

The Effect of Cash Injections: Evidence from the 1980s Farm Debt Crisis*

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Abstract

What is the effect of cash injections during financial crises? Exploiting variation arising from random weather shocks during the 1980s Farm Debt Crisis, we analyze and measure the effect of cash injections on the real and financial sector. Cash injections are shown to have significant economic impact on a host of outcomes including asset prices, loan delinquency rates, and the probability of bank failure. Further, we measure how cash injections affect local-level labor markets, analyzing the impact on employment and wages both within and outside of the sector receiving injections.

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1 Introduction

The role of interventions meant to strengthen firm balance sheets during a financial crisis is a much discussed and debated question. For instance, during the 2008-2009 financial crisis, there was substantial debate regarding the effectiveness of the Stimulus bill, which reduced firms' tax obligations and in so doing provided cash injections to the real sector. In the presence of financial frictions, weak firm balance sheets detrimentally affect economic activity, and so such cash injections could mitigate the extent of a crisis. Furthermore, cash injections could not only have an effect on firms receiving the intervention, but also general equilibrium spillovers to other firms as well as to households.

To understand the effect of interventions during financial crises that strengthen firm balance sheets, we focus on the farm debt crisis of the 1980s. Assembling a yearly, county-level dataset of weather and farm data, our identification strategy relies on exploiting variation arising from random weather shocks to analyze the general equilibrium effects of cash flow variation during the crisis. As a large literature in agronomics shows, weather shocks affect crop yields and hence farm income. Geographic differences in weather thus provide plausibly exogenous variation in firm cash flow. In this paper, we analyze and measure the effect of such exogenous cash injections on both the real and financial sector during a debt crisis.

The 1980s farm debt crisis was similar in many ways to the 2008-2009 recession. The crisis was preceded by large increases in both farm real estate debt as well as agricultural land prices. Subsequently, during the crisis, land prices plummeted by nearly 50 percent. The farming sector was in disarray with numerous agricultural banks failing throughout the period.¹

¹ For studies of the farm debt crisis see e.g. Calomiris, Hubbard, and Stock, 1986.

As a first step in our analysis, we use data on weather shocks and confirm that county-level weather variation is related to farm yields. We focus on corn production in Iowa and use the fact that corn yields are highly sensitive to small changes in temperature, with excessive heat reducing yields. We measure how temporary shocks in weather during the corn growing season affect yields, and consistent with the agronomics literature, find economically significant effects.

Since variation in local weather affects yields, weather shocks provide exogenous variation in firm cash flows and balance sheets during the debt crisis. We exploit this variation in our empirical strategy by relating weather-driven cash flow shocks to a host of real and financial variables. While during normal times, firms should be able to smooth temporary shocks, in financial crises and other periods of large financial frictions, such smoothing is difficult since external finance may be prohibitively costly or unavailable. An inability to smooth shocks during a crisis is predicted to translate to a host of market outcomes, both real and financial. We empirically show that this was indeed the case: a reduction in cash positions during the crisis did indeed have detrimental general equilibrium effects in asset markets, the financial sector, and labor markets.

We start by examining the effect of cash-flow driven weather shocks on agricultural land prices. We expect that during a financial crisis, increases in cash available to firms will increase asset prices through a liquidity pricing effect, as in Shleifer and Vishny (1992) and Allen and Gale (1994). When financial frictions are high, the amount of funds available to firms will tend to affect asset prices, as economic agents cannot raise external finance to bring prices to fundamental value.²

² As in all models of liquidity pricing, an implicit assumption is that asset markets are at least partially segmented and capital cannot flow seamlessly from one market to the other. The market for agricultural land fits this assumption well, as land is often purchased by neighboring local farms.

We examine the effect of cash flow shocks on asset prices by exploiting county-level weather variation. We first show that land prices are indeed negatively related to exogenous county-level temperature shocks. Since our specifications include both year and county fixed effects, our identification strategy is driven by comparing, within a given year, counties that received differential weather shocks (as compared to their sample mean). The results show that counties that receive a negative weather shock—in that temperature during the growing season was high—do indeed exhibit lower land values. To understand the economic magnitude of this effect, we utilize an instrumental variables (IV) strategy in which, as a first stage, we instrument county-level yields with the weather shock variable, and as a second stage, we relate land prices to (predicted) yields. The results show that the elasticity of land prices to yields is approximately 0.7%. Cash flow injections during the farm debt crisis thus had a significant effect on land prices.

As a placebo test, we rerun our analysis but focus on the period outside of the crisis. The reduced financial frictions and stronger farm balance sheets outside of the crisis would predict that land values are less sensitive to cash flow shocks in this period. This is exactly what the results show. Outside of the crisis there is no statistically significant relation between land values and weather shocks, or between land values and farm yields (as instrumented with weather shocks).

We continue our analysis by examining the relation between cash flow injections, loan delinquencies, and bank failures. Once again, our main strategy is to exploit weather shocks to generate variation in farm cash flows. Using the IV strategy described above, we first show that during the crisis, counties that experience reduced average yields due to bad weather shocks exhibit higher agricultural loan delinquencies. As would be predicted, farms in these counties find it more difficult to repay their obligations.

We then analyze how temporary cash flow variation during the crisis affects financial intermediaries. To do so, we relate county crop yields, as instrumented by weather shocks, to county bank failures. During financial crises, temporary shocks to borrowers that translate into higher delinquencies may also filter through and affect banks. As a result, we expect cash flow variation at the borrower-level to translate into financial distress at the bank-level. This is what the results indicate: during the crisis, counties that experience higher crop yields due to favorable weather shocks exhibit lower bank failure rates. The effect is economically significant, with a 10 percent change in crop yields increasing the probability of a county bank failure by 3.2 percent. When financial frictions are high and firms' ability to smooth shocks is limited, temporary cash flow shocks thus appear to translate into the financial sector in the form of bank failure rates.³

We next turn to the effect of cash flow injections during crises on labor markets. We begin by focusing on the agricultural labor market and then turn to examining spillovers into labor markets in other sectors. Consistent with our prior reasoning, the main hypothesis is that firms in the crisis find it difficult to smooth temporary cash flow shocks and, as part of their response, will tend to reduce their labor workforce. Consistent with this view, we find that counties that experience a negative (weather-driven) cash flow shock during the crisis exhibit lower agricultural employment rates.⁴ We find that these counties also exhibit a reduction in average county agricultural wages, consistent with a shift inward in the effective labor demand.⁵ Next, we confirm that outside of the crisis period, weather driven cash flow

³ As a placebo test, we rerun the analysis relating cash flow shocks to bank failures and loan delinquencies outside of the crisis. As expected, we find no significant relations.

⁴ As usual, all regressions are run with county and year fixed effects, implying that the results refer to the relation between changes in employment and the weather shocks, net of the county means of both variables and common year effects.

⁵ We cannot, though, rule out a compositional effect in which higher wage workers are fired following a negative shock. This would of course, still be consistent with the main hypothesis that cash flow shocks create labor market disruptions.

shocks have no effect on employment or on average wages in the agricultural sector, consistent with firms' greater ability to smooth shocks during these periods either by relying on internal funds or on available external finance. The results thus show that during the debt crisis when financial frictions were high, temporary cash flow shocks translated into labor market disruptions in the agricultural sector.

As a final step, we examine the spillover effects of cash flow shocks in the agricultural sector on other sectors during the crisis. We find that most of the adjustments in terms of wages and employment primarily occur in services.⁶ We have two main findings. First, at the county-level, negative cash flow shocks in the agricultural sector are related to employment *increases* in the local services sector. Second, average service sector wages decline in counties that experienced negative cash flow shocks in the agricultural sector. During the crisis, therefore, workers appear to be leaving agriculture following a temporary negative cash flow shock in that sector, and reallocate towards the service sector. Then, consistent with an increase in labor supply in services, average wages in this sector then declines. During the debt crisis, firms' inability to smooth a shock in one sector—namely agriculture—therefore transmits into other industries as workers reallocate in the economy.

Taken together, our results show how, in a debt crisis, temporary shocks to firm cash flows can have important effects on a host of real and financial outcomes. Consistent with the presence of high financial frictions during debt crises, firms are unable to smooth short-term negative shocks to their cash balances. When cash balances are reduced, asset prices decline, delinquency rates rise, banks are more likely to fail, and labor market disruptions ensue. Viewed from the perspective of policy, our results thus point to the potential value of cash

⁶ When we examine wages and employment in manufacturing, we do not find any significant effects.

injections during a financial crisis that may serve to aid firms in smoothing short-term shocks and strengthening firm balance sheets.

The next section presents the empirical strategy, data and a description of the farm debt crisis along with the summary statistics. Section 3 presents the empirical results. Section 4 concludes.

2 Empirical Methodology and Data

2.1 Empirical Strategy

Our empirical strategy involves using idiosyncratic weather shocks, through their effect on agricultural growing productivity, as a source of variation in cash flow. An extensive body of literature has shown that variation in weather has a strong effect on agricultural productivity (see Dell, Jones, and Olken, 2014, for a review). This variation is exogenous to farm-level activity, certainly within the frequency we study.

