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Climate Variability and Agricultural Loan Delinquency in the US

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Abstract

Inter-annual climate variability in the Southeastern US that affects farm productivity and cash flows is largely dependent on the predictable El Nino Southern Oscillation (ENSO) phenomenon. In this paper, we estimate the association between the ENSO anomalies and the performance of agricultural loan portfolios of the Farm Credit System (FCS) institutions - the largest agricultural lender in this region. We find that, compared to neutral years, the share of delinquent loans in the FCS portfolio decreases by 1.5 to 2 percentage points following La Nina years and increases by 1.5 to 2 percentage points following El Nino years. These delinquencies are generally resolved because the impact on loan write-offs is much smaller, although statistically significant which suggests that the FCS institutions have well-diversified portfolios. The results also suggest that agricultural insurance markets are complementary to credit markets, that land values at loan origination have a positive impact on delinquencies, and that loan write-offs decrease with the lender's size.

Keywords: loan delinquency and default, farm credit system, climate variability and climate change, ENSO, farm debt, Southeastern USA

1. Introduction

Increased frequencies of the El Nino Southern Oscillation (ENSO) anomalies related to climate change have increased the incidence of extremes in temperature and precipitation (The Economist, 2010) (Note 1). The resulting draughts and floods affect crop production and disrupt farmers' cash flows which has negative consequences for loan repayment patterns of highly leveraged producers. These impacts would be reflected in measurable changes in the delinquency rate of loan portfolios of the lenders specializing in agricultural lending. This paper evaluates the extent to which the loan portfolios of the Farm Credit System Institutions - a cooperative system of lending institutions serving US farmers, ranchers, and others in rural areas - is affected by weather shocks measurable by the ENSO anomalies**.**

It is believed that advanced economies are relatively less vulnerable climate variability due to greater availability of financial tools and other risk management strategies (Kahn, 2005). Indeed, farmers and financial institutions in the US use numerous risk management tools to mitigate risks including that related to the changing climate. Farmers, can change profit maximizing crop mix under the new climate patterns (Mendelsohn, Nordhaus, & Shaw, 1994) or adopt new crop varieties resistant to weather extremes (Olmstead & Rhode, 2011). However, there is evidence of high sensitivity of US crop yields to extreme heat, in spite of the introduction of new genetic traits and improvements in infrastructure (Roberts & Schlenker, 2011; Burke & Emerick, 2016). Moreover, measurable improvement in heat tolerance seems to be achieved at the cost of average yield reductions, which is likely to affect farmers' cash flows and thus loan repayment (Schlenker, Roberts, & Lobell, 2013).

Financial theory suggests that banks successfully diversify risks within their loan portfolios, producer subsidies support mechanisms help mitigate the adverse shocks including those caused by climate change. Theoretical work has also highlighted the importance of well-developed complementary insurance markets. Garmaise and Moskowitz (2009) argue that imperfect insurance markets (e.g. non-competitive markets) restrict the provision of bank credit and prevent undertaking positive net present value projects by less wealthy entrepreneurs and thus affect economic growth in disadvantaged areas exposed to catastrophic risks. The authors offer supporting evidence of economic impacts of hurricanes, earthquakes, and other extreme events. In the US, agricultural insurance markets are subsidized and thus not fully competitive. Evaluating if weather shocks directly affect loan delinquency in the portfolio of a major agricultural lender, therefore, is an important empirical question the answer to which can help to establish whether agricultural credit and insurance markets are relatively well-developed and complementary.

Our approach is related to the emerging empirical literature that relates bank lending to extreme weather events. For example, Ewing, Hein, and Kruse (2005) examine community bank performance in hurricane and tornado prone areas. Community banks are similar to agricultural lenders because they are less geographically diversified and face high systemic, location-specific, risks. Their results show regional differences in bank performance shortly after a catastrophic event. The most important finding was that, after an event, the affected banks did better than the non-affected ones and the gain in performance depends on the severity of the event, suggesting a role for the complementary financial markets.

There are empirical studies linking weather variability and loan portfolios of community banks. For example, during La Niña phases, community banks in the southeastern U.S. issue lager and more numerous agricultural production loans than in neutral years suggesting ENSO impact on the demand for agricultural loans (Nadolnyak & Hartarska, 2010) which is consistent with Garmaise and Moskowitz (2009). There is also evidence that delinquencies in the portfolios of agricultural banks are related to weather shocks that can be predicted by the ENSO realizations (Nadolnyak & Hartarska, 2013). However, these studies did not control for the possible impact of relevant insurance markets or for the use of other risk management tools.

