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# The Impact of Supply and Demand Changes on Non-Real-Estate Agricultural Loans*

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**Abstract**

This study examines the degree to which changes in non-real-estate agricultural loans at commercial banks are driven by changes in supply or demand. Our identification strategy exploits information provided by agricultural lending surveys conducted by three Federal Reserve Banks: Chicago, Kansas City, and Minneapolis. Building on recent studies of loan officer opinion surveys, we estimate the changes in agricultural loan supply and demand using an unbalanced panel of 1,028 banks across the 2002-2021 period. The survey responses provide instruments for supply and demand changes to examine fluctuations in bank-level agricultural loan volumes obtained from Federal Financial Institutions Examinations Council quarterly "call reports." We find that changes in the volume of non-real-estate farm loans at commercial banks are principally driven by changes in excess loan demand. These findings support a careful approach for policies aimed at boosting supply of agricultural credit.

*JEL Codes:* Q13, Q18

*Keywords:* Agricultural lending, banks, demand for agricultural loans.

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# 1 Introduction

Non-real-estate loans play a critical role in the agricultural sector. Farmers use non-real-estate loans to purchase inputs, to invest in capital, and as a source of short-term liquidity. The existing literature, however, suggests that farmers often cannot borrow as much as they need (Weersink and Tauer, 1989; Hubbard and Kashyap, 1992; Turvey and Weersink, 1997; Bierlen and Featherstone, 1998; Briggeman et al., 2009), possibly limiting farmers' ability to accumulate capital and suppressing aggregate farm output (Barry et al., 2000; Briggeman et al., 2009). Credit constraints may be severe in the agricultural sector since there is a substantial time lag between purchasing inputs and selling outputs, but also because of the relative small-scale nature of farm operations, the lack of flexibility in farm-specific capital, and limited collateral that stems from the direct link between private wealth and farm capital (Blancard et al., 2006; Khwaja and Mian, 2008).

As a result, there are a number of policy interventions designed to support the supply of non-real-estate loans to the agricultural sector, such as the expansion of the Farm Credit System's lending authority and the USDA's guaranteed loan program. However, empirical regularities, such as the countercyclical movement between farmers' demand for loans and farm income, as well as the low level of delinquency rates observed since 2000 (Federeral Reserve Bank of Kansas City, 2024), suggest that changes in agricultural loan volumes may be driven, at least in part, by changes in demand. As Turvey and Weersink (1997) note, a meaningful portrayal of loan supply cannot be viewed in isolation of demand and *vice versa*. It can be difficult, empirically, to isolate changes in either supply or demand for loans because both credit supply and demand are influenced by economic conditions and monetary policy (Bernanke and Gertler, 1995; Bernanke et al., 1996; Kiyotaki and Moore, 1997), and observed changes in loan volumes reflect shifts in both credit supply and demand. Given the prominent role of credit in the agricultural sector and prior evidence that farmers may not be able to borrow as much as they need, this study examines the degree to which non-real-estate agricultural loan volumes in the United States banking system are driven by changes in supply and demand.

Several studies have examined the functioning of agricultural credit markets. Early studies use structural economic models of the agricultural sector to examine periods of excess supply or demand in credit markets, changes in interest rates, farm technological progress, and the restructuring of farm organizations (Hesser and Schuh, 1962; Melichar, 1973; Boyette and White, 1987; Hubbs and Kuethe, 2017). A more recent stream of literature uses measures of credit market frictions obtained from surveys of farmer-borrowers both in the U.S. and international context to examine the degree to which credit rationing may have delete-

rious effects on farm production (Petrick, 2004; Foltz, 2004; Briggeman et al., 2009). Most recently, Kandilov and Kandilov (2018) exploit regulatory changes that expand banks' ability to lend to show positive impacts on farm production and income.

Our empirical approach, however, builds on recent studies in the general banking literature that rely on individual responses to loan officer opinion surveys to create orthogonal measures of both the supply and demand of credit (Del Giovane et al., 2011; Pintaric, 2016; Van der Veer and Hoeberichts, 2016; Altavilla et al., 2021; Vojtech et al., 2020; Hogg et al., 2021). Loan officer opinion surveys, such as the U.S. Federal Reserve Board of Governor's *Senior Loan Officer Opinion Survey on Bank Lending Practices* (SLOOS) and the European Central Bank's *Euro Area Bank Lending Survey* (BLS), provide information to central banks on credit market demand and supply to assist monetary policy decisions. Within this line of research, changes in supply are measured by changes in credit standards or "any of the various non-price lending terms specified in the typical bank business loan or line of credit: collateral, covenants, loan limits, etc (Lown and Morgan, 2006, pp. 1577)." While farmers respond to changes in interest rates by cutting their demand for credit or shifting between lending institutions, including nontraditional lenders (Brewer et al., 2019, 2022), macroeconomists argue that interest rates may fail to equate supply and demand for loans because they do not behave the same way as "prices" in standard markets (Laffont and Garcia, 1977; Stiglitz and Weiss, 1981; Jaffee and Stiglitz, 1990). In standard markets, a seller's delivery occurs simultaneously with a buyer's payment. In credit markets, however, a lender provides debt capital to a borrower in exchange for a promise of future repayment, and asymmetric information on the probability of repayment may lead to problems of adverse selection and moral hazard between the lender and borrower (Akerlof, 1970; Stiglitz and Weiss, 1981). Debt, therefore, contributes to the financial risk of the borrower and to the business risk of the lender (Turvey and Weersink, 1997). As such, lenders systemically tighten or ease credit credit standards over a business cycle to reflect changes in lending policies (Asea and Blomberg, 1998). Aggregate measures of changing loan standards derived from loan officer opinion surveys have been used in empirical models to examine the effects of lending supply on economic activity (Lown and Morgan, 2006; Bassett et al., 2014; Ciccarelli et al., 2015), bank risk-taking (Paligorova and Santos, 2017), and consumption (Aron et al., 2012).

Since the early 2000s, several regional Federal Reserve Banks conduct opinion surveys of agricultural bankers to track changes in supply and demand conditions for non-real-estate agricultural loans in a manner similar to the more general loan officer opinion surveys. We construct an unbalanced panel of individual responses from agricultural banker surveys conducted by three Federal Reserve Banks: Chicago, Kansas City, and Minneapolis. We match these survey responses to administrative data on non-real-estate agricultural loan volumes

and bank characteristics obtained from the Federal Financial Institutions Examination Council (FFIEC) quarterly "call reports" from 2000 through 2021, adjusted for mergers following English and Nelson (1998). We focus on non-real-estate agricultural loans for several reasons. First, changes in demand and supply of non-real-estate agricultural loans are the only questions related to credit conditions that are included in all of the agricultural banker surveys conducted by the Federal Reserve Banks. Second, non-real-estate agricultural loans have a shorter maturity than real estate loans, which allows for more variability in loan volumes, as well as supply and demand at the bank level. Finally, commercial banks hold the majority of non-real-estate loans in the U.S., about 41% of non-real-estate agricultural debt according to the USDA 2024 Farm Income and Wealth Statistics.

