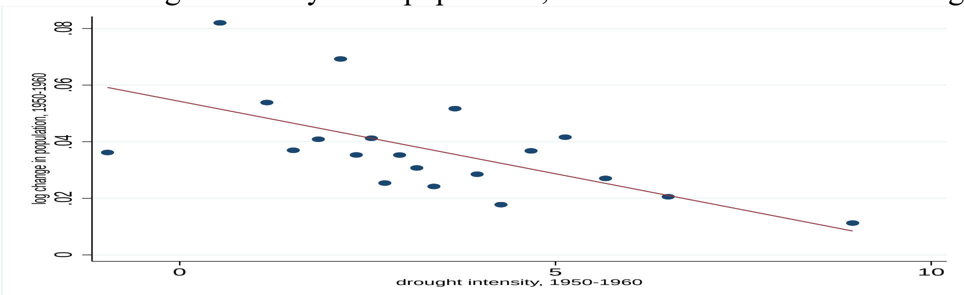
Figure A1.4 Log of loans per capita, 1950 vs number of banks per 10,000 people in county



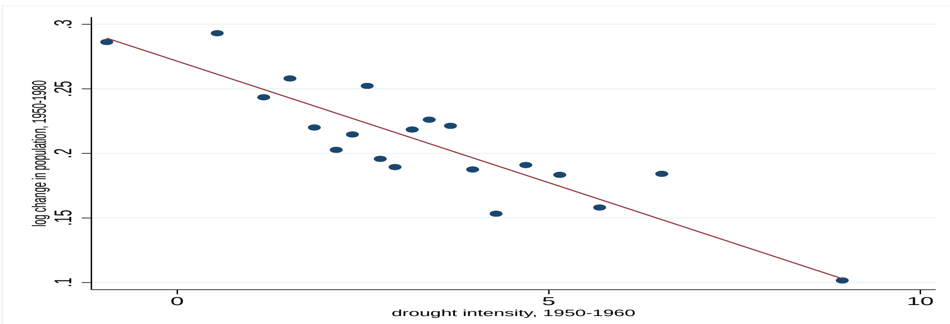
This figure is a binned scatter plot of loans per capita, 1950 (log) in a county and the number of banks per 10,000 people in the county, also observed in 1950. The two series are first purged of state-fixed effects.

Figure A1.5 Population growth and the 1950s drought

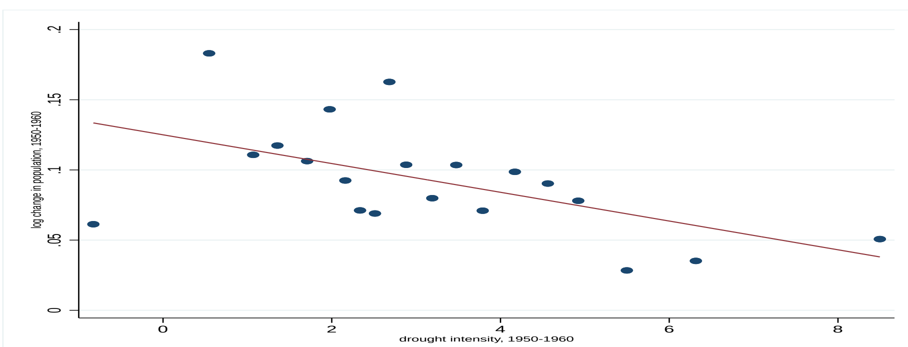
A. Change in county-level population, 1950-1960 and the 1950s drought



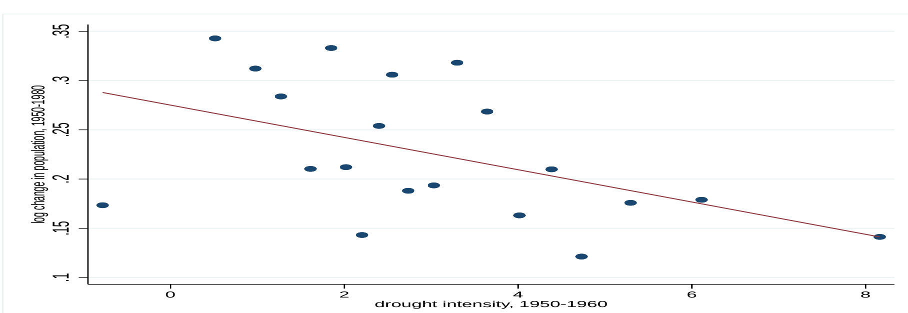
B. Change in county-level population, 1950-1980 and the 1950s drought



C. Change in town-level population, 1950-1960 and the 1950s drought



D. Change in town-level population, 1950-1980 and the 1950s drought



Notes: These figures are binscatter plots that illustrate the relationship between population growth at different time and spatial frequencies and drought intensity in 1950-1960 using the SPI. Panels A and B examine the impact of the drought on county-level population growth between 1950-1960, and from 1950-1980. Panels C and D repeat this exercise at the town level.