We focus on the state of Iowa, which provides an ideal setting for examining the effects of weather on agricultural outcomes. Agricultural production is significant in Iowa and constitutes a large portion of economic activity for the state.⁷ Iowa also ranks first out of all states in terms of the production of corn, which is the most plentiful U.S. crop and which is also well understood in terms of its growth response to temperature fluctuations. Finally, agricultural data for Iowa are available at a more detailed level and for a much longer time period compared to other states, allowing for a more complete time series of our empirical tests.⁸

⁷ According to the Iowa Farm Bureau, the agriculture sector brings \$72 billion into Iowa's economy each year and creates one out of every six new jobs.

⁸ Farmland values are only available for Agricultural Census years (at five-year intervals) for most other states.

Our main empirical strategy is to use an instrumental variables (IV) approach in order to examine the effects of adverse temperature shocks on various outcomes. More specifically, a number of papers have noted that exposure to temperatures above a certain threshold during the corn growing season (the months from April through September) are harmful for corn yields (e.g. Schlenker and Roberts, 2006, 2009). Figure 1, taken from Schlenker and Roberts (2006), demonstrates this negative effect of high temperatures on corn yields. We therefore instrument for corn yields using the number of days in the growing season above 83°F as a measure of cumulative exposure in each year to harmful temperatures, a threshold corresponding to that identified in the literature.⁹

The first-stage regression that we run is given by:

$$\log(\text{Corn Yield}_{i,t}) = \beta_0 + \beta_1(\text{Days Above } 83)_{i,t} + \delta_t + \gamma_i + \varepsilon_{i,t} \quad (1)$$

where *Corn Yield* is measured in bushels per acre and *Days Above 83* is the number of days in the corn growing season which have an average temperature above 83 degrees Fahrenheit. Regression (1) is run at the county-year level, and includes year fixed effects δ_t as well as county fixed effects γ_i to take into account time-invariant omitted characteristics at the county level (like soil quality), or county-invariant shocks. Our second-stage regression specification examines the effect of instrumented corn yields, given by (1), on various outcome variables:

$$Y_{i,t} = \beta_0 + \log(\widehat{\text{Yield}}_{i,t}) + \delta_t + \gamma_i + \varepsilon_{i,t} \quad (2)$$

where $Y_{i,t}$ is the outcome variable of interest for county i in year t , $\log(\widehat{\text{Yield}}_{i,t})$ is predicted log corn yield using harmful temperature as an instrument via regression (1), δ_t are county fixed

⁹ Schlenker and Roberts (2009) note that temperature becomes harmful past 28°C.

effects, and γ_i are year fixed effects.¹⁰ The outcomes that we examine are agricultural land values, agricultural loan delinquencies, bank failures, wages, and employment. An important assumption underlying the validity of the IV approach is the exclusion restriction—that temperature only affects the outcome variables in (2) through its effect on corn yields affecting the cash flow of farms. As discussed later, in support of this assumption as we do not find any effects of these weather shocks on the outcome variables (despite having an effect on yields) in non-crisis periods when financing frictions are less likely to bind.

2.2 Data Sources

We construct a novel dataset of outcomes at the county-level for Iowa. Our dataset is constructed using a variety of different sources. For our temperature data, we collect daily weather station data for Iowa from the National Oceanic and Atmospheric Administration (NOAA) from 1950 to 2010. Using this daily data, for each weather station we calculate the number of days in the corn growing season (from April to September) where the average daily temperature is above 83 degrees Fahrenheit.¹¹ We then construct county-level estimates of this temperature measure for Iowa using the procedure of Deschênes and Greenstone (2012). Using geographical data for each county in Iowa from the U.S. Census Bureau, we construct a county-level estimate of the number of hot days in the growing season by using a weighted average of all weather station estimates within a 50km radius of the geographical center of each county. The weights are the inverse of the squared distance from each weather station to the geographical center of the county. As there are 99 counties in Iowa, this yields a total of

¹⁰ We cluster our standard errors at the year-level, in order to account for any spatial correlation between counties. In particular, by clustering at the year-level we are assuming that *all* counties in Iowa are correlated regardless of their distance to one another, which is a stronger assumption than a typical spatial correlation adjustment of standard errors (e.g. Conley (1999)) which assumes that the correlation decays with distance.

¹¹ In any given year, we only use weather stations that have non-missing data for every day in July.

6,032 county-year temperature observations for the sample period from 1950 to 2010, and 693 observations for the crisis period from 1981 to 1987.

Our measure of corn yields come from the USDA's National Agricultural Statistics Service (NASS) yearly crop surveys. The NASS provides yearly data at the county level of average corn yields from 1950 to 2010, measured in bushels per acre harvested.

Our measure of farmland values come from the Iowa State University Farmland Value Survey, which provides yearly county-level estimates (as measured in November of each calendar year) of the average value per acre of Iowa farmland from 1950 to 2010.¹² The respondents to the survey are individuals that are considered to be knowledgeable of land market conditions, such as agricultural real estate brokers. In each year, respondents are asked to provide their estimate of current farmland prices in the county they are located. Studies have shown that these survey values closely track actual land sales prices (see Stinn and Duffy, 2012, and Kuethe and Ifft, 2013).

We use two different data sources to examine the effect of shocks on banks. The first source is data on agricultural loan delinquencies from the Federal Reserve's Commercial Bank Data Call Reports. This is defined as the outstanding balance of agricultural loans that are 90 days or more past-due and upon which the bank continues to accrue interest, which is available from 1984 to 2000. The second source is data on bank failures for each county, taken from the Federal Deposit Insurance Corporation (FDIC). These data on bank failures run from 1984 to 2010. In order to properly attribute the effects of temperature shocks during the growing season to bank failures, a bank failure is defined as occurring in a given year if it

¹² A potential concern with the estimates of farmland value is that some parcels of land may be irrigated (thus leading to a higher value) while others may not. However, very little of the farmland in Iowa is irrigated, implying that this is not a concern for our sample. For example, according to data from the U.S. Agricultural Census and the NASS, only roughly 2.6% of total Iowa farmland was irrigated in 2012.

happened within the period from the end of the growing season in that year (October and onwards) through the growing season of the following year (September and earlier).

Finally, we collect data on wages and employment from the Bureau of Labor Statistics' (BLS) Quarterly Census of Employment and Wages. We take data on county-level employment, average annual wages, total (aggregate) wages, and number of establishments for the period from 1975 to 2000. We collect these data items for the agricultural crop production sector, as well for other sectors in order to show spill-over effects.¹³

2.3 The Farm Debt Crisis

As with many financial crises, the period preceding the farm debt crisis in the 1980s saw sharp increases in debt and land prices. In the 1970s, increasing commodity prices along with an expansion in exports led to increased farm production, financed by debt. For example, between 1971 and 1980, agricultural exports roughly doubled, farmland values rose by 88 percent and farm debt rose by 66 percent (see Calomiris, Hubbard, and Stock, 1986).

The farm debt crisis was triggered in the early 1980s by the combination of a sharp increase in interest rates to combat inflation undertaken by the Federal Reserve under Paul Volcker and Russia's imposition of an embargo on U.S. agricultural imports. The result was a period of severe financial distress for farmers, leading to significantly weaker farm balance sheets, sharp drops in farm land values, and an erosion in farm credit conditions. For example, across the U.S., the average value of farmland dropped by 29% between 1980 and 1984; delinquent loans rose to 7.5% of total loans at small agricultural banks by 1985; and there were

¹³ The agricultural crop production sector is defined as SIC code 01. In addition, we use the services sector (SIC division 0I) and manufacturing sector (SIC division 0D). The caveat with our agricultural wage and employment data is that the Quarterly Census of Employment and Wages only covers larger farms—it does not cover most agricultural workers on small farms or self-employed agricultural workers.

100 small agricultural bank failures in 1984 and 1985, an increase from 7 in 1983 (see Calomiris, Hubbard, and Stock, 1986). These effects were even more pronounced in the U.S. Corn Belt states, with their significant agricultural sectors. For example, in Iowa, farmland prices dropped by an average of 46% across all counties. And Iowa alone experience 39 commercial bank failures between 1981 and 1987.

One unique feature of the debt crisis is that farming was the sector that was primarily affected, while other sectors were not impacted nearly as severely. This allows us to explore spill-over effects between the agricultural sector and other industries. As a result, the farm debt crisis provides an ideal setting for exploring the effects of exogenous shocks to the agricultural sector, as well as broader effects in other industries.

2.4 Summary Statistics

Table 1 presents the summary statistics of the main variables. During the crisis, the average number of days in the growing season where the average temperature exceeds 83 degrees Fahrenheit is 2.4. The overall standard deviation of is roughly 3 days, indicating a fair amount of variability. As expected, the number of days above 83 degrees Fahrenheit does not differ substantially from that during the crisis (panel B). Figure 2, Panel A reports the density plots of the distribution of days above 83 degrees Fahrenheit over our entire sample. As our main specifications include county and year fixed effects, Figure 2 exhibits variation which we do not exploit in our identification strategy. Figure 3, therefore, presents density plots of temperature variation demeaned with year and county fixed effects. The distribution of demeaned days above 83 degrees Fahrenheit is symmetric around zero, but also exhibits substantial variation. The density plots for the individual years (Figure 4) in the crisis and non-

crisis period indicate substantial variability across counties for any given year, with some years exhibiting a significantly higher number of days above 83 degrees Fahrenheit.