This paper evaluates the portfolios of the main competitors of agricultural banks - the institutions comprising the Farm Credit System which also represent the largest agricultural real estate lender in the US and in the region. The Farm Credit System is a cooperative network of borrower-owned lending institutions that specialize in lending and related financial services to farmers, ranchers, and aquaculture. For the purpose of this study, we evaluate the lending portfolio of 33 Agricultural Credit Associations operating in the Southeast United States.

The southeastern region is chosen because the ENSO deviations there have one of the strongest impacts on temperature and precipitation extremes (Halpert & Ropelewski, 1992; Higgins et al., 2002) and because significant ENSO impacts on yields have been documented by agronomists (Mourtzinis, Ortiz, & Damianidis, 2016; Royce, Fraisse, & Baiggorria, 2011; Lobell & Asner, 2003) (Note 2). While the ENSO impacts differ among crops, experimental field data suggest that yields are usually higher in neutral years and lower in El Niño years due to freezes and excess moisture, whereas La Niña years are beneficial for some crops, e.g., corn and peanuts, and harmful for others, e.g., cotton (Lobell, Schlenker, & Costa-Roberts, 2011; Shin et al., 2010; Martinez, Baigorria, & Jones, 2009; Baigorria et al., 2008). Our analysis of agricultural loan portfolios, accounts for the fact that farmers can adapt their crop mix, chose different level of insurance, and otherwise hedge their risks or rely on government payments in case of a disaster (Nadolnyak & Hartarska, 2011). In addition, mostly rain fed crop production in the region makes agriculture more vulnerable to weather variability and appropriate for studying weather impacts on the portfolios of agricultural lenders (Note 3).

Our paper makes several contributions. First, we study a region with a known strong impact of the ENSO phases on inter-annual climate realizations. The ENSO forecasts are typically announced prior to planting and lending but, as far as we know, neither producers nor lenders used this information explicitly during the study period. If a link between the ENSO and the agricultural loan portfolio performance is detected, farmers may improve their risk mitigation strategy and lenders can take measures to improve loan provision and to avoid excessive delinquencies. Second, our approach allows farmer adaptation and in fact assumes that farmers used risk management tools to adapt and withstand weather extremes by choosing their crops mix. Thus, by measuring changes in delinquency patterns in specialized agricultural lenders from related borrowers' cash flow disruptions, we indirectly measure the impact of climate variability through weather shocks on farming. Third, we explicitly control for the use of insurance by farmers and thus can show indirectly if insurance markets are complementary to agricultural lending are well-developed. Next, since we examine the portfolio of a major specialized and, to some extent, subsidized agricultural lender, the Farm Credit System Institutions, we are able to evaluate to what extent they meet their charter stipulations to serve farmers and ranches in the region that is not particularly wealthy. Since we look at both delinquency and default patterns we can tell not only whether climate variability affects farming (if a link to ENSO is detected on delinquency) but also if the lender's losses are avoided or are small, which would justify continuous support for this 100-year old specialized financial institution. Finally, by using panel data we are able to address a lot of criticism present in the climate impact literature pointing out that weather impacts are attributable to omitted variables related to the individual lenders or regional characteristics.

Our results show that climate variability measured by several ENSO indexes is linked to delinquency of the FCS loans, suggesting that climate variability continues to affect the US farming in spite of improvements in crops variety, technology, and infrastructure. In particular, relative to neutral years, El Nino years are associated with higher 1.5 percentage points higher, while La Nina year are associated with 1.5 percentage points lower delinquency rates of loans overdue 30 days. We also find that the FCS institutions were successful in diversifying their risks because, relative to neutral ENSO years, El Nino years were associated with only 0.08 percent point increase in write-offs while and La Nina years were associated with 0.51 percent decrease in write-offs. The results also suggest that agricultural insurance markets in the US are complementary to agricultural credit markets in that delinquency and defaults are negatively affected by the farmers' use of insurance.

The policy implications of this work are important as both the FCS institutions and producers that borrow from them could benefit from the ENSO forecasts if the performance of agricultural portfolios of the Agricultural Credit Associations or the ACAs is affected by the ENSO. If there is such an impact, the FCS and other financial institutions could use climate forecasts to improve on contract terms and introduce expected loss provisions while borrowers could incorporate the forecasts in production and risk management practices. Moreover, such links would indicate the degree to which the producers' financing needs are met by the existing financial markets and support mechanisms and of how the weather risks are absorbed by the financial system.

The rest of the paper is organized as follows. Section 2 describes the empirical analysis framework. Section 3 contains data description. Section 4 presents discussion of the results, followed by the conclusion.