Table A1.1 The share of a county's land area in extreme drought using the Standard Precipitation Index (SPI) during the Dustbowl and the 1950s drought, by census geographic region.

	Mean	SD	Min	Max
		New England		
1950s Drought	2.02	1.45	0	6.17
Dustbowl	2.37	1.31	0.01	5.55
		Mid-Atlantic		
1950s Drought	0.84	0.96	0	5.77
Dustbowl	4.44	2.91	0.03	13.57
		East North Central		
1950s Drought	2.8	2.08	0	8.62
Dustbowl	7.54	3.15	0.52	16.04
		West North Central		
1950s Drought	4.5	3.26	0	15.09
Dustbowl	5.67	3.14	0.05	16.52
		South Atlantic		
1950s Drought	2.33	1.88	0	7.68
Dustbowl	4.23	2.6	0	10.44
Table 1, cont'd				
		East South Central		
1950s Drought	2.54	1.82	0	8.22
Dustbowl	5.64	3.87	0	16.31
		West South Central		
1950s Drought	5.03	3.64	0	20.37
Dustbowl	1.37	1.53	0	9.42
		Mountain		
1950s Drought	4.01	3.13	0	18.3
Dustbowl	3.66	2.83	0	11.62
		Pacific		
1950s Drought	1.56	1.1	0.04	7.31
Dustbowl	4	3.29	0.01	13.03

The county-level data are from the National Oceanic and Atmospheric Administration

Table A1.2 Sources of farm credit, 1950

		Non-real estate		Real estate		All	
		$ (million)	%	$ (million)	%	$ (million)	%
Banks		2,048	39.9%	937	16.8%	2,985	27.9%
Merchants and Dealers		2,300	44.8%	0	0.0%	2,300	21.5%
Life Insurance Companies		0	0.0%	1,172	21.0%	1,172	10.9%
Individuals		0	0.0%	2,312	41.4%	2,312	21.6%
Non-market		784	15.3%	1,158	20.8%	1,942	18.1%
Total		5,132		5,579		10,711	

Source: Agricultural Credit and Related Data, 1968, American Bankers Association. Non-market sources include the Farmers Home Administration; Production Credit Associations and Federal Land Banks.

Table A1.3 The impact of drought exposure on demographic outcomes—county-level evidence

Vital Statistics

	(1) migration	(2) births per capita, 1960	(3) births per capita, 1980	(4) deaths per capita, 1960	(5) deaths per capita, 1980
4th quartile drought intensity, 1950-1960	-14.78**	-0.230	-0.221	0.572***	0.612***
	(6.266)	(0.141)	(0.184)	(0.187)	(0.163)
log loans per capita, 1950	-0.177	-0.000497	0.00479	-0.00254	0.00124
	(0.250)	(0.00322)	(0.00364)	(0.00378)	(0.00561)
4th quartile drought intensity*loans per capita	0.799**	0.0152*	0.00809	-0.00520	-0.0193*
	(0.369)	(0.00787)	(0.00638)	(0.00832)	(0.0110)
N	988	988	988	988	988
adj. R^2	0.302	0.579	0.452	0.584	0.346
mean	16.66	-3.788	-4.130	-4.617	-4.617
sdev	7.470	0.161	0.159	0.215	0.215
The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per capita distribution:					
10th percentile	-1.666	-0.0313	0.00334	0.0294	0.0871
p-val	0.0430	0.0269	0.803	0.112	0.00125
50th percentile	-0.239	-0.00415	0.0178	0.0201	0.0525
p-val	0.689	0.729	0.0662	0.132	0.0197
90th percentile	0.750	0.0147	0.0278	0.0137	0.0286
p-val	0.365	0.433	0.0447	0.449	0.321

Notes: This table examines the impact of drought exposure on migration, births and deaths. All regressions include state fixed effects, and linearly include the log population in 1950 and county area (log), as well as interacted with the top quartile drought indicator variable. Columns 2-5 also include the dependent variables observed in 1950 to absorb level differences. Standard errors in parentheses and are clustered at the state level * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Migration, 1960" is the percent of the population within a county in 1960 that in-migrated from elsewhere in the previous decade. The mean and standard deviation of this variable is 16.65 and 7.47 respectively. The marginal effect of top quartile drought exposure is always evaluated at the mean of the other covariates.