The mean corn yield for counties in Iowa in our sample is roughly 124 bushels per acre of land harvested during the crisis. Mean corn yields have increased over time from a value of 48.1 bushels per acre in 1950 to a value of 154.6 bushels per acre in 2010, consistent with technological improvements in the sector. The mean (real) value per acre of farmland during the crisis, defined as the years from 1984 to 1987, is \$2,000 per acre. However, during this time period farmland prices dropped by an average of 46% across all counties. Figure 5 depicts the evolution of average corn yield, land value, and agricultural debt across all counties for each year in the sample. Average corn yield increases over the sample period, as would be expected with technological improvements in agriculture. Land values increase gradually from 1950 to 1970, and then substantially from 1970 to 1980. However, in the early 1980s, corresponding to the period of the farm debt crisis, land values drop precipitously. By contrast, corn yields do not exhibit such a trend during the debt crisis, suggesting that changes in land productivity were not the primary driver of the large decline in farmland prices. Finally, agricultural debt increases steadily from 1960 to 1980 but drops significantly during the farm debt crisis, as would be expected.

3 Empirical Results

3.1 Weather Shocks, Cash Flow Injections, and Asset Prices

As explained in Section 2, we analyze the effect of cash flow injections during a crisis by exploiting variation in weather shocks across counties and over time in Iowa. These weather shocks, and the associated effect on corn yields, provide an exogenous source of variation in cash flow, and hence firm balance sheets, during the crisis.

In measuring weather shocks, we follow the agricultural economics literature that has shown how high temperature during the growing season—from April through September—adversely affects corn yields. We thus construct a variable, *Days Above 83*, defined at the county-year level, which equals the number of days during the growing season where the average daily temperature within the county was above 83 degrees Fahrenheit. This temperature threshold is taken from Schlenker and Roberts (2009), although our results are robust to alternate definitions of high temperature values.¹⁴

As a first step in the analysis, we run the following reduced-form specification that relates yields and land values to weather shocks:

$$\log(Y_{i,t}) = \beta_0 + \beta_1(\text{Days Above } 83)_{i,t} + \delta_t + \gamma_i + \varepsilon_{i,t} \quad (3)$$

where $Y_{i,t}$ is either corn yields (bushels of corn produced per acre) or farm land values in county i in year t , and *Days Above 83* is the weather shock measure capturing hot average-temperature years, as described above. All regressions include a vector of year fixed effects, δ_t , and most also include a vector of county fixed effects, η_i . Following the literature in agronomics (e.g. Deschênes and Greenstone, 2007, Schlenker and Roberts 2006, 2009), standard errors are calculated correcting for spatial correlation as in Conley (2008).

Table 2 reports the results for corn yields, running regression (3) over the Farm Debt Crisis sample period of 1981 to 1987. Employing year, but not county, fixed effects, Column (1) shows that high temperature is indeed detrimental to corn yields. As can be seen in Column (2), adding county fixed effects does not substantially change the results. Interpreting the coefficient, adding an extra day during the growing season with an average temperature above 83 reduces corn yields by 3.3 percent. While seemingly high, this result is in line with much

¹⁴ Specifically, Schlenker and Roberts (2009) note that for the geographical region that Iowa is located in, temperature becomes harmful past 28°C or 29°C (82.4°F or 84.2°F). We thus use 83°F as our threshold.

prior work in the literature such as Schlenker and Roberts (2009). Corn is extremely sensitive to high temperature values during the growing season—an established fact in the agronomics literature that is at the heart of our identification strategy. It is important to emphasize that the variation we exploit for identification is not periods of drought or extreme heat throughout the growing season, but variation in temperature across counties, with some experiencing a number of days in the growing season where the average temperature is above 83 degrees Fahrenheit.

In Column 3, we report the results for the period of 1984 to 1987—the peak of the farm debt crisis—and find similar results. In Column 4 we estimate the results for the non-crisis periods and find again that the estimated coefficients are very similar to those during the crisis. The effect of weather on yields is biological and hence, as expected, is similar both during and outside the crisis.¹⁵ In Column 5, we examine the effect of weather shocks on yields over the entire sample and again do not find any significant differential effects over time.

Having confirmed the effect of temperature on yields, we analyze how temperature shocks, and the variation they induce in farm cash flows, affect local asset prices. Table 3 reruns the reduced form specification in regression (3) but employs $\log(\text{Land Value})$, the average county-level price per acre of farmland (in 2010 dollars), as the dependent variable. We hypothesize that during debt crises, when financial frictions and the cost of external finance are high, counties which receive negative cash flow shocks (stemming from weather variation) will exhibit lower land prices.¹⁶ Assuming some degree of localization in the market for land, negative weather shocks will decrease the amount of cash and net worth of local

¹⁵ Note that hedging markets were not well developed during that period: most of these markets developed in the 1990s.

¹⁶ To reiterate, a reduction in the variable *Days Above 83* captures exogenous positive cash flow injections into a county.

buyers—i.e. nearby farmers. When the cash available to these local buyers is reduced, the price of land should fall: a cash-in-the-market pricing effect as in Shleifer and Vishny, 1992, and Allen and Gale, 1994.

Consistent with the prediction, Table 3 shows that land prices do indeed respond negatively to detrimental weather shocks. Focusing on Column (2), which includes county fixed effects and hence is identified off of temperature variation within a county, an additional day during the growing season with an average temperature greater than 83 degrees Fahrenheit reduces average price per acre by 0.4 of a percent. In Column 3, which reports the results for the period during the peak of the farm debt crisis, the estimated magnitudes are even larger (0.7 of a percent).

To provide intuition as to why land prices move following a negative weather shock, it is instructive to conduct a back-of-the-envelope estimate of the effect of weather variation on farm balance sheets. First note that farming involves low profit margins—on the order of 6%.¹⁷ Consider then a shock that adds an extra high temperature day to the growing season—i.e. with average temperature above 83 degrees Fahrenheit—which as discussed above, reduces average annual yield by 3.3%. Assuming conservatively that costs are unaffected by the bad weather shock, annual profits are expected to decline by approximately 50%.¹⁸ Because of small profit margins, variation in weather can have a large influence on farm cash positions—a standard operating leverage effect—which then feeds into land prices as shown in Table 3.

Table 3 focuses on the farm debt crisis period, and shows that weather variation and the attendant cash flow effects have an impact on land prices. At the center of the theoretical

¹⁷ See USDA Economic information bulletin, May 2006.

¹⁸ With a 6% profit margin, $P = 0.06 * R$ and $C = 0.94 * R$, where P , R , and C are profit, revenue, and cost, respectively. Since the weather shock reduces revenue by 3.3%, the resultant profit—i.e. post-weather shock—will be $0.027R$ rather than $0.06R$. Profit thus declines by approximately fifty percent.

argument is the assumption that financial frictions prevent firms from raising external financing to smooth shocks, or make it prohibitively costly for them to do so. According to this argument, we expect that outside of the crisis, the effect of weather shocks on land prices is greatly diminished (or non-existent), even while these shocks continue to affect yields and hence cash flows. Column 4 conducts this test by considering the impact of exogenous weather shocks, and the implied impact on firm balance sheets, *outside* of the 1980s Farm Debt Crisis. In contrast to the results in earlier columns, and consistent with an increased ability of firms to smooth cash flow shocks, outside of the crisis years weather variation has no statistically significant relationship with asset prices. Thus, even though negative weather shocks continue to detrimentally affect yields outside of the crisis (Table 2, Column 4), they have no effect on land values outside the crisis.

Tables 2 and 3 provide a reduced form estimation of the relation between weather shocks and both yields as well as land values. To understand the economic impact of how variation in yields affects land values, we employ an instrumental variable approach. The first stage instruments for yields using exogenous weather shocks, as in regression (1). The second stage then relates county average land value to the predicted yields taken from the first stage. Specifically, we run:

$$\log(\text{Land Value}_{i,t}) = \beta_0 + \log(\widehat{\text{Yield}}_{i,t}) + \delta_t + \gamma_i + \varepsilon_{i,t} \quad (4)$$

where, as before, $\log(\widehat{\text{Yield}}_{i,t})$ is instrumented log corn yield estimated via (1) in county i in year t , and $\text{Land Value}_{i,t}$ is the land value of county i in year t . In the above, δ_t , represents a vector of year fixed effects, and γ_i represents a vector of county fixed effects.

The results are shown in Table 4. Column (1) of the Table provides the first-stage estimation. As can be seen, the F-test is 12.79, well above 10, showing that there is little

concern of a weak instruments problem. Column (2) of the table exhibits the results of the second stage, finding an elasticity of land values to yields of 0.114: a 10% increase in county yields is associated with a 1.14% increase in land values. Exogenous cash flow injections (driven by weather variation) are thus found to affect asset prices during the debt crisis. Columns (3) and (4) conduct the IV strategy starting from 1984—the height of the crisis years—and up to its end in 1987. While the first-stage effect relating weather shocks to yields is attenuated, the second stage elasticity of land prices to yields is 0.33, or roughly three times larger than the effect during the entire crisis period.¹⁹

3.2 Delinquencies and Bank Failures

Having shown how weather shocks affect yields and land prices, in this section we analyze how temporary shocks in cash flow translated into the financial sector during the debt crisis. In the presence of financial frictions, temporary negative weather shocks will reduce farms' ability to repay loans. If this effect is sufficiently severe, cash flow shocks will transmit into the financial sector with increased bank failure rates. Cash injections and the strength of firm balance sheets in the real sector can therefore impact and spill over into the financial sector.