Our first set of evidence uses the Federal Reserve Bank of Chicago's *Land Values and Credit Conditions Survey* which contains an *annual* question on changes in lending standards for non-real-estate agricultural loans that closely mirrors the wording and structure of more general loan officer opinion surveys. Building on Altavilla et al. (2021) and others, we construct orthogonal measures of changes in supply and demand conditions that also net out business cycle fluctuations and bank-related confounders. We find no empirical evidence that non-real-estate agricultural loan volumes at commercial banks are linked to changes in supply conditions between 2000 and 2021. In contrast, we find that the changes are driven primarily by changes in loan demand.

However, this annual measure of changes in lending standards likely masks the seasonal variation in agricultural loan volumes. As a result, we also consider alternative measures of supply conditions obtained from the survey. One important non-price loan term in agricultural lending is collateral. According to the *Survey of Terms of Bank Lending to Farmers*, approximately 96 percent of agricultural loans made by commercial banks between 2001 and 2021 were secured with collateral (Federal Reserve Bank of Kansas City, 2021). The Federal Reserve Bank of Chicago's agricultural banker opinion survey includes a *quarterly* question on changes in collateral requirements for non-real-estate agricultural loans, as does the Federal Reserve Bank of Kansas City's *Survey of Agricultural Credit Conditions* and the Federal Reserve Bank of Minneapolis's *Agricultural Credit Conditions Survey*. Thus, we are able to measure the degree to which quarterly fluctuations in non-real-estate loan volumes are associated with changes in demand and collateral requirements. This higher frequency measure of supply may more accurately capture seasonal fluctuations in agricultural credit market conditions. In addition, expanding our unbalanced panel to include all three Federal Reserve Districts greatly expands the geographic footprint of our study area from 339 to 1,061 counties across 16 states. The combined panel represents approximately 80 percent of U.S. banks with at least 25 percent of their loans dedicated to the agricultural sector, a widely used def-

inition of "agricultural banks"(Federal Financial Institutions Examinations Council, 2021, as of June 30, 2021). Again, we find no empirical evidence that non-real-estate agricultural loan volumes at commercial banks are linked to changes in supply conditions between 2000 and 2021, but the changes are positively correlated with changes in loan demand.

Our results suggest a careful approach to public interventions in agricultural credit markets. Given the strong impact of demand on the growth rate of non-real-estate agricultural loans and the muted impact of supply, efforts to support the volume of agricultural debt from commercial banks depends greatly on farmers' loan demand. In periods of high demand for loans, such as periods of limited cash flows, public intervention may lead to an inefficient allocation of public resources. Conversely, public interventions during periods of low demand for agricultural loans, such as periods of high cash flows, may increase liquidity among lenders without a corresponding increase in loan volumes or investment. Farmers demand is, in turn, partially a function of farmers' response to interest rates and loan terms, as well as competition between credit institutions (Brewer et al., 2019; Turvey et al., 2021).

The remainder of this study is organized as follows. Section 2 provides an overview of our conceptual approach and identification strategy. Section 3 provides a replication of *status quo* methods of measuring loan supply with changes in lending standards, such as those employed in loan officer opinion surveys. Specifically, we apply our two-stage estimation strategy to an unbalanced panel of annual responses to the Federal Reserve Bank of Chicago's *Land Values and Credit Conditions Survey* and find that changes in non-real-estate agricultural loan volumes are primarily driven by changes in demand. Section 4 expands this framework to quarterly measures of agricultural loan market conditions across the three Federal Reserve Districts. Finally, we conclude with a discussion of key findings, policy implications, and suggestions for future research in Section 5.

# 2 Modeling Approach

As previously stated, the goal of this study is to measure the degree to which changes in non-real-estate agricultural loan volumes are driven by changes in supply and demand. It is difficult to identify the relative importance of supply and demand for agricultural credit because of the many confounding factors that impact both supply and demand. For example, changes in demand depend on the short- and long-term financial needs of farm operations and households, but also partially on the strategic choices banks make on the price and the quantity of loans available for borrowers. Banks strategic choices, in turn, are affected by regulatory and macroeconomic fluctuations. Therefore, there are many levers that jointly impact demand and supply supply of farm loans and determine how they affect each other

(Vives, 2016).

A number of previous studies circumvent these challenges in the study of broader lending markets by using microdata on changes in residual demand and standards of loans collected by bank surveys (Bassett et al., 2014; Del Giovane et al., 2011; Pintaric, 2016; Van der Veer and Hoeberichts, 2016; Altavilla et al., 2021; Vojtech et al., 2020; Hogg et al., 2021). The studies measure the changes in demand for and supply of credit using qualitative perceptions collected through loan officer opinion surveys, such as SLOOS and the BLS. For example, SLOOS queries respondents, "Over the past three months, how has the demand for loans of type [type of loan here] at your bank changed?," and respondents select from the discrete and directional Likert scale "eased considerably," "eased somewhat," "unchanged," "tightened somewhat," or "tighten considerably." Similar questions are also used to capture changes in supply, as measured by changes in lending standards. Answers to these questions therefore provide measures of supply and demand for loans that vary across time and across banks. Central banks conduct loan officer opinion surveys to track changes in credit market conditions to assist in monetary policy decisions.

As in Altavilla et al. (2021), the individual survey responses can be used to calculate orthogonal measures of supply and demand using a two-stage identification strategy. The first stage partials out (i) the co-movement of demand and other factors from supply and (ii) the co-movement of supply and other factors from demand. Through linear regression, the first stage nets out macroeconomic variation, bank characteristics, and the effect that supply has on demand and that demand has on supply. A naïve panel data estimation of changes in outstanding non-real-estate farm loans on changes in supply and demand conditions, for example, ignores that macroeconomic disturbances jointly affect both credit demand and supply (Bassett et al., 2014). The remaining variation, therefore, corresponds to changes in demand and supply that are not explained by these other confounding factors. The second stage of the identification strategy then uses these orthogonal measures of supply and demand resulting from the first stage to examine their impact on observed loan volumes, typically collected through administrative data, such as the quarterly Reports of Condition and Income for Insured U.S. Commercial Banks ("call reports") (Del Giovane et al., 2011; Van der Veer and Hoeberichts, 2016; Pintaric, 2016; Altavilla et al., 2021; Vojtech et al., 2020; Hogg et al., 2021).