Table A1.4 Age Distribution, 1960

	(1) median age, 1960	(2) median age, 1980
4th quartile drought intensity, 1950-1960	0.298***	0.234**
	(0.0680)	(0.0916)
log loans per capita, 1950	-0.00176	-0.00332
	(0.00171)	(0.00215)
4th quartile drought intensity*loans per capita	-0.00894**	-0.00841**
	(0.00415)	(0.00399)
N	988	988
adj. R^2	0.806	0.433
mean	3.381	3.427
sdev	0.142	0.105
The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per capita distribution:		
10th percentile	0.0249	0.0218
p-val	0.00820	0.0360
50th percentile	0.00897	0.00688
p-val	0.253	0.354
90th percentile	-0.00209	-0.00352
p-val	0.843	0.696

Notes: This table examines the impact of drought exposure on the log median age in counties in 1960 and 1980. All regressions include state fixed effects, and linearly include the log population in 1950, as well as interacted with the top quartile drought indicator variable. All regressions also include an analog of the dependent variable observed in 1950. Standard errors in parentheses and are clustered at the state level * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A1.5 Correlates of Loans Per Capita, 1950

Panel A. Univariate Regressions

	(1) 4th quartile drought intensity, 1950-1960	(2) log population, 1950	(3) log, area	(4) deposits per capita, 1950, log	(5) median income, 1950, log	(6) rural share of population, 1950	(7) mean rainfall
	0.0556	0.00627	-0.317***	0.763***	0.743***	-0.705***	-0.0286***
	(0.114)	(0.0725)	(0.0975)	(0.111)	(0.216)	(0.228)	(0.00870)
N	993	994	991	992	994	994	991
adj. R^2	0.074	0.073	0.091	0.141	0.093	0.094	0.091

	(8) standard deviation of rainfall	(9) mean snow fall	(10) standard deviation of snow fall	(11) west of 98th meridian	(12) HHI agricultural market value	(13) HHI employment
	-0.000926	0.00463	0.0151	0.310	0.239	-0.961
	(0.0307)	(0.00332)	(0.0105)	(0.277)	(0.477)	(1.098)
N	991	989	989	993	978	993
adj. R^2	0.075	0.077	0.078	0.077	0.075	0.075

Panel A regresses loans per capita (log), 1950 separately on each of the 13 variables named in the columns. Each row reports the coefficient and standard error from these univariate regressions. All regressions include state fixed effects. Standard errors in parentheses and are clustered at the state level * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Panel B. Partial Correlations

	(1) all correlates
4th quartile drought intensity, 1950-1960	0.0256
	(0.0787)
log population, 1950	-0.300**
	(0.112)
log, area	-0.141
	(0.110)
deposits per capita, 1950, log	0.688***
	(0.120)
median income, 1950, log	0.101
	(0.231)
rural share of population, 1950	-1.071***
	(0.284)
mean rainfall	-0.0118
	(0.00961)
standard deviation of rainfall	-0.00638
	(0.0325)
mean snow fall	0.00101
	(0.00666)
standard deviation of snow fall	0.0143
	(0.0195)
west of 98th meridian	-0.0621
	(0.197)
HHI agricultural market value	0.0865
	(0.433)
HHI employment	2.892**
	(1.072)
N	975
adj. R^2	0.157

Panel B regresses loans per capita (log), 1950 jointly on the 13 variables named in the columns. All regressions include state fixed effects. Standard errors in parentheses and are clustered at the state level * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A1.6. Differences at the border

A. Counties up to 200 miles from a state border

	in-state	out-of-state	difference	difference≠0	difference<0	difference>0
					p-value	
Median income, 1949	2485.02	2457.96	-27.07	0.547	0.726	0.274
Loans per capita, 1950	152.23	159.65	7.42	0.844	0.422	0.578
Deposits per capita, 1950	630.95	600.14	-30.81	0.257	0.872	0.128
Retail stores per capita, 1948	12.45	12.46	0.01	0.968	0.484	0.516
Number of manufacturing establishments per capita, 1940	0.87	0.88	0.00	0.935	0.467	0.533
Mean farm size, 1950	304.83	303.68	-1.15	0.982	0.509	0.491
Annual mean rainfall, 1900-2000	36.63	36.25	-0.38	0.503	0.749	0.251
Log of total population, 1950	10.60	10.41	-0.19	0.011	0.994	0.006
Population growth, 1940-1950	0.07	0.05	-0.02	0.084	0.958	0.042

This table restricts the sample to counties in the sample no further than 200 miles from a state border. For 9 key variables, the table then reports the mean separately for counties on either side of the state border, and tests whether these means are statistically different.