To analyze this mechanism, we first verify that negative cash flow shocks do indeed translate into higher delinquencies on agricultural loans during the crisis. For each county-year we calculate the aggregate outstanding balance of agricultural loans that are 90 days or more past-due. Data on agricultural loan delinquencies are taken from the Federal Reserve Call Reports.

As above, we use an IV approach in which we run a first-stage regression where county

¹⁹ This is potentially indicative of higher financial constraints during the height of the crisis.

average corn yields are instrumented with *Days Above 83*, the weather shock variable.²⁰ The second stage then relates county-level aggregate balance of delinquent loans to county average yields. Specifically we run:

$$\log\left(\widehat{Ag\ Delinquencies}_{i,t}\right) = \beta_0 + \log\left(\widehat{Yield}_{i,t}\right) + \delta_t + \gamma_i + \varepsilon_{i,t} \quad (5)$$

where, as in prior regressions, $\log\left(\widehat{Yield}_{i,t}\right)$ is instrumented log corn yield estimated via (1) in county i in year t , and *Ag Delinquencies* is the total outstanding balance of delinquent agricultural loans.

Column (1) of Table 5A presents the results. As can be seen, delinquency levels vary negatively with yields. Indeed, the coefficient imply an elasticity of 3 between county aggregate delinquent loans and average yields. During the crisis, counties which experience a 10% increase in yields (as compared to their mean) exhibit a 30% increase in aggregate delinquency amounts. During the debt crisis, positive cash injections driven by weather shocks translated into reduced delinquencies among borrowers, as would be expected.

The loan delinquencies analyzed in Column (1) of Table 5A represent, of course, shocks to bank balance sheets. As a next step, then, we examine whether the increased loan delinquencies driven by (weather-induced) variation in cash flows were transmitted into the local financial sector in the form of county bank failures. We employ our standard IV approach, first instrumenting county average yields with the weather shocks, and then relating the instrumented yields to bank failure rates at the county-level. Specifically we run the following IV linear probability model:

$$Bank\ Failure_{i,t} = \beta_0 + \log\left(\widehat{Yield}_{i,t}\right) + \delta_t + \gamma_i + \varepsilon_{i,t} \quad (6)$$

where *Bank Failure* _{i,t} takes on the value of one if there was a bank failure in county i in year t ,

²⁰ See Column 3 of Table 2 for the first stage results.

and zero otherwise. Note that we measure bank failures in the period that follows the growing season in year t up to the end of the growing season next year.

Column (2) of Table 5A presents the results. As the table shows, a 10% increase in yields leads to an approximately 3.2 percentage point increase in the probability of bank failure. The effect is economically sizeable, as 28% percent of the county-year observations during the period of 1984 to 1987 exhibit a bank failure. Consistent with the hypothesis, temporary cash flow variation driven by exogenous weather shocks did indeed lead to spillovers into the financial sector in the form bank failures.

Column (3) of the table repeats the analysis, but allows a lag in the time to bank failure. Specifically, we define an indicator variable Bank Failure Crisis that takes on the value of one if there was a bank failure from the given year until the end of the crisis (i.e. to 1987), and zero otherwise. As can be seen, the effect of predicted yields on bank failures rises when a time lag to failure is accounted for, with a coefficient in the level-log specification that is approximately -0.4.

As a placebo test, Panel B of Table 5 examines the effect of temporary cash flow shocks outside of the debt crisis—i.e. during the years 1988 to 2010.²¹ Lower financial frictions and stronger balance sheets during this period would predict muted effects. This is indeed what the results indicate. As can be seen in Column (1) and Column (2) of Table 5B, cash flow shocks outside of the crisis are not related to delinquency rates or bank failure rates.

3.3 Cash Flow Shocks and Labor Markets

We continue by analyzing the effect of temporary cash flow shocks during the crisis on local employment and wages, focusing first on the agricultural sector itself. Panel A of

²¹ There were 8 failures during this period, though 7 of them took place in 1988 and 1989.

Table 6 focuses on the debt crisis years, examining the relation between cash variation and labor markets outcomes within the agricultural sector. We collect county average pay and county employment levels from the quarterly census of employment and wages. All regressions employ the IV approach, whereby county average yields are instruments first with the weather shock variable, and then predicted yields are related to either wages or employment. Specifically, we run

$$Y_{i,t} = \beta_0 + \log(\widehat{Yield}_{i,t}) + \delta_t + \gamma_i + \varepsilon_{i,t} \quad (7)$$

where Y_{it} is a county-level labor-market outcome, and $\log(\widehat{Yield}_{i,t})$ is instrumented log corn yield estimated via (1) in county i in year t . For the labor-market outcomes, *Ag Total Wages* is the sum total of all wages for agricultural crop production, *Ag Avg Wages* is the average annual wage for an individual in agricultural crop production, and *Ag Employment* is the total employment in agricultural crop production.

Column (1) of the table shows the results using total county-level employment as the dependent variable.²² As can be seen, there is a positive relation between yields and total county employment. Thus, during the crisis, farms in counties that received a positive cash flow injection (driven by relatively good weather) reduced by less their total agriculture employment relative to those that received a negative cash flow shock. The coefficient on predicted yields indicates that a one percent rise in yields leads to a 0.3 more people employed in agriculture within the county. Thus, consistent with increased financial frictions during the crisis, negative shocks to firm balance sheets lead to reduced employment rates. This is consistent with a drop in labor demand when financial constraints bind and external capital is costly.

²² Note that the data from QCEW does not have information for small farms, thus one could expect the true magnitudes to be larger as small farms tend to be more financially constrained.

Continuing with labor market outcomes, Column (2) replaces employment with average county wages per employee as the dependent variable. As can be seen, predicted crop yields are positively related to average wages per employee. Counties that experienced a negative weather-induced cash flow shock exhibit a relative decline in average wages per employee. The elasticity of yields to average county pay is approximately 2.9. Thus, consistent with a drop in labor demand stemming from an inability to finance employee wages out of internal capital, a 1% reduction in yields is associated with a substantial 3% relative reduction in average wage per employee. Column (3) combines the results in Columns (1) and (2) by analyzing total county wages, which includes variation both in employment as well as average wage per employee. Unsurprisingly, given the results in the prior columns, we find that weather driven cash flow injections are positively related to total county wages, with a total wages to yield elasticity of 4.4.

Panel B of the table repeats the analysis but focuses on the period outside of the farm debt crisis. Outside of financial crises, firms' ability to smooth temporary cash flow shocks is greatly enhanced, and so we expect the relation between employment and predicted yields to be dampened. Consistent with this, the results show that outside of the debt crisis, county level employment, average wage per employee, and total wages are unrelated to exogenous (weather-driven) variation in yields. While the strength of a firm's balance sheet, and variation in it, plays a role in determining labor market outcomes during periods of high financial constraints, they play no role outside of the crisis.

Table 7 continues by analyzing how cash flow shocks spill over into other labor markets during the debt crisis. Specifically, we use the IV strategy, instrumenting for county yields, and then relate predicted yields to county level employment and wages in the *service* sector. We focus our attention on the service sector as it is a natural place for people who are

displaced from farming to seek employment.²³

Column (1) of Table 7A shows that total employment in the service sector is *negatively* related to cash flow shocks in the agricultural sector. Thus, when a county is hit with a negative cash flow shock in the agricultural sector, the data show that agricultural employment declines while employment in services rises (compared to the mean county level). Following a temporary negative cash flow shock, workers thus appear to be shifting from the adversely affected agricultural sector towards other industries. The coefficient on the employment variable shows that a 1% reduction in predicted yields is associated with an increase of 7 employees in the service sector. Note that the number estimated here is greater than the reduction in employees in the agricultural sector. This is driven by the fact that employment data from QCEW for the agricultural sector only tracks large agricultural operations and hence does not incorporate changes in small farms. Visual inspection of the overall employment Iowa also confirms that there was hardly any change in the overall employment rate over the period of the farm debt crisis (see Figure 7).

Still focusing on the debt crisis period, Column (2) of the table examines how average wages in the service sector relate to cash flow shocks in the agricultural sector. Consistent with an outward shift in the supply of workers in services, the results show that counties that experienced an exogenous negative (weather-driven) cash flow shock in agriculture exhibit a relative *decline* in wages in the service sector. The elasticity of average county wages in the service sector to county yields is 0.075—i.e., a ten percent decline in yields translates into a 1% drop in service sector wage.

Column (3) of the table relates aggregate county wages in the service sector and finds

²³ We also examined manufacturing sector and found no significant adjustments in employment in manufacturing. Data is taken from QCEW as discussed earlier.

that they are unrelated in a statistically significant manner to yields. This is not altogether surprising, since following a negative shock to yields the effect on wages and employment run in opposite directions: while average wages in the service sector falls, county employment in the sector rises.