Formally, the first stage linear regressions can be specified:

$$\Delta Demand_{it} = \alpha_1 \Delta Supply_{it} + \sum_k \theta_k^{demand} x_{it-4}^k + \sum_w \theta_w^{demand} x_t^w + \gamma_i + \gamma_t + \nu_{it} \tag{1a}$$

$$\Delta Supply_{it} = \alpha_2 \Delta Demand_{it} + \sum_k \theta_k^{supply} x_{it-4}^k + \sum_w \theta_w^{supply} x_t^w + \gamma_i + \gamma_t + \varepsilon_{it} \tag{1b}$$

where $i$ indexes a bank, and $t$ indexes a year-quarter pair. $\Delta Demand_{it}$ and $\Delta Supply_{it}$ are encoded such that answers that indicate higher demand or supply get a value of 1, answers that indicated no change get a value of 0, and answers that indicated a value of lower conditions get a value of –1. Both (1a) and (1b) control for time invariant bank characteristics ($\gamma_i$) and year-quarter ($\gamma_t$) fixed effects.[1] Both equations also control for several time-varying observable bank characteristics ($x^k_{it-4}$), such as size, leverage, and liquidity. Because the surveys examined specifically ask about about changes in supply and demand conditions in relation to the same quarter of the previous year, time-varying bank controls enter as one year lag (captured by the index $t-4$, representing the same quarter one year ago). Both (1a) and (1b) also control for contemporaneous macroeconomic conditions ($x^w_t$), including the growth rate of the Federal Funds Rate (averaged over the quarter) in relation to the same quarter of the previous year, changes in volatility of assets (VIX), and changes in expectations about GDP and the 10-year Treasury rates obtained from the surveys of professional forecasters.

In (1a) and (1b) the parameters $\alpha_1$ and $\alpha_2$ capture the co-movement between supply and demand. When we fail to reject the constraint $\alpha_j = 0$, we conclude that supply and demand move independently of one another. Alternatively, $\alpha_j > 0$ implies that positive shift in demand (supply) leads to a shift in the same direction in supply (demand), or a cyclical relationship between supply and demand. Finally, $\alpha_j < 0$ implies that a positive shift in demand (supply) leads to a shift in supply (demand) in the opposite direction, or a counter-cyclical relationship between supply and demand.

The remaining variation in loan demand and supply are therefore captured by the error terms $\{\nu_{it}, \varepsilon_{it}\}$ in (1a) and (1b). Thus, the two residuals represent the share of demand or supply that cannot be explained by the other, conditioned on bank characteristics and macroeconomic conditions, or the "pure" changes in demand or supply. Armed with an estimation of the orthogonalized change in supply ($\hat{\varepsilon}_{it}$) and demand ($\hat{\nu}_{it}$),[2] the second stage estimates the impact of changes in "pure" demand and "pure" supply in the growth rate of non-real-estate agricultural loans. More specifically, we regress the growth rate of non-real-estate agricultural loans, $y_{it}$, on $\hat{\varepsilon}_{it}$ and $\hat{\nu}_{it}$ and the same macroeconomic conditions and bank-specific variables in (1a) and (1b). The growth rate $y_{it}$ calculates the percentage change

[1] Commercial banks with a large footprint of agricultural loans in their loans portfolio tend to be community banks that practice relationship lending (Gorton and Winton, 2003; Marsh and Sengupta, 2017). Relationship lending limits the geographical scope of lending, so this bank fixed effects also capture the mix of economic activities in the area. Controlling for U.S. state-quarter-year fixed effects produces similar results.

[2] We follow the literature in several aspects here. We leverage the properties of linear regression to construct orthogonal measures of supply and demand, despite the discrete and ordered nature of our dependent variable in equations 1a and 1b. Doing so allows us to compare our results to the broader literature and have a easier interpretation of first-stage equations.

in loan volumes from the same quarter a year ago, consistent with the loan officer survey structure. The model is expressed:

$$y_{it} = \omega_1 \hat{\nu}_{it} + \omega_2 \hat{\epsilon}_{it} + \sum_k \theta_k^{loan} x_{it-4}^k + \sum_w \theta_w^{loan} x_t^w + \gamma_i + \gamma_t + \xi_{it} \tag{2}$$

where the parameters of interest are $\omega_1$ and $\omega_2$, and $\xi$ refers to the structural residual.

# 3 Changes in Lending Standards

Previous studies measure changes in loan supply using qualitative responses about changes in loan standards collected through loan officer opinion surveys (Bassett et al., 2014; Del Giovane et al., 2011; Pintaric, 2016; Van der Veer and Hoeberichts, 2016; Altavilla et al., 2021; Vojtech et al., 2020; Hogg et al., 2021). The Federal Reserve Bank of Chicago's *Land Values and Credit Conditions Survey* includes the question, asked once a year, "How have your credit standards for approving agricultural loans during the past three months changed relative to a year earlier?" Respondents choose from five options: (i) "tightened considerably," (ii) "tightened somewhat," (iii) "remained basically unchanged," (iv) "eased somewhat," and (v) "eased considerably." This question is included in the fourth quarter survey, completed in January of each year. Thus, for the months of October – December each year, the survey provides information on the changes to "credit standards" for their non-real-estate farm loans. For changes in non-real-estate farm loan demand,[3] we employ the responses to the questions, "What changes occurred in non-real-estate farm loans at your bank in the past three months relative to a year earlier?" for which respondents can choose between "higher," "same," or "lower".

Following previous studies, we match survey responses to bank level financial measures, such as agricultural loan volumes and bank characteristics, obtained from quarterly Reports of Condition and Income for Insured U.S. Commercial Banks ("call reports") (Del Giovane et al., 2011; Van der Veer and Hoeberichts, 2016; Pintaric, 2016; Altavilla et al., 2021; Vojtech et al., 2020; Hogg et al., 2021). We obtain the data through repositories maintained by the Federal Reserve Board of Governors. The source data is available for public download via the Federal Financial Institutions Examination Council (FFIEC) Central Data Repository's Public Data Distribution. The call report data are adjusted for mergers, following English

[3]Change in non-real-estate loan demand and supply include changes in conditions to machinery and equipment loans and other operating loans. While the loan terms for these two types of loans may differ considerably, machinery loans are less frequent and smaller in aggregate than other non-real-estate loans, according to the Survey of Terms of Lending to Farmers published quarterly by the Federal Reserve Bank of Kansas City. Nevertheless, the change in demand conditions in this paper must be understood as the average of all non-real-estate loans reported by individual banks.

and Nelson (1998). Additionally, we obtain data on federal funds rate from the Federal Reserve Board of Governors, expectations about rates on the 10-year Treasury Bond and expectations about real GDP 4 quarters ahead from the Survey of Professional Forecasters from the Federal Reserve of Philadelphia. Finally, we obtain VIX measures from the Chicago Board of Options Exchange. Table 1 reports mean, standard deviation, first quartile, median, and third quartile of the variables considered in our model.