2. Empirical Model

The ENSO events (La Nina, EL Nino and their strengths) are early predictors of expected extreme weather. As an exogenous factor affecting crop yields, weather affects farmer's cash flows and potentially loan repayment such as delinquency and defaults on agricultural loans. The effect is likely to be mitigated by adequate insurance and other support mechanisms available to farmers. Our main hypothesis is that the ENSO cycle/events, by influencing the short-run climate outcomes, are associated with loan delinquency and default measured by the shares of non-performing loans in the portfolios of the Agricultural Credit Associations (ACAs) within the Farm Credit System. Specifically, we evaluate if loan delinquency and default are affected by the ENSO events (climate variability measures) controlling for farmers use of crop insurance.

Agricultural (production) loans include crop production loans as well as loans for animal production and other loans which are less likely to be affected by weather. Therefore, there is a need to carefully select measures of loan delinquency and default as well as to identify the period when these loans' performance is likely to be recorded in the quarterly balance sheet data. Nadolnyak and Hartarska (2010) suggest and Nadolnyak and Hartarska (2013) use only defaults on real estate backed loans because they are more likely to be loans for crop production and thus are more affected by the weather. However, until 2005, the FCS did not collect detailed data on loan delinquency and default by loan type. The data available since 2005 shows that about 66% of the loans granted by the ACAs are real estate backed loans. Therefore, we believe that it is reasonable to assume that for the study period 2000-2010, the total nonaccrual loans overdue more than 30 days, 90 days, and total loan charge-offs are reasonable measures of real estate backed loan performance within the ACAs' portfolio which is likely to be affected by weather variability. Potential measurement error due to loans to animal producers remains an issue. We note, however, that non-crop loans are randomly given during the year while crop production loans are very seasonal. Thus we chose to use only quarterly data that reflect the time when seasonal crop production loans become due based on our conversations with the ACAs personnel (Note 4).

Delinquency and default (real estate backed and other long and medium term) loans that can be either strategic or due to inability to repay are assumed to be related to weather related risks. Strategic default occurs when the value of collateral falls below the value of the remaining (mortgage) loan balance. In empirical work, such cause for default is typically captured by the default option value or by farmland value and interest rates for all of which we control in the estimation. Non-strategic loan delinquency is due to inability to repay and typically results from shocks such as loss of income (Hartarska & Gonzalez-Vega, 2005, 2007). Aside from weather related events, non-strategic loan delinquency and default may be caused by shocks such as illness, death, or divorce but we assume that on the aggregate level these risks are minimal due to diversification within the agricultural loan portfolio of the Agricultural Credit Association which is the unit of observation out our analysis. Therefore, we model loan delinquency and default as a function of the main delinquency factors and the exogenous impact of weather captured by the ENSO events and controls.

The empirical model is as follows:

$$D_{i,t} = \beta_0 + \beta_1 ENSO_{t-g} + \beta_2 LandValue_{i,t} + \beta_3 LandValue_{i,t-g} + \beta_4 New\ Loan_{i,t-g} + \beta_5 Insurance_{i,t-g} + \beta_6 Control_{i,t-g} + v_i + \varepsilon_{it} \quad (1)$$

where $D_{i,t}$ measures loan delinquency or default in an ACA *i* in quarter *t* and *g* is the lag used for different default measures (30 days, 90 days, and write-offs discussed in the data section). Agricultural production loans are seasonal and most loans are generated in the quarter before the growing season (first quarter). While the ACAs offer flexible loan contracts to match the cash flow of various types of farmers, we use the relevant lags related to that seasonality to capture the impact of ENSO phases on crop production and loan delinquency. As crops are harvested and sold in the fall, crop production loans are repaid in the first quarter of the following year. Communications with the southeastern ACAs personnel made it clear that crop production loans typically become due in February or March and will first show as overdue 30 days at the end of the first quarter financial statements (Note 5). These loans will be 90 days overdue in the second quarter financial statement in June and charged off in the following statements in September. Thus, we use the corresponding subsamples of financial statements from March, June, and September to study delinquency of 30 and 90 days and charge-offs respectively (Note 6).

The ENSO indexes proxy inter-annual climate variability as agronomic literature suggests they capture the impact of weather on farming in the Southeast. In particular, we use the Japan Meteorological Agency (JMA) index and the Multivariate ENSO Index (MEI). The first index is composed of three-month running means of the Sea Surface Temperature anomalies (mean deviations) recorded in Nino3 areas of the Pacific. The second index which is a composite computed on a sliding bi-monthly basis and is based on sea surface temperature, sea-level pressure, zonal and meridional components of surface wind, surface air temperature, and total cloudiness fraction of the sky over the tropical Pacific region. This index is considered a very good predictor because it is based on multiple climactic parameters. We use the MEI values during the crop growing season (Note 7).