The final column of Table 7A examines the relation between predicted yields—instrumented as usual by the weather shock variable—and the number of service sector establishments within each county. As can be seen, there is a negative relation between the two variables: during the financial crisis, negative cash flow shocks to the agriculture sector are associated with an increase in the number of new establishments in the service sector. This is consistent once again with spillovers between sectors in which employees are shifting away from agriculture and opening new establishments in the service sector.

The results in Panel A of Table 7 thus paint a picture by which firms' inability to smooth shocks in one sector create externalities in other sectors within the labor market. Workers shift away from firms hit by temporary cash flow shocks, increasing the supply of labor in other sectors. The end result is higher employment and lower wages in sectors unrelated to the original shock.

For completeness, Panel B of Table 7 conducts a placebo test and reruns the specifications of Panel A focusing on the period outside of the crisis. As was shown in Panel B of Table 6, outside of the crisis farms are able to smooth weather shocks, consistent with the greater availability of external finance outside of the crisis. Because the agriculture sector is able to smooth cash flow shocks, we expect to find no effect on labor outcomes in the services sector outside of the crisis. This is what we find: using the IV specification outside of the crisis, none of the service sector labor market outcomes are related in a statistically significant manner to (predicted) county level yields.

4 Conclusion

In this paper, we examine the general equilibrium effects of variation in firm cash flows during a financial crisis, and how these affect the propagation of shocks. In order to do so, we construct a novel database in the agricultural industry encompassing the 1980s farm debt crisis. Using weather shocks as a source of exogenous cash flow variation, we examine the relation between cash flow shocks during the crisis and a host of general equilibrium outcomes in the real and financial sector.

We find that temporary cash flow shocks during the crisis have significant effect on farmland values, delinquencies, and employment and wages in the agricultural sector. Beyond the direct effects in the farming sector, we also find that these shocks spill-over to other sectors. We find that the likelihood of failure of banks increases in counties that experience a negative cash flow shock. Furthermore, we find that the services sector picks up the workers displaced from farming, but that the average wage of employees in services drops by more in counties where there is a negative cash flow shock. Overall, temporary shocks that affect firm balance sheets during a crisis create externalities for other sectors.

Our results highlight the potential importance of cash injections to firms during a financial crisis. The results also underscore how injections in one sector can spillover to other sectors of the economy. More broadly the results highlight the adjustments that occur in the economy in equilibrium during a financial crisis, when firms experience shocks that affect the strength of their balance sheet.

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Table 1: Summary Statistics

This table contains summary statistics for all variables, split between the crisis and non-crisis years. All variables are yearly county-level averages. *Corn Yield* is defined as bushels of corn produced per acre of harvested land. *Land Value* is the dollar value of farmland per acre, in real (2010) dollars. *Days Above 83* is the number of days where the average temperature is above 83 degrees Fahrenheit during the growing season. Statistics for the non-crisis period are presented from 1950-1980 and from 1988-2010; statistics for the crisis period are presented from 1984 to 1987. All dollar amounts are scaled by the consumer price index (CPI), and are in real 2010 dollars.

Panel A: Crisis Years

Variable	# Obs	Mean	Std. Dev.	p25	Median	p75
<i>Days Above 83</i>	396	2.377	3.070	0.285	1.222	3.054
<i>Corn Yield</i>	396	123.827	15.214	115.15	125.75	134.30
<i>Land Value</i>	396	1,977.861	751.778	1,488.387	1,868.923	2,299.06

Panel B: Non-Crisis Years

Variable	# Obs	Mean	Std. Dev.	p25	Median	p75
<i>Days Above 83</i>	5,339	2.512	3.642	0.047	1.069	3.216
<i>Corn Yield</i>	5,346	105.671	41.483	71.100	100.700	139.100
<i>Land Value</i>	5,346	2,753.98	1,361.00	1,893.49	2,424.75	3,127.98

Table 2: Temperature Shocks on Corn Yields

This table provides regression results for the effects of temperature shocks on corn yields. All variables represent county-level values in the indicated year. *Corn Yield* is defined as bushels of corn produced per acre of harvested land. *Days Above 83* is the number of days where the average temperature is above 83 degrees Fahrenheit during the growing season. *Crisis* is a dummy variable that equals 1 if the year is between 1981 and 1987, and 0 otherwise. Standard errors are given in parentheses, and are corrected for spatial correlation (as in Conley, 2008), as indicated. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. All regressions include an intercept term (not reported). The crisis period is defined from 1981-1987 in columns (1) and (2), and from 1984-1987 in column (3); the non-crisis period runs from 1950-1980 and 1988-2010; the full sample runs from 1950 to 2010.

Dependent Variable: $\log(\text{Corn Yield})$					
	(1)	(2)	(3)	(4)	(5)
Time Period:	Crisis, 1981-1987		Crisis, 1984-1987	Non-crisis	Full Sample
<i>Days Above 83</i>	-0.034*** (0.008)	-0.033*** (0.008)	-0.022*** (0.004)	-0.026*** (0.003)	-0.026*** (0.003)
<i>Days Above 83</i> \times <i>Crisis</i>					-0.005 (0.008)
Year FE	Yes	Yes	Yes	Yes	Yes
County FE	No	Yes	Yes	Yes	Yes
Standard Errors	Spatial	Spatial	Spatial	Spatial	Spatial
Observations	693	693	396	5,339	6,032
R ²	0.660	0.800	0.754	0.925	0.919

Table 3: Temperature Shocks on Land Values

This table provides regression results for the effects of temperature shocks on farm land values. All variables represent county-level values in the indicated year. *Land Value* is the dollar value of farmland per acre, in real (2010) dollars. *Days Above 83* is the number of days where the average temperature is above 83 degrees Fahrenheit during the growing season. *Crisis* is a dummy variable that equals 1 if the year is between 1981 and 1987, and 0 otherwise. Standard errors are given in parentheses, and are corrected for spatial correlation (as in Conley, 2008), as indicated. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. All regressions include an intercept term (not reported). The crisis period is defined from 1981-1987 in columns (1) and (2), and from 1984-1987 in column (3); the non-crisis period runs from 1950-1980 and 1988-2010; the full sample runs from 1950 to 2010.

Dependent Variable: $\log(\text{Land Value})$					
	(1)	(2)	(3)	(4)	(5)
Time Period:	Crisis, 1981-1987		Crisis, 1984-1987	Non-crisis	Full Sample
<i>Days Above 83</i>	-0.031*** (0.008)	-0.004*** (0.001)	-0.007*** (0.002)	-0.001 (0.001)	-0.0005 (0.001)
<i>Days Above 83</i> \times <i>Crisis</i>					-0.005*** (0.002)
Year FE	Yes	Yes	Yes	Yes	Yes
County FE	No	Yes	Yes	Yes	Yes
Standard Errors	Spatial	Spatial	Spatial	Spatial	Spatial
Observations	693	693	396	5,339	6,032
R ²	0.709	0.996	0.994	0.982	0.983

Table 4: Temperature Shocks, IV Regressions during the Crisis

This table provides instrumental variables regression results for the effects of temperature shocks on corn yields and land values during the farm debt crisis. All variables represent county-level values in the indicated year. *Corn Yield* is defined as bushels of corn produced per acre of harvested land. *Land Value* is the dollar value of farmland per acre, in real (2010) dollars. *Days Above 83* is the number of days where the average temperature is above 83 degrees Fahrenheit during the growing season. $\widehat{\log(Yield)}$ is instrumented log corn yield. Standard errors are given in parentheses, and are clustered at the year level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. All regressions include an intercept term (not reported).

	(1)	(2)	(3)	(4)
Time Period:	1981-1987		1984-1987	
IV Stage:	First Stage	Second Stage	First Stage	Second Stage
Dep. Variable:	$\log(Corn\ Yield)$	$\log(Land\ Value)$	$\log(Corn\ Yield)$	$\log(Land\ Value)$
<i>Days Above 83</i>	-0.033*** (0.004)		-0.022*** (0.002)	
$\widehat{\log(Yield)}$		0.114*** (0.031)		0.330*** (0.057)
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Observations	693	693	396	396
F-stat	12.79		9.18	
R ²		0.996		0.99

Table 5: Agricultural Loan Delinquencies and Bank Failures

This table provides second-stage instrumental variables regression results for the effects of temperature shocks on bank failure rate during the farm debt crisis and non-crisis years. All variables represent county-level values in the indicated year. *Ag Delinquencies* is the outstanding balance of agricultural loans that are 90 days or more past-due and upon which the bank continues to accrue interest, in real (2010) dollars. *Bank Failure* is a dummy variable that takes a value of 1 if there was a bank failure in the given year, and 0 otherwise. *Failure Crisis* is a dummy variable which takes a value of 1 if there was a bank failure from the given year until the end of the crisis, and 0 otherwise. $\log(\widehat{Yield})$ is instrumented log corn yield. Standard errors are given in parentheses, and are clustered at the year level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. All regressions include an intercept term (not reported). The crisis period in Panel A runs from 1984 to 1987, while the Non-Crisis period in Panel B runs from 1988-2000 for column (1) and from 1988-2010 for column (2).