Table 1: Summary statistics for banks in the survey from the Federal Reserve Bank of Chicago

| Variables in Call Report | Mean | SD | Q1 | Median | Q3 |
|---|---|---|---|---|---|
| Share Ag Loans, percent | 32.45 | 19.12 | 17.03 | 31.17 | 45.18 |
| Asset Size, mil. | 3276.86 | 28129.61 | 66.88 | 120.07 | 226.68 |
| Equity Ratio | 342.79 | 2871.29 | 7.19 | 13.32 | 24.52 |
| Non-Real Estate Ag Loans, mil. | 36.17 | 162.98 | 4.15 | 9.84 | 20.73 |
| Real Estate Ag Loans, mil. | 33.08 | 106.29 | 4.85 | 12.01 | 24.06 |
| Liquid Asset Ratio | 23.71 | 14.039 | 12.92 | 21.22 | 32.56 |
| Variables in the Chicago Survey | | | | | |
| Loan Std Change | -0.30 | 0.49 | -1.00 | 0.00 | 0.00 |
| Demand Change | 0.10 | 0.71 | 0.00 | 0.000 | 1.00 |
| Collateral Req. Change | -0.14 | 0.36 | 0.00 | 0.00 | 0.00 |
| Change Aval. Funds | 0.19 | 0.56 | 0.00 | 0.00 | 1.00 |
| Change Repayment | -0.04 | 0.62 | 0.00 | 0.00 | 0.00 |
| Macroeconomic Variables | | | | | |
| Fed Funds, growth rate | -0.14 | 0.97 | -0.54 | 0.07 | 0.51 |
| Change T-Bond rate, expec. | -0.18 | 0.60 | -0.56 | -0.14 | 0.19 |
| Change GDP, bill. $, expec. | 481.28 | 679.11 | 105.58 | 281.02 | 465.35 |
| Change in VIX | -0.19 | 9.45 | -3.84 | -0.69 | 3.59 |

Note: Quarterly data for 482 unique banks from 2002 to 2020. SD refers to standard deviation, Q1, and Q3 for the first and third quartiles of the data.

The Federal Reserve Bank of Chicago covers the Federal Reserve's Seventh District, which includes the northern portions of Illinois and Indiana, southern Wisconsin, the lower peninsula of Michigan, and the entire state of Iowa. Since 2015, the survey sample includes approximately 550 banks with about 150 banks responding in each quarter.[4] As of June 30, 2021, approximately 28 percent of commercial banks with agricultural loans representing at least 25% of total loans were headquartered in the Seventh District (Federal Financial Institutions Examinations Council, 2021). We constructed an unbalanced panel of 482 banks from the Chicago Survey for the years 2002 to 2020. Again, the data refers to the last quarter

[4]Our sample comprises a period in which several banks consolidated, see Kim and Katchova (2022) and Regmi and Featherstone (2022) for a discussion. Changes in supply are still captured by the survey regardless of the changes in the degree consolidation in a lending area. If consolidation was a major factor impacting credit supply at the bank level (either by strengthening credit supply because of lower costs post merger or weaking supply due to market power), this variation would still be captured in the regressions by the measures of supply conditions reported by banks. Consolidation, of course, may impact the unbalanced nature of our data.

of each year and shows yearly variation in supply, demand, and bank-specific variables, including outstanding non-real-estate agricultural loans.

Table 2 reports the regression results of our model using the fourth quarter responses to the Federal Reserve Bank of Chicago survey. The first two columns include the first-stage estimates for demand from equation (1a) and the first-stage results for supply, as measured by changes in credit standards, from equation (1b), respectively. The final column includes the second stage estimates using the first-stage residuals, as described by equation (2). The reported standard errors (in parentheses) are clustered at the bank level, and all models are estimated as linear square dummy variables (LSDV).

The first-stage demand equation suggests that loan demand is negatively associated with the bank's share of agricultural loans and changes in volatility and positively associated with expected changes in GDP and U.S. Treasury rates. Alternatively, the first-stage supply equation suggests that loan supply is negatively associated with bank size (as measured by assets), changes in federal funds rates, and changes in volatility and positively associated with expected GDP and U.S. Treasury rates. The first-stage demand estimates imply that changes in demand are independent of changes in supply.

Table 2: Effect of changes in supply and demand on change in non-real-estate agricultural loans at commercial banks, quarterly frequency, Chicago sample.

| | Demand, 1st stg. | Supply, 1st stg | Change Op. Loans |
|---|---|---|---|
| Change Supply | 0.0103 | | -0.0289 |
| | (0.0400) | | (0.0205) |
| Change Supply, lag | | 0.0757*** | |
| | | (0.0281) | |
| Change Demand | | 0.0025 | 0.0213** |
| | | (0.0171) | (0.0106) |
| Change Demand, lag | 0.0311 | | |
| | (0.0263) | | |
| Asset Size, log | -0.0325 | -0.1088* | -0.1235* |
| | (0.1007) | (0.0588) | (0.0688) |
| Liquid Asset Ratio | 0.0019 | 0.0029 | 0.0002 |
| | (0.0029) | (0.0019) | (0.0014) |
| Equity to Capital Ratio | 0.0042 | 0.0109 | 0.0027 |
| | (0.0147) | (0.0102) | (0.0081) |
| Share of Ag Loans | -0.0074** | -0.0025 | -0.0015 |
| | (0.0035) | (0.0026) | (0.0025) |
| Branch answered (1/0) | 0.1282 | -0.0209 | -0.1478** |
| | (0.1037) | (0.0712) | (0.0745) |
| Change Fed Funds | -0.3033 | -0.5109*** | -0.0200 |
| | (0.2317) | (0.1550) | (0.0473) |
| Change Vix | -0.0482* | -0.0567*** | -0.0036 |
| | (0.0289) | (0.0197) | (0.0042) |
| Change GDP expec. | 0.0006** | 0.0006*** | $3.24 \times 10^{-5}$ |
| | (0.0003) | (0.0002) | $(4.93 \times 10^{-5})$ |
| Change U.S. Treasury expec. | 0.3081* | 0.2858*** | 0.0233 |
| | (0.1616) | (0.1075) | (0.0322) |
| Change Op. Loans, lag | | | -0.1521* |
| | | | (0.0897) |
| Bank Fixed Effects | Yes | Yes | Yes |
| Year-Quarter Fixed Effects | Yes | Yes | Yes |
| Observations | 2,488 | 2,488 | 1,773 |
| Adjusted $R^2$ | 0.169 | 0.284 | 0.092 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Residualized supply change and demand change reported in the third column. Change in non-real-estate loans (i.e., Change Op. Loans) as yearly growth rate, $Loan_t/Loan_{t-4} - 1$. All models estimated as linear square dummy variables (LSDV). Standard errors from cluster-bootstrap estimation of residual demand and supply produce qualitatively identical results. The inclusion of state × year-quarter fixed effects instead of year-quarter fixed effects leads to qualitatively identical results.

After we partial out macroeconomic variation and the co-movement between supply and demand, column 3 in table 2 shows that our orthogonalized measure of agricultural loan demand has a positive and statistically significant impact on the changes in non-real-estate agricultural loan volumes. Thus, positive changes in loan demand are associated with increased lending volumes. By contrast, our orthogonalized measure of agricultural loan supply has no statistically significant impact on changes in non-real-estate agricultural loan volumes, as the estimated coefficient is indistinguishable from zero.