We use categorical annual ENSO indexes for the relevant quarters in the year preceding delinquency because agricultural production loans are issued prior to the growing season. The loan repayment schedules usually match farmers' repayment capacity determined by output value of output and the timing of the cash flows from sales. A loan becomes non-performing, or is written off, only after it is classified as delinquent for 30 days and then for 30-90 days. Therefore, possible weather related impact on loan performance is observed only in the first quarter of the year following the growing season, hence our use of corresponding lags for the ENSO variables.

To summarize, the first index, JMA, is defined as a categorical dummy variable to identify the different phases of ENSO events during the growing season of the study period in the year preceding March and June delinquency and September write-off, while the MEI index is continuous and derived from several observed variables. The MEI index is averaged over the growing season and three months before it which closely corresponds to the ENSO year.

During the study period, producers have had access to several risk management tools. Since theory shows that the effect on financial institutions lending depends on complementary insurance markets level of development (efficient or not), we control for these factors. The availability and use of subsidized crop insurance and other support programs reduces yield and income volatility and may indirectly affect agricultural lenders. These factors are controlled for in our analysis by including *Indemnity,* which measures the payment that producers received based on the insurance policies, and the insurance coverage (*Coverage ratio*) chosen by the agricultural producers given the previous ENSO conditions (Note 8).

Garmaise and Moskowitz (2009) theoretical work suggests that with imperfectly (perfectly) competitive insurance markets, credit is decreasing with (independent of) the weather risks in terms of both number of loans and dollar amount. We analyze 3 data subsamples matched to the quarters when crop production loans may become overdue. We assume that loans to finance livestock production are independent of the weather risks affecting crop producers, thus their number is stable across seasons and balance sheet quarters. In the relevant quarters, we control for the quarterly variations in loan volumes extended by each ACA by including the *Number of New Loans.* It also controls for a potential measurement error in the total loan performance because, ceteris paribus, when an ACA extends new loans, the overall risk level increases.

Strategic defaults are not typical in agricultural production loans, but we control for the *land* values nevertheless. We also include the lagged land values as they proxy for the impact during the period of production loan origination when farmland is appraised as collateral. Farmers may sell land not used as collateral to repay their loan depending on land prices, but overvalued appraisal at loan origination may lead to default and bank repossession of the land with lower current value. Recent studies of agricultural bank performance find that current and previous years' land values are the main indicator of bank losses pointing out to strategic default (Briggeman, Gunderson, & Gloy, 2009).

Other control variables include ACAs' assets (*FCS asset*) to control for scale economies, annual interest rate level to control for the price of capital, and the number of farms within a state to control for the loan demand each year. While the prices of the farm outputs, crops and livestock products, and the price of farm inputs, such as fertilizer, fuel and machinery, could be included to control for the price risks, they are highly collinear. We control for price risks instead by including the farm input-output price index ratio as well as annual dummies.

3. Data

The data on the loan performance used in this research comes from the Farm Credit System and is for the period from 2000 to 2010. All ACAs serving southeastern states whose weather is affected by the ENSO events are included in the sample and include Alabama, Georgia, Florida, Louisiana, Mississippi, and South Carolina (Nite 9). The final data set contains 33 institutions and 301 quarterly observations per subsample (Note 10). Variable summary statistics are presented in Table 1. The average assets of the ACAs which serve the southeastern U.S. are $324 million, ranging from $3.8 million to $1,594 million. The ACAs in our dataset have an average portfolio of $297 million with 1.5% of the loans 30 day past due, 0.64% past due over 90 days, and 0.05% of the total loans charged off (written off). It is assumed that the ACAs make the decision to grant new loans based on their expectation of the risk return characteristics of each new loan and the number of new loans.

Table 1. Summary statistics

Variable	Mean	Std. Dev.	Min	Max
Loan Delinquent >30 days (%)	1.49	1.65	0	11.13
Loan Delinquent >90 days (%)	0.64	0.98	0	6.54
Total Loan Charge offs (%)	0.05	0.19	-0.04	2.22
Non Real Estate Loans (%)	63	35.71	0	100
Real Estate Loans (%)	66	26.34	0	100
Total Loans (US$ Millions)	297	263	0.59	1,494
Total Assets (US$ Millions)	324	284	3.76	1,594
Land Value (US$ Billions)	2,071	1,183	754	5,640
Number of Farms in State (Millions)	41	8	24	51
Coverage Ratio (state level)	0.87	0.59	0.08	2.15
Indemnity (US$ Millions, state level)	51	53	5	335
Farm output Price /Input Price	87	7	74	98
Interest Rate Index (1991=100)	111	17	87	147
Number of New Loans (`000)	149	856	-1,641	9,824
JMA Cold La Nina	0.13	0.34	0	1
JMA Warm El Nino	0.24	0.43	0	1
MEI (Feb-Aug)	0.46	0.69	-0.71	1.61
MEI^2	0.69	0.90	0	2.59