<i>Panel A: Crisis</i>			
	(1)	(2)	(3)
Dep. Variable:	$\log(\widehat{Ag\ Delinquencies})$	<i>Bank Failure</i>	<i>Bank Failure Crisis</i>
$\log(\widehat{Yield})$	-3.249*** (0.836)	-0.324** (0.144)	-0.402*** (0.064)
Year FE	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Observations	396	396	396
R ²	0.504	0.239	0.740

<i>Panel B: Non-Crisis</i>		
	(1)	(2)
Dep. Variable:	$\log(\widehat{Ag\ Delinquencies})$	<i>Bank Failure</i>
$\log(\widehat{Yield})$	-0.707 (1.276)	0.065 (0.044)
Year FE	Yes	Yes
County FE	Yes	Yes
Observations	1,273	2,270
R ²	0.375	0.068

Table 6: Agricultural Wages and Employment

This table provides second-stage instrumental variables regression results for the effects of temperature shocks on agricultural wages and employment during the farm debt crisis and non-crisis years. All variables represent county-level values in the indicated year. *Ag Total Wages* is the sum total of all wages for agricultural crop production. *Ag Avg Wage* is the average annual wage for an individual in agricultural crop production. *Ag Employment* is the total employment in agricultural crop production. $\log(\widehat{Yield})$ is instrumented log corn yield. All dollar amounts are in real (2010) dollars. Standard errors are given in parentheses, and are clustered at the year level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. All regressions include an intercept term (not reported). The crisis period in Panel A runs from 1984 to 1987, while the Non-crisis period in Panel B runs from 1975-1980 and from 1988-2000.

<i>Panel A: Crisis</i>			
	(1)	(2)	(3)
Sector:	Agricultural Crop Production		
Dep. Variable:	<i>Ag Employment</i>	$\log(\text{Ag Avg Wage})$	$\log(\text{Ag Total Wages})$
$\log(\widehat{Yield})$	29.955** (14.725)	2.866** (1.360)	4.368** (2.005)
Year FE	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Observations	396	396	396
R ²	0.662	0.748	0.740

<i>Panel B: Non-Crisis</i>			
	(1)	(2)	(3)
Sector:	Agricultural Crop Production		
Dep. Variable:	<i>Ag Employment</i>	$\log(\text{Ag Avg Wage})$	$\log(\text{Ag Total Wages})$
$\log(\widehat{Yield})$	-6.386 (7.147)	1.130 (0.918)	1.419 (1.175)
Year FE	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Observations	1,875	1,875	1,875
R ²	0.370	0.436	0.454

Table 7: Wages and Employment in the Services Sector

This table provides second-stage instrumental variables regression results for the effects of temperature shocks on wages and employment in the services sector during the farm debt crisis and non-crisis years. All variables represent county-level values in the indicated year. *Services Total Wages* is the sum total of all wages for the services sector. *Services Avg Wage* is the average annual wage for an individual in the services sector. *Services Employ* is the total employment in the services sector. *Services Estabs* is the number of establishments in the services sector. $\log(\widehat{Yield})$ is instrumented log corn yield. All dollar amounts are in real (2010) dollars. Standard errors are given in parentheses, and are clustered at the year level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. All regressions include an intercept term (not reported). The crisis period in Panel A runs from 1984 to 1987, while the Non-crisis period in Panel B runs from 1975-1980 and from 1988-2000.

Panel A: Crisis

	(1)	(2)	(3)	(4)
Sector:	Services Sector			
Dep. Variable:	<i>Services Employ</i>	$\log(\textit{Services Avg Wage})$	$\log(\textit{Services Total Wages})$	<i>Services Estabs</i>
$\log(\widehat{Yield})$	-720.705*** (106.572)	0.075** (0.033)	-0.002 (0.045)	-41.349*** (8.079)
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Observations	396	396	396	396
R ²	0.997	0.970	0.998	0.999

Panel B: Non-Crisis

	(1)	(2)	(3)	(4)
Sector:	Services Sector			
Dep. Variable:	<i>Services Employ</i>	$\log(\textit{Services Avg Wage})$	$\log(\textit{Services Total Wages})$	<i>Services Estabs</i>
$\log(\widehat{Yield})$	-158.728 (715.692)	0.074 (0.098)	0.063 (0.159)	-1.727 (45.914)
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Observations	1,875	1,875	1,875	1,875
R ²	0.916	0.317	0.868	0.999

Figure 1: Response of Corn Yields to Temperature

This figure, taken from Schlenker and Roberts (2006), shows the response of corn yield to temperature during the growing season. The curve represents the impact of one day of exposure of the indicated temperature on yearly log yields, relative to a temperature of 8°C.

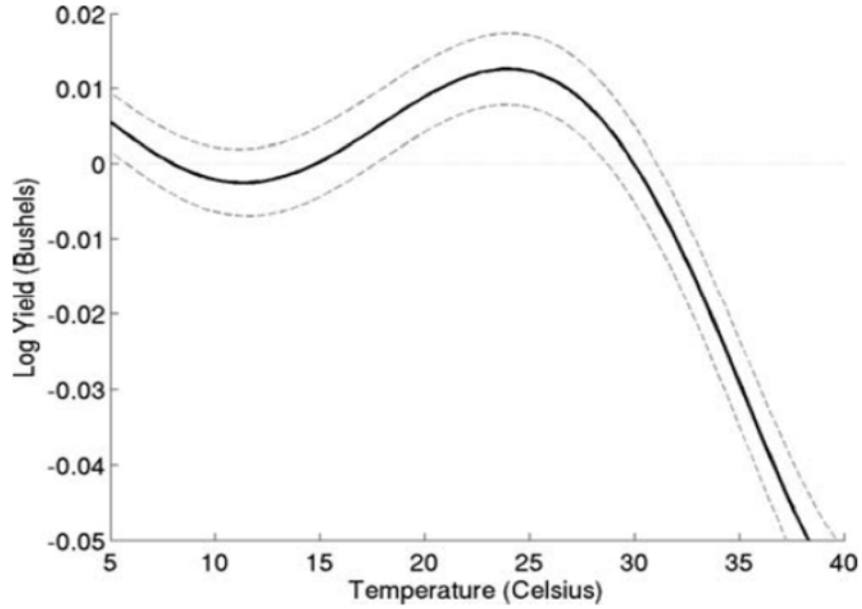


Figure 2: Distribution of Temperature Shocks

This figure shows the distribution of temperature shocks during the growing season, for the entire sample from 1950 to 2010. The vertical axis represents the density, while the horizontal axis gives the number of days in the growing season for a given county-year that were above 83 degrees Fahrenheit.

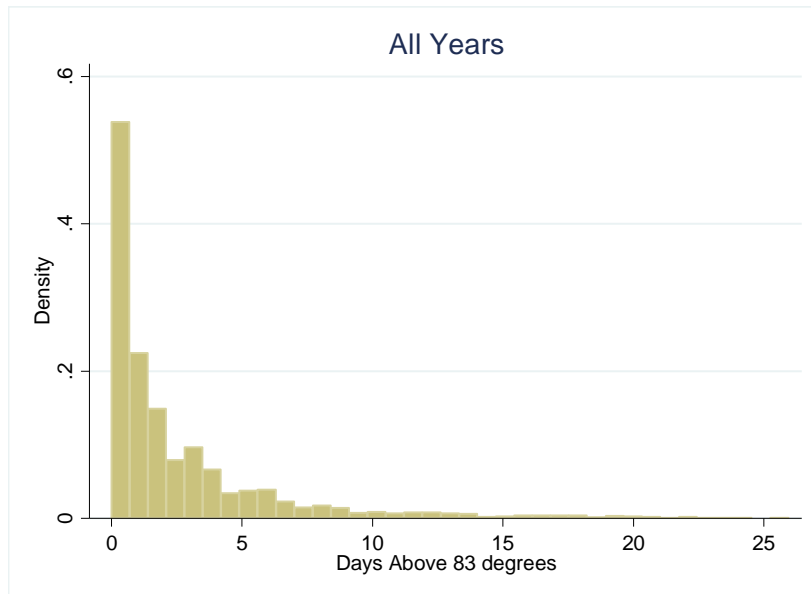


Figure 3: Distribution of Temperature Shocks in Excess of Averages

This figure shows the distribution of temperature shocks during the growing season, in excess of county and yearly averages, for the entire sample from 1950 to 2010. The vertical axis represents the density, while the horizontal axis gives the de-meanned number of days in the growing season for a given county-year that were above 83 degrees Fahrenheit.