The muted effect of supply on changes in non-real-estate agricultural loan volumes suggests that credit market fluctuations are principally driven by the demand for these agricultural loans. While our fixed effects control for annual variation, the fourth quarter observation period may mask some strategic considerations of banks throughout the year. More specifically, with only quarter four data, it is impossible to rule out that the demand variation is more important than supply variation in adjustments to bank's balance sheets at the end of the year. For example, banks covered by the Federal Reserve Bank of Chicago may adjust their standards of loans during planting and harvest season more than during the end of the year. This possibility may be a concern for banks in the Federal Reserve Bank of Chicago district, which is dominated by large exposure to row crops, particularly corn and soybeans. The limited temporal variation in the previous analysis, however, may be overcome by using more frequent measures of supply changes and by expanding the geographic scope of the study area.

# 4 Alternative Measures of Supply

Absent a more frequent measure of changes in loan standards, we explore the degree to which alternative loan market characteristics obtained by the Federal Reserve Bank of Chicago survey may serve as a proxy for changes in the supply of agricultural credit. The quarterly survey question 'What changes occurred in non-real-estate farm loans at your bank in the past three months relative to a year earlier?" offers three additional characteristics that may serve as agricultural credit supply proxies. In a fashion similar to loan demand, for each category respondents can choose between "higher," "same," or "lower", which we encode as 1, 0, and -1. First, respondents provide subjective measures of changes in the "amount of collateral required." These changes may be informative to changes in supply conditions because higher collateral requirements indicate tighter credit conditions, and collateral is one of the non-price lending terms specified in the tyical bank business loan or line of credit (Lown and Morgan, 2006). Further, according to a survey of a representative sample of commercial agricultural bankers, approximately 96 percent of agricultural loans made by commercial

banks from 2001 to 2021 were secured with collateral (Federal Reserve Bank of Kansas City, 2021). Second, respondents provide subjective measures of changes in the "availability of funds." As depository institutions, agricultural commercial banks capture deposits in wholesale and retail markets and offer lines of credit to fund projects and investments. As such, the availability of funds may indicate a higher stock of resources to fund projects and investments and therefore a larger supply of credit. Third, respondents provide subjective measures of changes in the "rate of loan repayment." Higher rates of loan repayment may also suggest higher availability of funds and higher credit worthiness of borrowers. Thus, higher repayment rates may be associated with efficient flow of loans from year to year and a higher supply of credit.

Of the three candidate measures, mean changes in collateral requirements most closely mirror the changes in loan standards, as shown in Figure 1.[5] For both standards and collateral requirements, negative values imply tighter supply conditions, and, since 2002, both series are on average negative with a correlation coefficient of 0.82. The similar variation is not surprising given that collateral requirements are one of the key aspects of credit standards, as well as the high percentage of agricultural loans secured by collateral.

[5]The interested reader will find a complete discussion of other measures of supply in the Appendix of the paper.

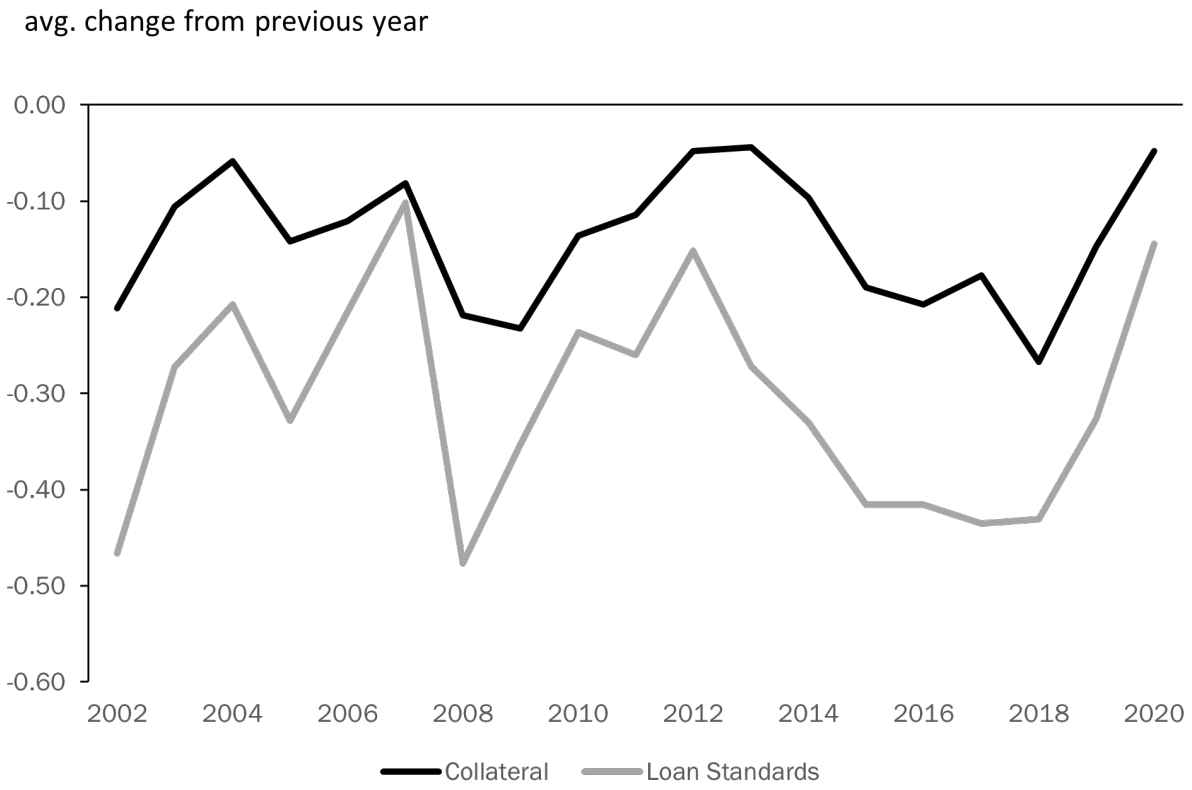


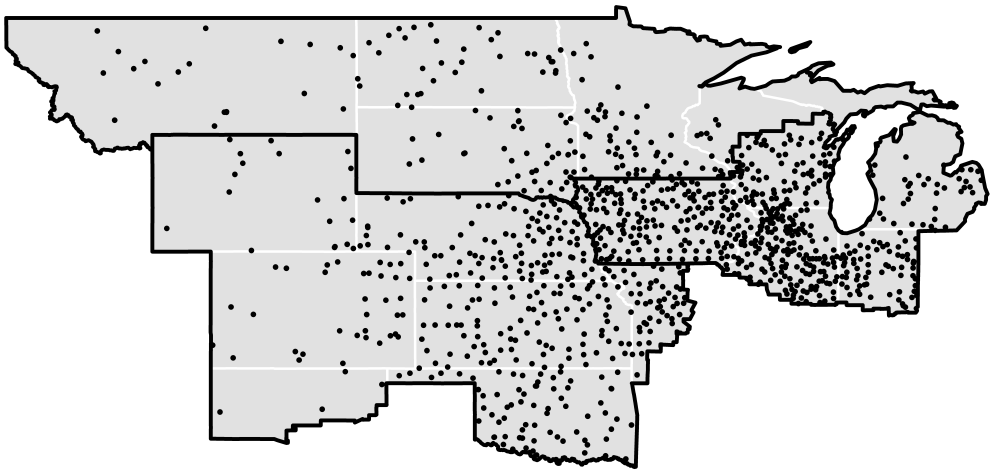

Figure 1: $\Delta$ collateral and $\Delta$ in loan std. based on Chicago Survey data