In the summary statistics data, we present loan performance by type: real estate backed and non-real estate backed loans. These series start only in 2005 so the number of observations is reduced to 76 for the 17 ACAs. For the sub-sample period of 2005-2010, for which we do not estimate regressions, we note that the majority of the loans are real estate (66%). Therefore, it is appropriate to use total loans and their delinquency and default rates as dependent variable for the study period 2000-2010 to capture the effect of the ENSO. In fact, our data also show that 63% of the nonperforming loans are real estate backed loans for the sub-period and at least 25% of the observations have registered only real-estate backed loans as nonaccruals. Thus, we assumed that delinquency and default have had the same pattern for the whole study period and that the majority of the nonperforming loans before 2005 come from real estate backed loans (even if nonperforming loans contain loans not affected by the ENSO events). We further improve on this assumption by controlling for the number of new loans. With this variable measure we control for the theoretical aspect relating loan initiation to complementary insurance market efficiency because the different Farm Bills pertinent to the study period have had different impact on the use of agricultural insurance by providing different subsidy levels and withdrawing traditional subsidies in some years. That is why annual dummy variables may capture some of the complimentarity of the crop insurance markets.

The impact of the farmer demand for insurance is measured by the state level insurance coverage measured as percentage of crop acreage covered by an insurance plan (percent of total crop area covered by crop insurance), matched to the states of ACA’s headquarter (Note 11). This ratio is on average 0.87, and ranges from 0.08 to 2.15.

The actual payment by insurance companies on state level is also included in the specification. Summary statistics shows an average of $51 million paid in indemnities per state, with a range from 5 million to 335 million.

The two measures of the strength of ENSO events include a set of dummies for the JMA index and one set of continuous variables for the MEI index. The data shows that, during the period of 2000-2010, 63% of the observations with the JMA index were from *Neutral* years, 24% from *El Nino* years, and 13% from *La Nina* years.

The rest of the other control variables come from the USDA NASS database. They include the annual interest rate to measure the cost of capital which affect loan demand, and the state level number of farms to measure potential demand for agricultural loans.

4. Discussion of Results

This paper differs from existing work that links climate variability to delinquency and default on agricultural loans because it is focused on a US region where the literature shows that crop production is particularly susceptible to ENSO related weather variability. Furthermore, this is an area where crop production is mostly rain-fed, making it more susceptible to extreme temperature and precipitation. More importantly, we control for the impact of complementary agricultural insurance markets through the use of state level insurance coverage levels and indemnities paid. These specification improvements complicate direct comparison with previous work evaluating the impact of weather indexes on farm profitability or agricultural banks' portfolios and of hurricanes on community banks because the role of the insurance markets was not taken into account.

We estimate a fixed-effects model, with standard errors clustered by state and year dummies. This specification addresses concerns for omitted variable bias and ACAs heterogeneity (Note 12). The main hypothesis that we test is that weather shocks affect farmers' yields and thus cash flows and can show as changes in the delinquency and defaults on agricultural (crop) production loans in the Farm Credit System Institutions' portfolios. Thus, we expect that the weather variation by the ENSO anomalies, as captured by the indexes, will be positively (or negatively) associated with agricultural loan delinquency and possibly default relative to a neutral (base) year in a regression that controls for crop insurance and strategic default.

Table 2 presents the results from regressions where the dependent variables are percentage of loan portfolios past due 30 days, past due 90 days or more, and loan charge-offs. The impact of the ENSO phases is measured here by the categorical annual (November to October) JMA index with the neutral years serving as the base.