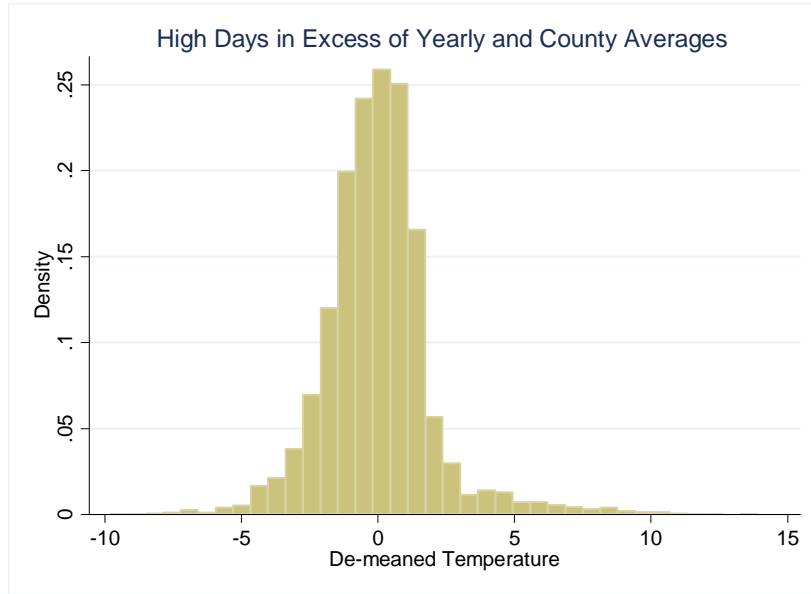


Figure 4: Distribution of Temperature Shocks in Different Years

This figure shows the distribution of temperature shocks during the growing season, for various years. In each graph, the vertical axis represents the density, while the horizontal axis gives the number of days in the growing season for a given county in the indicated year that were above 83 degrees Fahrenheit.

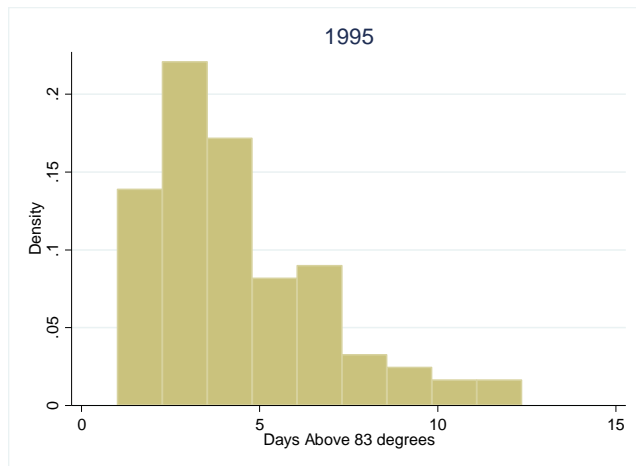
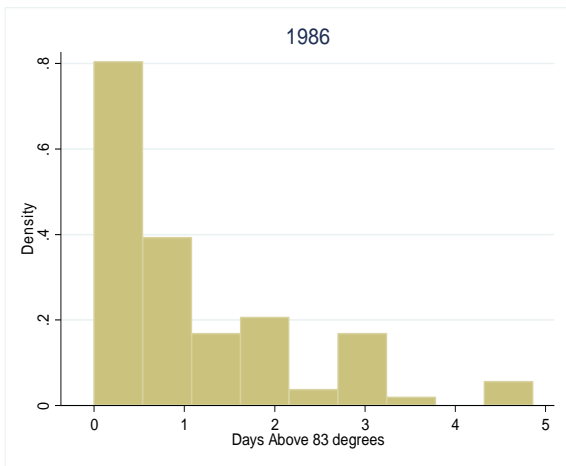
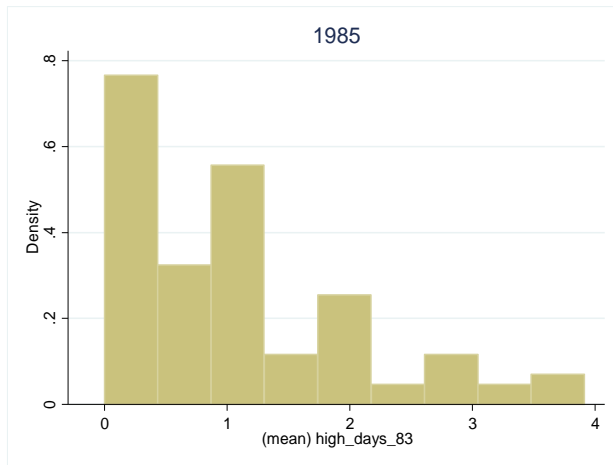
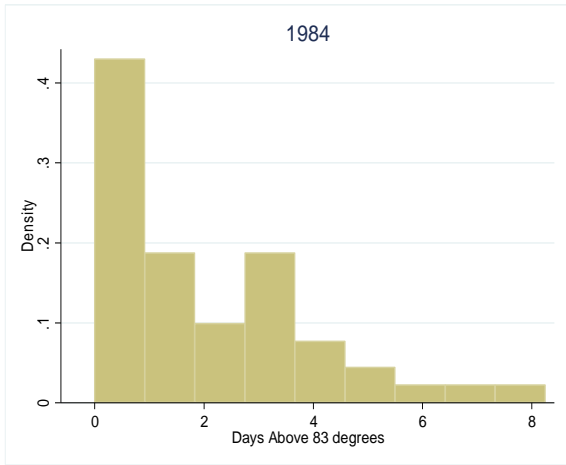
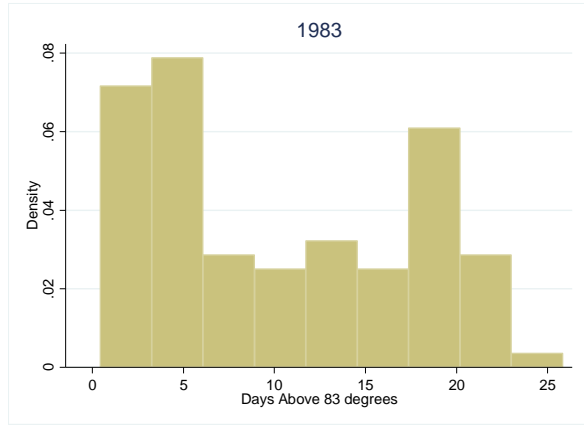
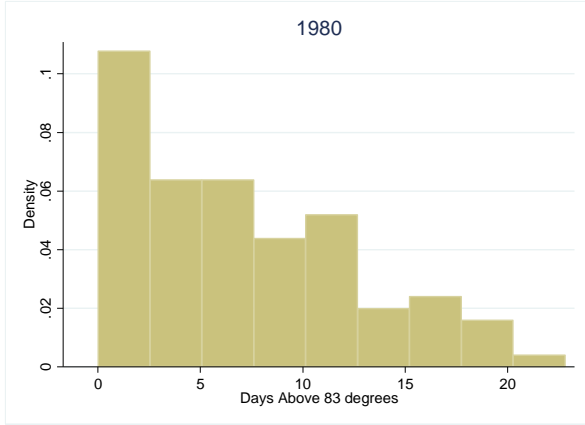


Figure 5: Corn Yields, Farm Land Values, and Agricultural Debt over Time

This figure depicts average corn yields, land values, and agricultural debt over time. Each data point is an average across all counties in Iowa. Corn yield is defined as bushels of corn produced per acre of harvested land. Land Value is the dollar value of farmland per acre, in real (2010) dollars. Total agricultural debt is the sum of agricultural loans to finance production and real estate debt secured by farmland, in real (2010) dollars.