In sum, both theoretical and empirical evidence suggests that collateral requirements may serve as the best quarterly proxy for changes in the supply of agricultural credit among the three candidates. Given the high correlation between changes in collateral requirements and the broader loan standards question of the Federal Reserve Bank of Chicago survey, collateral will serve as our preferred measure of changes in agricultural loan supply.

Collateral requirements is also collected by similar agricultural lender surveys conducted by the Federal Reserve Bank of Kansas City (*Survey of Agricultural Credit Conditions*) and the Federal Reserve Bank of Minneapolis (*Agricultural Credit Conditions Survey*). The sample population for both surveys include any commercial bank or branch of a commercial bank that has an operational presence in agricultural lending that allows an executive officer or senior loan officer to accurately assess the conditions described in the survey. The sample of the Kansas City survey includes 380 banks, with about 150 banks responding each quarter, and the sample of the Minneapolis survey includes 166 banks, with about 75 banks responding each quarter. As of June 30, 2021, approximately 30 percent of agricultural banks were headquartered in the Kansas City District, and approximately 28 percent were headquartered in the Minneapolis District (Federal Financial Institutions Examinations

Council, 2021).

When combined, the Chicago, Kansas City, and Minneapolis Federal Reserve Districts represent roughly 80 percent of agricultural banks (Federal Financial Institutions Examinations Council, 2021, June 30, 2021). The combined districts span the entirety of 12 U.S. States (Colorado, Iowa, Kansas, Michigan, Minnesota, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, Wisconsin, and Wyoming), as well as the western portion of Missouri and the northern portions of Illinois, Indiana, and New Mexico (Figure 2). This area represents some of the most important agricultural areas in the U.S. Thus, the alternative measures of the supply of agricultural credit allow us to increase both temporal and geographic variation in supply conditions beyond the traditional measure using loan standards collected by the Chicago survey.



Source: Federal Reserve Banks of Chicago, Kansas City, and Minneapolis

Figure 2: Study Area and Respondent Banks

Table 3 reports mean, standard deviation, first quartile, median, and third quartile of the combined Federal Reserve surveys. Summary statistics for each bank separately can be found in Appendix A. In general, the summary statistics provide a similar depiction as those for the annual Chicago survey alone, as shown in table 1. However, the quarterly survey results for all Federal Reserve Banks suggest that the sample is more skewed toward banks with share of total loans dedicated to agriculture, banks with a larger share of agricultural operating loans, and smaller banks as judged by asset size.

Table 3: Summary statistics for banks in the surveys conducted by the Kansas City, Minneapolis, and Chicago Federal Reserve Banks

| Variables in Call Report | Mean | SD | 1st Quartile | Median | 3rd Quartile |
|---|---|---|---|---|---|
| Share Ag Loans, percent | 39.219 | 21.052 | 22.906 | 37.764 | 55.199 |
| Asset Size, mil. | 2030.365 | 28377.664 | 48.804 | 98.104 | 205.459 |
| Equity Ratio | 208.430 | 2893.964 | 5.233 | 10.882 | 22.404 |
| Non-Real Estate Ag Loans, mil. | 37.741 | 186.686 | 4.512 | 10.032 | 22.987 |
| Real Estate Ag Loans, mil. | 30.996 | 107.439 | 3.846 | 9.323 | 22.087 |
| Liquid Asset Ratio | 20.933 | 13.850 | 10.106 | 18.276 | 29.460 |
| Survey Measures | | | | | |
| Demand Change | 0.094 | 0.683 | 0.000 | 0.000 | 1.000 |
| Collateral Req. Change | -0.140 | 0.357 | 0.000 | 0.000 | 0.000 |
| Macroeconomic Variables | | | | | |
| Fed Funds, growth rate | -0.17 | 1.01 | -0.54 | 0.07 | 0.51 |
| Change T-bond rate, expec. | -0.19 | 0.61 | -0.60 | -0.18 | 0.19 |
| Change GDP, bill. $, expec. | 494.64 | 700.89 | 105.58 | 281.02 | 467.26 |
| Change in VIX | -0.30 | 9.79 | -3.90 | -0.72 | 3.59 |

Quarterly data for 1,028 unique banks from 2002 to 2021. SD refers to standard deviation. Macroeconomic variables differ from table 1 because data from the Federal Reserve Bnaks of Kansas City and Minneapolis contain 2 quarters of data for 2021.

We estimate equations (1a) – (2) with changes in collateral requirements.[6] In contrast to the annual Chicago survey results (table 2), the first-stage demand estimates suggest that changes in demand are negatively correlated with changes in supply, after controlling for bank characteristics and macroeconomic conditions. The negative correlation is consistent with empirical regularities in the agricultural market and may highlight the importance of examining the relationship between supply and demand at a quarterly, rather than annual frequency. The first-stage supply estimates also shows the negative association with changes in demand and changes in supply. Further, the significant coefficient estimates for a number of the control variables suggest that macroeconomic and bank-specific measures of bank size and liquidity are important to understanding the variation in supply and demand.

[6]While we showed that collateral requirements seems to be better a measure of supply, one could argue that macroeconomic and bank-specific characteristics are driving the divergences we see if figure 1. Netting out these variables, then, could lead other supply measures to perform more closely to changes in loan standards. Appendix B shows regression results using different supply measures: changes in availability of funds, changes in repayment, and an average of these two measures and collateral. Results confirm the intuition of figure 1: an increase in excess of funds is negatively correlated with changes in demand and tends to decrease agricultural debt, implying that excess funds is likely used to fund other projects. Higher repayment rate also implies more funds. These funds are likely allocated to other projects outside of the agricultural sector.