Table 2. Fixed effects regressions of loan delinquency and default with the JMA ENSO index

Variable	Loans past due 30 days	Loans past due 90 days	Loans Written off
JMA Warm El Nino	1.4998**	0.0426	0.0846**
	(0.4973)	(0.5896)	(0.0288)
JMA Cold La Nina	-1.5269*	-0.8888	-0.5139*
	(0.6498)	(0.5715)	(0.2084)
Lag FCS Asset	0.0010	0.0009	-0.0011**
	(0.0034)	(0.0026)	(0.0004)
Land Value	-0.0006*	-0.0004	-0.0000
	(0.0003)	(0.0002)	(0.0000)
Lag Land Value	0.0012**	0.0012***	0.0001
	(0.0003)	(0.0003)	(0.0000)
Number of Farms	83.3013	-35.5181	7.0086
	(65.5083)	(51.5720)	(6.7065)
Coverage Ratio	-0.1959	-0.6560*	-0.0659*
	(0.3819)	(0.2597)	(0.0278)
Indemnity	-0.0072***	-0.0063***	-0.0006**
	(0.0011)	(0.0013)	(0.0002)
Farm Output/Input Price Ratio	-0.1376**	-0.0789**	-0.0340*
	(0.0424)	(0.0230)	(0.0147)
Interest Rate	-0.0097	-0.0069	0.0087**
	(0.0371)	(0.0336)	(0.0033)
Number of New Loans	0.2834**	0.1723*	0.0001
	(0.0820)	(0.0691)	(0.0044)

Constant	11.5280	9.6372	2.4200
	(5.8985)	(5.3918)	(1.5301)
Year Dummy	Yes	Yes	Yes
Observations	301	299	292
R-squared	0.4581	0.4922	0.4504
Number of UNINUM	32	32	32

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Overall, the results show that, in the Southeast, ENSO events affect loan repayment on the ACAs' agricultural loans. As expected, the economic impact is relatively small for several reasons. First, individual ACAs likely had well diversified loan portfolios with good maturity management with crop production loans comprising only a part of their diversified portfolios. Next, to certain extent farmers may be using some sort of long-term weather forecast, such as The Old Farmer's Almanac forecasts prior to planting to improve their production/business risk. Third, farmers are likely to mitigate their risks through access to various sources of cash flows, as well as adequate crop insurance. Typically, farmers do not like debt and avoid it and farmers who do borrow are highly leveraged (Note 13). Thus, we expect delinquency to be associated with weather deviations simply because high leverage increases the risk of running short of cash given unexpected shocks.

The most direct result that we expect to see is on the delinquency measured by loans past due 30 days. For the annual JMA index, Table 2 shows that, compared to neutral years, the delinquency rate was 1.5 percentage points lower following La Nina years and 1.5 percent point higher following El Nino years. These results seem significant since the average delinquency rate is 1.5 percent so there is a distinct variation in this variable that is attributed to the ENSO realization alone. The results are consistent with previous findings from agricultural banks' data analysis (Nadolnyak & Hartarska, 2013). Typically, after a loan is identified as past due, the lender can work with the borrower to restructure the loan or to take actions to recuperate the money (by selling the collateral); finally, if there is no path to cover the losses, the lender can write off (charge off) these bad loans. In line with this reasoning, the results show that, relative to neutral years, La Nina or El Nino years did not result in more loans classified as past due 90 days or more, possibly because lenders were trying to resolve the non-payment and borrowers were looking for ways to repay. However, we find that loan write-offs increased by 0.08% following El Nino Years and decreased in by 0.51% after La Nina years relative to the loans written off after a neutral year. These are relatively small changes (and the average charge-off rate is only 0.05) but they are statistically significant. The results show that, while the Agricultural Credit Associations of the Farm Credit System are doing a good job diversifying their portfolios, ENSO phases still have an impact, albeit relatively small.

Regressions using the continuous MEI index are presented in Table 3. Both MEI and MEI^2 are used in order to capture non-linear impacts. The MEI index varies from -2 (the strongest La Nina years) to 2 (the strongest El Nino years). The results from Table 3 suggest that larger values of the MEI index are associated with more delinquent loans, consistent with the JMA results. We find that a change in the index from zero to 1 (neutral to El Nino) is associated with 2.2 percent point higher delinquency rate following El Nino growing season and, similarly, a change from La Nina to neutral (-1 to 0) would be associated with 2.2 percent point increase in delinquency rates (relative to La Nina year), measured by loans delinquent 30 days or more. This result is broadly consistent with the JMA index result but it is a bit larger in magnitude. The results for the loans past due 90 days or more show, however, that the relationship may be non-linear. We find that delinquency increases up to the index value of about 0.7 (El Nino) and then decrease. One possibility is that very strong El Nino years may be triggering insurance payments that are sufficient to help borrowers to cover their losses and repay their loans while more moderate values of the index affect delinquency mroe. Similarly, we also find that the percentage of loans written off increases from La Nina through Neutral years and then drops after the 0.7 value of the index confirming the results on loans overdue 90 days or more. This nonlinear impact corroborates the findings of Deschênes and Greenstone (2007) and Schlenker, Hanemann, and Fisher (2005) regarding the impacts of weather on profits and yields, respectively.