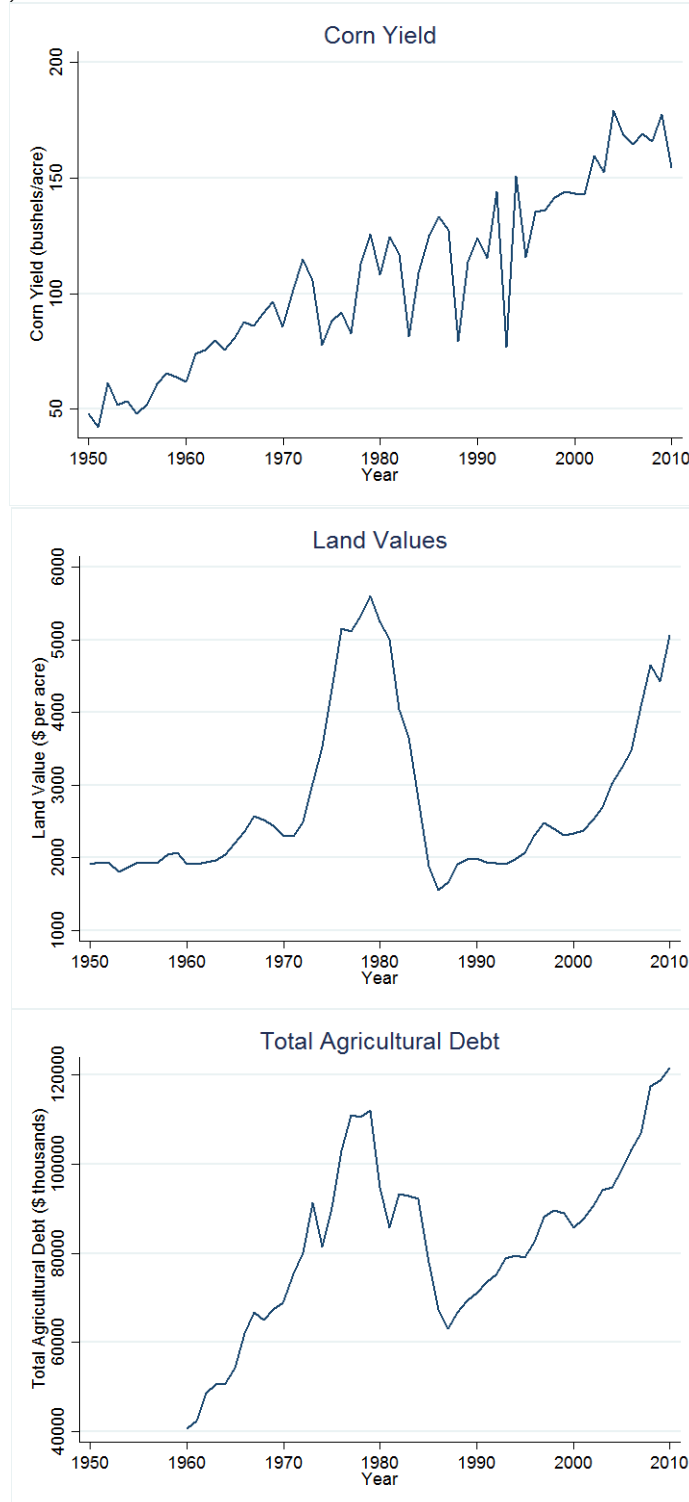


Figure 6: Employment and Wages in the Agriculture and Services Sectors

This figure gives total employment and total wages over time for the agricultural crop sector (top graph) and the services sector (bottom graph). Each data point represents the sum of employment or wages across all counties in Iowa. Wage numbers are in millions of real (2010) dollars.

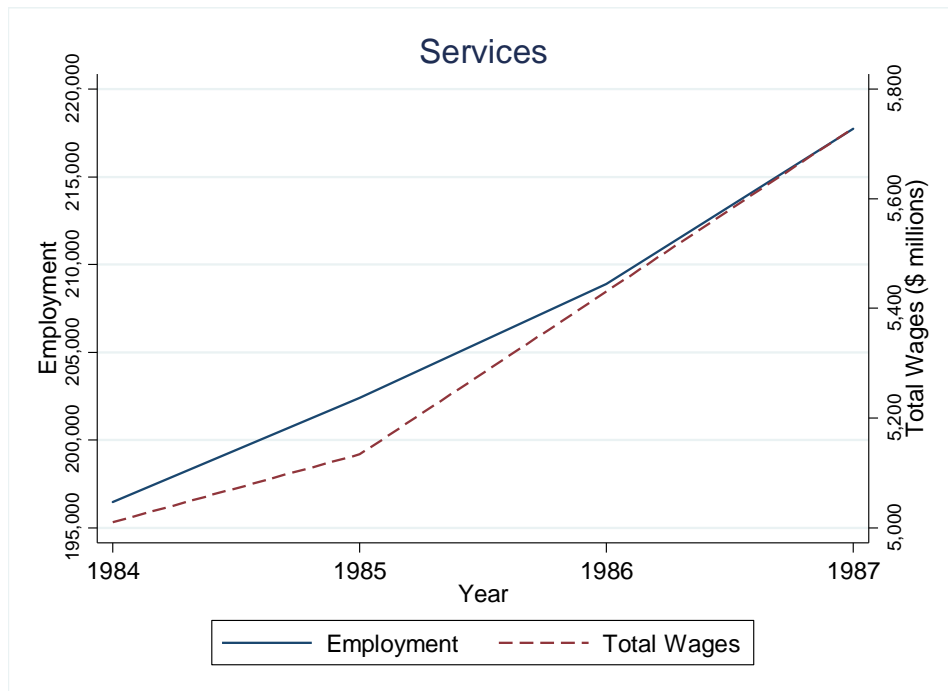
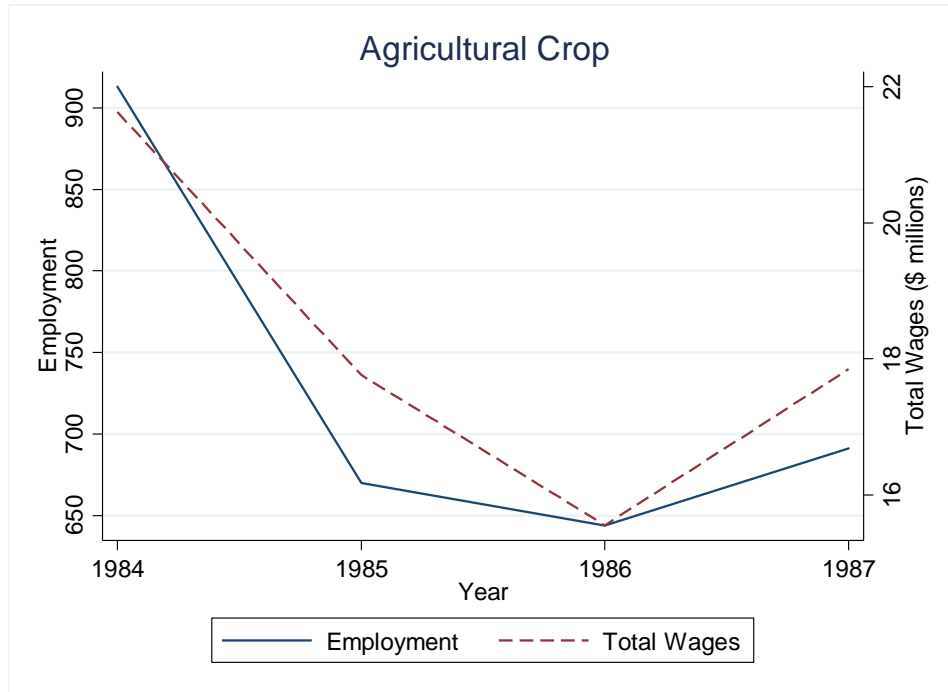
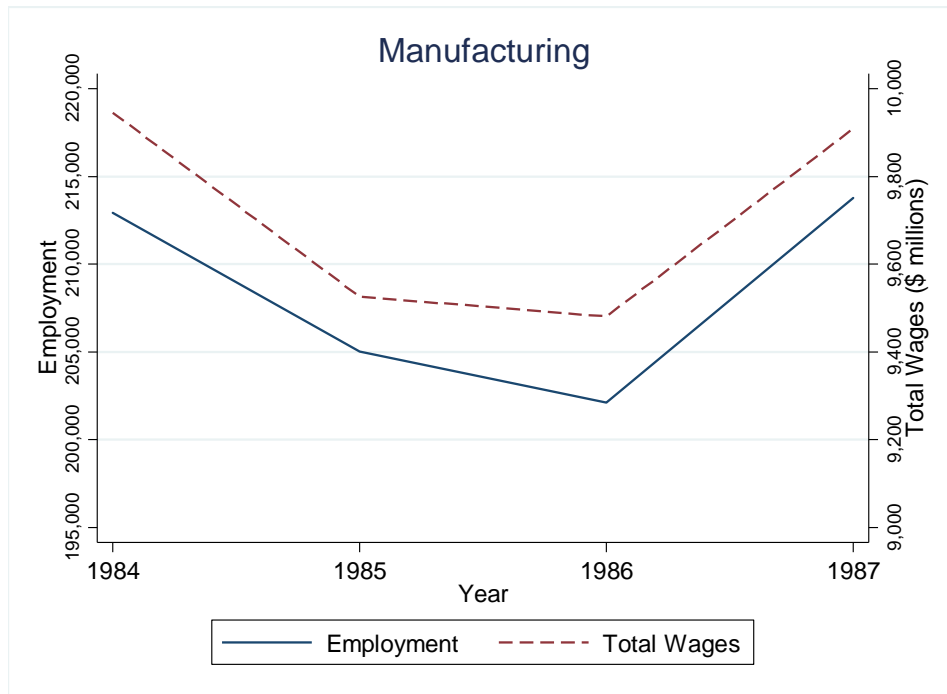


Figure 7: Employment and Wages in the Manufacturing Sector and in All Sectors

This figure gives total employment and total wages over time for the manufacturing sector (top graph) and all sectors (bottom graph). Each data point represents the sum of employment or wages across all counties in Iowa. Wage numbers are in millions of real (2010) dollars.



Appendix

Table A1: Robustness, July Temperature

This table provides robustness results for the effects of temperature shocks on corn yields during the farm debt crisis. All variables represent county-level values in the indicated year. *Corn Yield* is defined as bushels of corn produced per acre of harvested land. *Avg Temp July > 77* is a dummy variable that equals to 1 if the average temperature in July is above 77 degrees Fahrenheit, and 0 otherwise. Standard errors are given in parentheses, and are corrected for spatial correlation (as in Conley, 2008), as indicated. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. All regressions include an intercept term (not reported). Results are run from 1981 to 1987.

Dependent Variable:	log(<i>Corn Yield</i>)	log(<i>Corn Yield</i>)
<i>Avg Temp July > 77</i>	-0.139** (0.056)	-0.019* (0.010)
Year FE	Yes	Yes
County FE	Yes	Yes
Standard Errors	Spatial	Spatial
Observations	693	693
R ²	0.655	0.995