Table 4: Effect of changes in supply and demand on change in non-real-estate agricultural loans at commercial banks, quarterly frequency, full sample.

| | Demand, 1st stage | Supply, 1st stage | Change Op. Loans |
|---|---|---|---|
| Change Demand | | -0.0262*** | |
| | | (0.0047) | |
| Change Demand, lag | 0.1279*** | | |
| | (0.0086) | | |
| Change Supply | -0.1033*** | | |
| | (0.0193) | | |
| Change Supply, lag | | 0.1932*** | |
| | | (0.0127) | |
| Change Demand, res. | | | 0.0303*** |
| | | | (0.0032) |
| Change Supply, res. | | | 0.0017 |
| | | | (0.0070) |
| Asset Size, log | -0.0524** | -0.0344*** | -0.2180*** |
| | (0.0212) | (0.0117) | (0.0295) |
| Liquid Asset Ratio | 0.0016* | 0.0027*** | 0.0018*** |
| | (0.0008) | (0.0005) | (0.0005) |
| Equity to Capital Ratio | 0.0056 | 0.0013 | 0.0017 |
| | (0.0035) | (0.0020) | (0.0023) |
| Share of Ag Loans | -0.0016 | -0.0018*** | -0.0041*** |
| | (0.0010) | (0.0006) | (0.0006) |
| Branch answered (1/0) | 0.1578*** | 0.0249 | 0.5305*** |
| | (0.0582) | (0.0355) | (0.0730) |
| g.r. Fed Funds | -0.2642*** | 0.0633*** | 5.935*** |
| | (0.0401) | (0.0210) | (0.8061) |
| Change Vix | 0.0077 | -0.0067*** | -0.3724*** |
| | (0.0052) | (0.0020) | (0.0507) |
| Change GDP expec. | -0.0002*** | 0.0002*** | 0.0124*** |
| | (0.0000) | (0.0000) | (0.0017) |
| Change U.S. Treasury expec. | 0.7284*** | 0.4336*** | -30.97*** |
| | (0.1546) | (0.0744) | (4.197) |
| Change Op. Loans, lag | | | -0.0982*** |
| | | | (0.0202) |
| Bank Fixed Effects | Yes | Yes | Yes |
| Year-Quarter Fixed Effects | Yes | Yes | Yes |
| Observations | 31,720 | 31,720 | 24,914 |
| Adjusted $R^2$ | 0.174 | 0.216 | 0.202 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Change in non-real-estate loans (i.e., Change Op. Loans) as yearly growth rate, $Loan_t/Loan_{t-4} - 1$. All models estimated as linear square dummy variables (LSDV) model and include bank fixed effects and year-quarter fixed effects. *Branch answered* controls for the answers that given by loan officers at branches rather than headquarters. Standard errors from cluster-bootstrap estimation of residual demand and supply produce qualitatively identical results. The inclusion of U.S. state × year-quarter fixed effects instead of year-quarter fixed effects leads to qualitatively identical results.

We show estimates of the second-stage model of agricultural loan volumes, following equation (2) in the third column of Table 4. The estimated coefficient on "pure" supply changes is indistinguishable from zero, which suggests that loan volumes are independent of changes in farm loan supply. Taken together, our preferred specification suggests that the growth rate of non-real-estate agricultural loans are mainly driven by changes in demand, rather than by changes in supply.

Using our preferred measure of loan supply, changes in collateral requirements, the coefficient estimates suggest that non-real-estate loans are expected to increase by an average of 3% when the demand for loans increase relative to the same quarter a year before. Point estimates for supply response, on the other hand, are small, and the 95% confidence interval includes negative coefficient values. Thus, we are unable to distinguish whether tighter collateral requirements are associated with an increase or decrease in the growth rate of non-real-estate agricultural loans. Our results suggest that loan volumes respond more, on average, to changes in demand than to changes in supply. These findings suggest that, on average, the supply of credit was able to accommodate yearly variation in demand for non-real-estate agricultural loans from 2001 to 2021, and changes in demand drove changes in non-real-estate volume. Finally, as detailed in the appendix, these general findings are also robust to choices regarding the lag structure of the regressions, the use of a dynamic panel estimator, and different choices of fixed effects.

# 5 Conclusion

Non-real-estate loans play a central role in modern agricultural production. However, market imperfections, such as asymmetric information, may limit the scope of credit supply to meet demand, and demand may also be constrained by a number of factors, such as transactions costs or farmers' liquidity. Observed loan volumes are likely derived by changes in both supply and demand, and as a result, this study seeks to measure the impact of changes in demand and supply, individually, on the volume of non-real-estate agricultural loans. Understanding the individual impact of supply and demand on volume of credit is critical to agricultural policy. Credit markets that are more sensitive to supply factors may require policies that tackle the lack liquidity or informational tools to assess credit risk. Credit markets that respond mainly to changes in demand may require assessment on farmers' income fluctuation and policies that address willingness to invest in farm projects.

We construct a novel dataset that includes measures of the changes in demand and supply conditions from surveys conducted by three regional Federal Reserve Banks tied to bank-level administrative data. We employ a two-stage model that first nets the impact of supply from

demand and the impact of demand from supply, conditional on a set of bank-specific and macroeconomic controls. This first-stage yields "pure" measures of supply and demand. The second-stage regresses the growth rate of non-real-estate agricultural loans on these "pure" measures.

We apply this approach to two datasets. The first examines the responses to the agricultural banker survey conducted by the Federal Reserve Bank of Chicago. The Chicago survey includes an annual question on changes in loan standards that closely matches the language and content of other broader loan officers surveys which have been examined by previous studies using the same empirical approach. The results suggest that increases in farm loan demand are associated with a 2% increase in the volume of agricultural non-real-estate loans. Yet changes in loan standards are indistinguishable from zero.

The Chicago survey, however, only collects information on changes in loan standards once a year, in quarter four. As a result, we construct a second dataset that provides alternative measures of agricultural loan supply which spans three Federal Reserve districts: Kansas City, Minneapolis, and Chicago. The expanded dataset allows for quarterly observation, but does not directly ask about changes in loan standards. Instead we use collateral requirements as a proxy for supply. The second-stage estimates of our preferred credit supply measures suggest that demand impacts the growth rate of loans much more than supply. Specifically, the growth rate of non-real-estate agricultural loans would increase 3 percentage points on average if conditions for demand improves at the margin. Marginal changes in collateral requirements, on the other hand, are statistically indistinguishable from zero.

The first-stage estimates of our expanded dataset also suggest that the demand and supply of agricultural non-real-estate loans are negatively correlated. This finding is contrasted by prior studies that try to disentangle supply and demand for credit in the broader economy (e.g., Altavilla et al., 2021). In other loan markets, supply and demand are positively correlated, as they move together through business cycles. This seemingly counterintuitive finding is consistent with two important stylized facts for agricultural loans: demand for non-real-estate loans co-moves with changes in agricultural non-real-estate loans, but demand for operational loans is countercyclical to movements in net farm income. This observation is consistent with farmers using cash for operating expenses rather than debt, and demanding debt when liquidity is low.