Table A1.7. Intention-to-treat at the border—county-level evidence

	(1) population growth, 1950-1960	(2) population growth, 1950-1980
4th quartile drought intensity, 1950-1960	1.477*** (0.483)	1.831*** (0.678)
4th quartile drought intensity*in-state credit	-0.0743* (0.0395)	-0.107* (0.0595)
4th quartile drought intensity* out-of-state credit	-0.00705 (0.0232)	-0.00910 (0.0336)
R-sq	0.24	0.23
N	1,817	1,817
The marginal impact of drought exposure after a one standard deviation increase in credit		
In-state	-0.029	-0.043
p-value	0.063	0.076
Out-of-state	-0.003	-0.004
p-value	0.762	0.787

Table A1.7 develops county-level border tests based on an intention-to-treat "intuition". Drought exposed counties located near in-state sources of finance might lose relatively more population as people migrate to nearby in-state areas in search of credit. Building on the basic approach in (Holmes 1998, Brown and Matsa 2020, Fonseca 2022), we restrict the sample to counties with a population weighted centroid that is no more than 200 miles from the state-border. We are thus left with 82 unique state-borders in the continental US—there are 109 state borders in all in the US—and 765 counties. On either side of the border, we then compute the mean loans per capita among these counties. The baseline specification examines whether the mean loans per capita in-state along the border mediates the impact of drought exposure in a reference county. The specification also includes the mean loans per capita along the border of out-of-state counties interacted with the drought exposure variable. As controls, these specifications include the reference county's mean distance from the state-border, as well as a third order polynomial of the county's distance along the state border; these specifications also include the county's population and area, as well as the mean population along the border, both in-state and out-of-state. Finally, we also include border fixed effects. This approach is analogous to a county-weighted, border-level regression based on counties on one side of the state border. Similar to the town-level regressions, a drought exposed county located near to in-state sources of credit experience a decline in population growth. In the case of population growth over the 1950-1960 period, a one standard deviation increase in loans per capita among in-state counties along the border is associated with a 2.8 percentage point decline in a drought exposed county's population growth. The coefficient on equi-distant out-of-state counties is about 4.75 times smaller and not significant (p-value=0.46). From column 2, a similar pattern emerges when we use population growth over the 1950-1980 period. Drought exposed counties experience a relative decline in population growth when in-state sources of credit along the border are plentiful. The coefficient on out-of-state sources of credit along the same border is both economically and statistically small.

Table A1.8 The Pattern of Agricultural Production A. Ownership, Acreage and Number

	(1) farm ownership, 1959	(2) farm ownership, 1982	(3) farm acreage, 1959	(4) farm acreage, 1982	(5) # farms, 1959	(6) # farms, 1982
4th quartile drought intensity, 1950-1960	-0.0427	-0.0504	-0.0352	0.139	-0.562**	-1.146**
	(0.0638)	(0.123)	(0.169)	(0.361)	(0.234)	(0.561)
4th quartile drought intensity*loans per acre	-0.00741**	-0.0132**	0.0442	0.00852	0.0221***	0.0245*
	(0.00281)	(0.00599)	(0.0270)	(0.0159)	(0.00697)	(0.0143)
N	979	977	981	978	983	982
adj. R^2	0.945	0.783	0.970	0.929	0.948	0.800
mean	0.558	0.563	5.579	5.322	7.152	6.589
stdev	0.182	0.142	0.850	1.046	0.687	0.783
The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per acre distribution:						
10th percentile	0.00446	0.0118	-0.0630	0.0335	-0.0258	-0.0415
p-val	0.499	0.275	0.289	0.305	0.218	0.314
50th percentile	-0.00653	-0.00948	0.0501	0.0485	0.0275	0.0367
p-val	0.200	0.337	0.0782	0.100	0.126	0.333
90th percentile	-0.0199	-0.0347	0.187	0.0662	0.0926	0.132
p-val	0.0472	0.113	0.139	0.297	0.00317	0.0422