Table 3. Fixed effects regressions of loan delinquency and default, MEI ENSO index

Variable	Loans Past due 30 days	Loans past due 90 days	Charge offs
MEI	2.2094**	1.1995**	0.5109*
	(0.6046)	(0.3026)	(0.2145)
MEI^2	-1.0011	-0.8547**	-0.3763*
	(0.5625)	(0.2262)	(0.1742)
Lag FCS Asset	0.0010	0.0009	-0.0011**
	(0.0034)	(0.0026)	(0.0004)
Land Value	-0.0006*	-0.0004	-0.0000
	(0.0003)	(0.0002)	(0.0000)
Lag Land Value	0.0012**	0.0012***	0.0001
	(0.0003)	(0.0003)	(0.0000)
Number of Farms	83.3013	-35.5181	7.0086
	(65.5083)	(51.5720)	(6.7065)
Coverage Ratio	-0.1959	-0.6560*	-0.0659*
	(0.3819)	(0.2597)	(0.0278)
Indemnity	-0.0072***	-0.0063***	-0.0006**
	(0.0011)	(0.0013)	(0.0002)
Farm Output/Input Price Ratio	-0.0791*	-0.0491*	-0.0304*
	(0.0364)	(0.0224)	(0.0126)
Interest Rate	-0.0066	-0.0060	0.0023
	(0.0267)	(0.0223)	(0.0029)
Number of New Loans	0.2834**	0.1723*	0.0001
	(0.0820)	(0.0691)	(0.0044)
Constant	6.0914	6.9889*	2.9042
	(5.0805)	(3.1386)	(1.6248)
Year Dummy	Yes	Yes	Yes
Observations	301	299	292
R-squared	0.4581	0.4922	0.4504
Number of UNINUM	32	32	32

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Overall, the results point to the fact that farmers' repayment in a La Nina year are better than that in a neutral year which is consistent with similar results for commercial agricultural banks provided by Nadolnyak and Hartarska (2013). Since, on average, the charge-off percent is 0.05, the economic impact is very small indicating that the FCS institutions hold well diversified portfolios and that insurance markets likely help farmers to remain current on their loan obligations. However, this is also evidence that climate variability affects farmers' cash flows in the short term.

The results from the rest of the control variables are consistent with expectations. First, they suggest that agricultural insurance markets in the southeastern US are complementary to credit markets and that crop insurance helps farmers fend off weather related shocks as reflected by loan repayment performance. Higher state level insurance coverage and thus higher indemnity received by farmers are associated with lower loan delinquency (about -0.60 percent for loans overdue 90 days or more) and lower defaults (-0.06 coefficient on charge-offs) in the lenders' loan portfolios. Higher insurance indemnity values are also clearly associated with fewer delinquencies and defaults.

As expected, we find that higher current land values are associated with lower delinquency, suggesting some strategic loan repayment/restructuring instead of risking valuable land when its price is high. Similarly, land values at loan origination are positively associated with consequent delinquency suggesting that land values helped farmers to get more loans. As expected, we also find that the output/input price ratio has a negative relationship with delinquency and default. The number of new FCS ACAs' loans is positively associated with the delinquency rate although the impact is small while default is unaffected. For example, additional 1,000 loans were associated with 0.28 and 0.17 percent higher rates of loans delinquent >30 days and >90 days but there is no impact on the loans written off. This suggests that the FCS lenders were trying to reach only reasonably risky borrowers. This is consistent with the charter of the FCS which directs it to serve borrowers in good and in bad years while the prudent lending meets the need of protecting the interests of its member–borrowers.

We also find some evidence that, while larger ACAs did not have lower (or larger) delinquencies relative to the smaller ACAs, larger ACAs charged off fewer loans – ACAs with one million more is assets resulted in 0.01 percent fewer loans charged off suggesting some economies of scale and supporting the consolidation process in the Farm Credits System that has taken place over the past 10-15 years. Finally, we find that the number of potential clients, measured by the number of farms per state, does not affect delinquency and default.

5. Conclusion

Previous work has evaluated how adverse weather events, natural disasters, or extreme El Nino Southern Oscillation (ENSO) phases affect the loan portfolio performance of financial institutions such as community banks and agricultural banks in the US and of microfinance institutions in developing countries. The findings range from variability in agricultural banks portfolios to improved performance of US community banks after wind-induced (hurricane) disasters (FDIC, 2005; Ewing, Hein, & Kruse, 2006; Nadolnyak & Hartarska, 2013). Possible variations in the results may be due to the differences in complementary financial and government support infrastructure and, in particular, developed insurance markets and support programs. In this paper, we set out to establish whether climate variability affects agriculture and to what extent agricultural financial markets are able to mitigate these risks in the Southeast US where the climate is significantly affected by the ENSO phases. We use loan portfolio data from a major provider of agricultural credit, the Farm Credit System and its retail institutions, and evaluate the delinquencies and defaults of loan portfolios of 33 ACAs headquartered in the Southeastern States during the 2000-2010 period. Unlike previous related studies, we control for the role of complementary insurance markets as part of the support infrastructure.