Notes: The dependent variable in A1.8 column 1 is the share of owner occupied farms in the county in 1959 (the rest are tenant occupied). The negative coefficient on the interaction suggests the tenant share is higher in counties with greater credit availability. In a county at the 90th percentile, the tenant share is 2.3 percentage points higher (p=0.01) while it is not different from zero in a county at the 10th percentile. In column 2, the dependent variable is share owned in 1982 and suggests the effect is persistent and even larger over time. Note that in all the columns in this table, we control for the lag of the dependent variable in 1950 to absorb the preexisting variation in these outcomes, as well as linearly for log population and area (in 1950) and interacted with the top quartile drought exposure. In column 3, the dependent variable is the total acres in farming in 1959. It is about 14.3 percent higher (p-value=0.08) in drought exposed counties at the 90th percentile of ex-ante loans per farm distribution. Note that the marginal effects are qualitatively similar when using loans per acre in 1950 as the measure of credit access (Panel B), but often less precisely estimated. This effect seems to die away by 1982 (column 4). Given that marginal farmers survive in greater numbers in the face of drought if buoyed by greater access to credit, we should see a higher number of farms at the end of the drought in 1959 in drought hit counties with greater credit availability. In column 5, the dependent variable is the number of farms in the county in 1959. The number of farms is about 7.6 percent (p-value<0.01) higher in counties at the 90th percentile of the credit distribution. Column 6 shows that by 1982, these positive effects are less precisely estimated. All regressions also include state fixed effects and log population and area in 1950 both linearly and interacted with the drought indicator variable; all regressions include the lag (1950) of the dependent variable. Standard errors, in parentheses, are clustered at the state-level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