We measure climate and weather variability with two different variables capturing the ENSO phases – the categorical JMA index, and the continuous MEI index. Overall, we find that the ENSO anomalies are associated with small changes in the loan delinquencies and defaults in the ACAs portfolios likely because their clients' production process depends on the weather even though financial and production risk management tools mitigate those impacts. The small magnitudes of the impacts are to be expected as farmers use risk mitigation tools and strategies and the FCS' ACAs hold well diversified portfolios and have sound business practices. In that respect, our work is consistent with Burke and Emerick (2016) who find little adaptation by the US producers to climate variability possibly because of lack of incentives. Specifically, our results show fewer delinquencies and defaults following La Nina growing seasons and more delinquencies associated with moderate El Nino. We also find that delinquencies are typically resolved by the farm supports or other risk management strategies because the impact on default (charge-offs) is negligible in magnitude. Nevertheless, even these small yet noticeable impacts suggest that climate variability affects producers' loan performance in the region. In addition, since the ENSO realizations are known prior to the planting season, our results should be useful to both the FCS institutions and to farmers.

Future work may identify non-diversifiable and/or non-manageable weather risk impact on agricultural loan performance by using actual weather variables such as temperature, precipitation, and growing degree days which would require more data collection. Such research would be complementary in that it would suggest further role of the ENSO forecasts and measurements.

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Notes

Note 1. Meteorological data show higher frequency of extreme weather events in recent years, with nine out of the ten hottest years happening during the 2000-2010 study period, according to the National Oceanic and Atmospheric Association (NOAA) and the Met Office Hadley Center and Climate Research Unit (UK), with ten hottest years over the same period according to the NASA.

Note 2. Other world regions that are most affected by the ENSO are the coastal areas of South and Central America, southeast Asia, and southeast Africa.

Note 3. Schlenker, Hanemann, and Fisher (2005) argue that irrigation may negatively bias the estimates of the climate impact on agriculture.

Note 4. The potential measurement error due to loans to animal producers and other in rural areas remains an issue but it is contained in the left hand side variable that with sufficient number of observations is seems acceptable. If anything we are likely to underestimating the effect of weather fluctuations with this specification.

Note 5. Specifically, our communications suggest that portfolios in the south typically consist of about a quarter of non-agricultural or “low-agriculture” loans, about a third of animal production (e.g., poultry) loans, and the rest are crop production with majority repaid in February or March the following year.

Note 6. Again, this classification comes from both our data analysis and private conversations with local ACA loan officers and managers.

Note 7. Choosing an interval over which the index is measured is important because it must correspond to the regional growing season or, even more importantly, account for the lag between the measurements taken over the Pacific Ocean and the actual weather realizations in the Southeast US which is estimated at between 1 and 2 months. The impacts vary by region, with most of the Southeast (except Florida and southern parts of the states) becoming warmer and dryer during the growing season in La Nina and vice versa in El Nino years. Both temperature and precipitation anomalies have complex impacts on agriculture so we cannot hypothesize the combined effects a priori.

Note 8. Disaster payments which are government payments based on the severity of the natural disasters was also included initially but it had to be dropped out from the final model due to collinearity with time variables.

Alternative specifications did not affect the results.

Note 9. The data set is adjusted for the merger activities that have taken place during the study period. These have accelerated in the following period and to a large extend determined the period of the study.

Note 10. The limited number of observations is due to the fact that FCS institutions went through significant merger activities and we are only able to classify ACAs within the region based on its headquarters location is in the states we cover. Therefore, we are likely missing lending activity by the FCS institutions in the region and therefore we only interpret the data in terms of percentage changes in the portfolio rather than the absolute numbers for an average ACA serving the region. Still it is important to keep in mind that the complicated structure of the FCS which evolved as a result of numerous changes and mergers makes it difficult to pinpoint the complete portfolios of each and all institutions serving the region.

Note 11. Insurance coverage is defined as “coverage at % of expected county revenue” (See http://www.rma.usda.gov/policies/)

Note 12. The Hausman specification test rejected the alternative random effect model (p-value<0.001).

Note 13. Authors’ analysis of USDA Agricultural Risk Management Survey for the study period shows that the majority of crop producing farmers in the region do not have crop production loans.