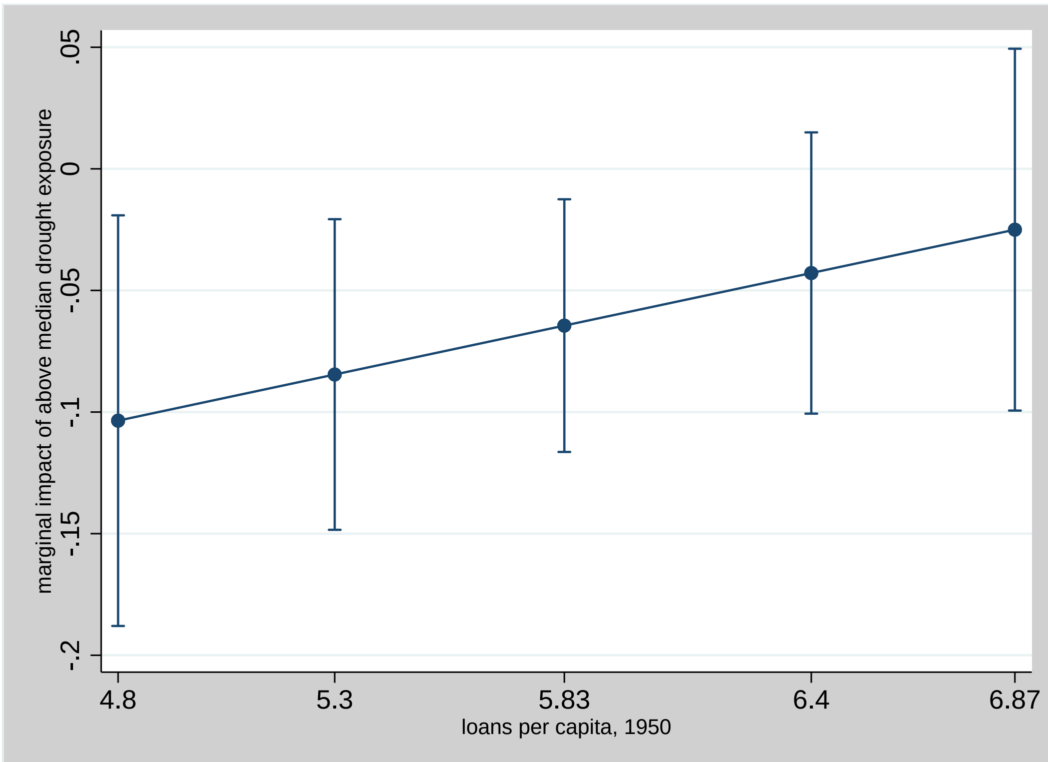
Table A1.9 Productivity and Income

	1 log mean value per farm in 1959	2 log mean value per farm in 1978	3 log median income in 1978
drought exposure	-0.3457	0.1337	-0.2302
	(0.4279)	(0.7100)	(0.1675)
drought exposure#loans per acre 1950	0.0094	0.0294**	0.0079
	(0.0164)	(0.0142)	(0.0094)
Nobs	982	983	986
R-squared	0.907	0.775	0.674
The marginal effect of top quartile drought exposure, evaluated at the 10^{th}, 50^{th} and 90^{th} percentiles of the log loans per acre distribution:			
10th percentile	-0.035	-0.078	-0.036
p-value	0.375	0.092	0.113
50th percentile	-0.015	-0.016	-0.019
pval50	0.506	0.660	0.086
90th percentile	0.008	0.058	0.001
p-value	0.864	0.268	0.960

Notes: This table studies the impact of drought exposure on county-level measures of farm productivity and income. The dependent variable in column 1 is the log mean value per farm in 1959; in column 2, the log mean value per farm in 1978; and in column 3, the log median income in 1978. All regressions include the log population in 1950 and county area both linearly and interacted with the drought indicator variable; all regressions also include state fixed effects; columns 1 and 2 include the log of mean farm values in 1949, while column 3 includes log median income in 1949.

Appendix A2 Additional robustness checks

Figure A2.1 The marginal impact of above median drought exposure on population growth, 1950-1960, as a function of loans per capita, 1950, log



Notes: This figure is a modified version of column 4 of Table 4. The modified regression replaces "top quartile drought exposure" with "above median drought exposure". The figure plots the marginal impact of above median drought exposure on town-level population growth, 1950-1960, over the 1950 loans per capita distribution.

Appendix A3. Town-level evidence

Table A3.1 The impact of drought exposure on population growth—town-level evidence

	(1) all towns	(2) in-sample	(3) quartiles	(4) baseline	(5) 1950-1980
drought intensity, 1950-1960, SPI continuous measure	-0.0107**	-0.0115**			
	(0.00448)	(0.00537)			
2nd quartile drought intensity, 1950-1960			-0.0134		
			(0.0300)		
3rd quartile drought intensity, 1950-1960			-0.0587		
			(0.0356)		
4th quartile drought intensity, 1950-1960			-0.0896**	-0.573***	-0.886**
			(0.0410)	(0.172)	(0.373)
log loans per capita, 1950				0.0442**	0.0816**
				(0.0191)	(0.0306)
4th quartile drought intensity*loans per capita				0.0371	0.0380
				(0.0245)	(0.0643)
N	1790	1302	1302	1302	1187
adj. R^2	0.084	0.074	0.075	0.090	0.140
The marginal effect of top quartile drought exposure, evaluated at the 10th, 50th and 90th percentiles of the log loans per capita distribution:					
10th percentile				-0.086	-0.168
p-val				0.018	0.014
50th percentile				-0.049	-0.130
p-val				0.172	0.022
90th percentile				-0.011	-0.093
p-val				0.836	0.357

Notes: This table examines the impact of drought exposure on the log change in population among incorporated towns. The dependent variable in columns 1-4 is the log change in population between 1950-1960; the dependent variable in column 5 is the log change in population between 1950-1980. All regressions include state fixed effects, and linearly include the log population in 1950, as well as interacted with the top quartile drought indicator variable. Standard errors in parentheses and are clustered at the state level * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3.2 Spatially corrected standard errors

	(1) 100km	(2) 200km	(3) 300km	(4) 500km	(5) 1000km
log loans per capita, 1950	0.0391***	0.0391***	0.0391***	0.0391**	0.0391***
	(0.0133)	(0.0124)	(0.0127)	(0.0161)	(0.0115)
4th quartile drought intensity*loans per capita	0.0456*	0.0456*	0.0456**	0.0456***	0.0456***
	(0.0274)	(0.0275)	(0.0202)	(0.0176)	(0.0116)
4th quartile drought intensity, 1950-1960	-0.617***	-0.617***	-0.617***	-0.617***	-0.617***
	(0.220)	(0.198)	(0.146)	(0.176)	(0.0159)
N	1267	1267	1267	1267	1267
adj. R^2	0.019	0.019	0.019	0.019	0.019

Notes: This table replicates the baseline town-level regression in column 4 of Table A3.1 but reports standard errors corrected for spatial dependence ((Conley 1999) at distances from 100km (column 1) through 1000km (column 5).