In sum, this study suggests that demand for credit should be central to our understanding of farm borrowing. We briefly propose a few implications for future research. First, future research should provide greater focus on the relationship between farm incomes and loan demand. In particular, this research may examine differences between shocks to farm costs (such as revenue or labor costs) and shocks to farm revenue (such as commodity prices or

yields). Second, given that farm loan demand is likely tied to farm incomes, future research would benefit from additional analysis of the secondary effects of farm income support on agricultural lenders. Third, our analysis is limited to non-real-estate loans at commercial banks, but farmers obtain credit from a variety of other sources, such as the Farm Credit System lenders. Future research could examine the supply and demand of credit from other lender types, especially in light of the documented competition among lending institutions (Kuethe et al., 2022).

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# A Additional Statistics and Alternative Measures of Supply

**Additional summary statistics** We present additional statistics not covered in the main text in this appendix, including additional measures of supply for the Chicago Survey and the average of selected variables by quarter for the Chicago Survey and for the sample excluding Chicago.

Table A1: Summary statistics from Chicago survey

| Variables in Chicago Survey | Mean | SD | Q1 | Median | Q3 |
|---|---|---|---|---|---|
| Loan Std Change | -0.30 | 0.49 | -1.00 | 0.00 | 0.00 |
| Demand Change | 0.10 | 0.71 | 0.00 | 0.00 | 1.00 |
| Collateral Req. Change | -0.14 | 0.36 | 0.00 | 0.00 | 0.00 |
| Change Aval. Funds | 0.19 | 0.56 | 0.00 | 0.00 | 1.00 |
| Change Repayment | -0.04 | 0.62 | 0.00 | 0.00 | 0.00 |

Note: Quarterly data for 482 unique banks from 2002 to 2020. SD refers to standard deviation, Q1, and Q3 for the first and third quartiles of the data.

Table A2: Average values for selected variables in the Chicago survey and call report variables associated with these observations

| | Quarter | | | |
|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 |
| Demand Change | 0.14 | 0.07 | 0.07 | 0.11 |
| Loan Std Change | | | | -0.31 |
| Collateral Req. Change | -0.16 | -0.15 | -0.14 | -0.13 |
| Change in Repayment | -0.03 | -0.07 | -0.08 | 0.02 |
| Change Avail. Funds | 0.21 | 0.18 | 0.15 | 0.22 |
| Asset Size, mil. | 2787.64 | 3907.37 | 3581.63 | 2836.36 |
| Liquid Asset Ratio | 24.70 | 23.72 | 22.92 | 23.48 |
| Equity Capital, mil. | 292.00 | 409.05 | 370.22 | 300.80 |
| Ag Loans as a Share of Total Loans | 32.54 | 32.64 | 32.18 | 32.48 |
| Farm Production Loans, mil | 30.97 | 40.40 | 38.69 | 34.75 |

Table A3: Average values for selected variables in sample, excluding Chicago data

| | Quarter | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Demand Change | 0.06 | 0.12 | 0.09 | 0.06 |
| Collateral Req. Change | -0.14 | -0.13 | -0.13 | -0.14 |
| Change in Repayment | 0.01 | -0.04 | -0.03 | 0.04 |
| Change Avail. Funds | 0.17 | 0.09 | 0.08 | 0.14 |
| Asset Size, mil | 1543.13 | 2239.42 | 1183.75 | 778.91 |
| Liquid Asset Ratio | 20.91 | 18.977 | 18.395 | 19.33 |
| Equity Capital,mil | 148.87 | 226.14 | 118.19 | 79.67 |
| Ag Loan as a Share of Total Loans | 42.08 | 42.86 | 42.97 | 42.98 |
| Farm Production Loans, mil | 34.10 | 40.031 | 35.19 | 31.78 |

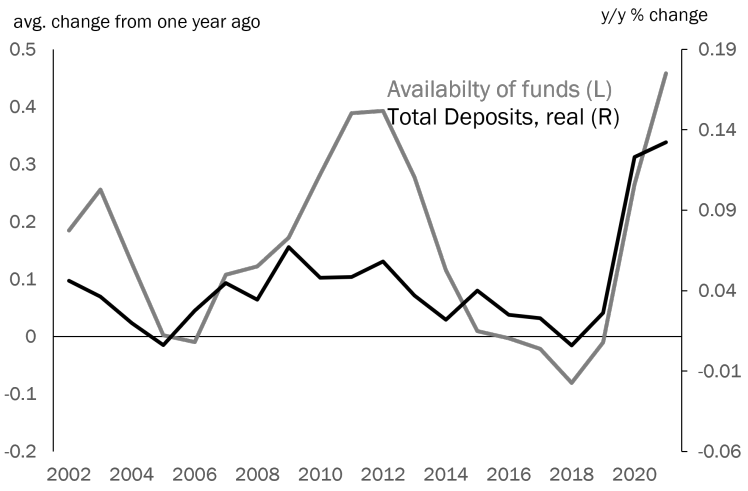
Table A4: Additional Summary Statistics by Federal Reserve District

| | Quarter | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Demand Change | 0.06 | 0.12 | 0.09 | 0.06 |
| Collateral Req. Change | -0.14 | -0.13 | -0.13 | -0.14 |
| Change in Repayment | 0.01 | -0.04 | -0.03 | 0.04 |
| Change Avail. Funds | 0.17 | 0.09 | 0.08 | 0.14 |
| Asset Size, mil | 1543.13 | 2239.42 | 1183.75 | 778.91 |
| Liquid Asset Ratio | 20.91 | 18.977 | 18.395 | 19.33 |
| Equity Capital,mil | 148.87 | 226.14 | 118.19 | 79.67 |
| Ag Loan as a Share of Total Loans | 42.08 | 42.86 | 42.97 | 42.98 |
| Farm Production Loans, mil | 34.10 | 40.031 | 35.19 | 31.78 |

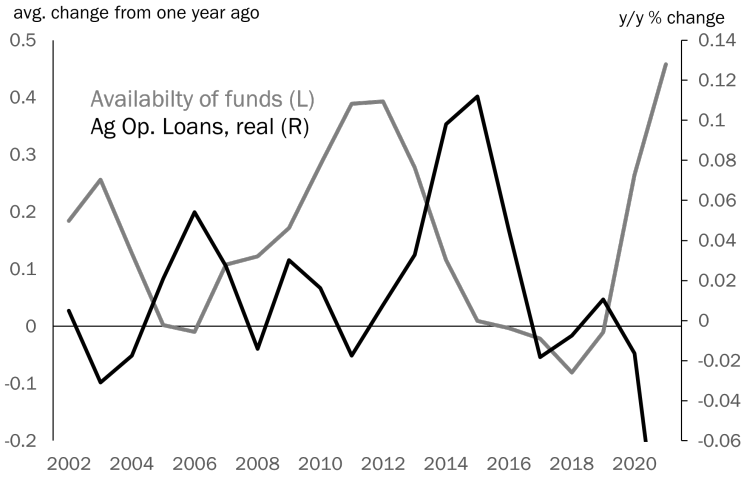
Table A5: Additional Sample Statistics by Federal Reserve District

| District | Number of Year-Quarter in sample | Number of unique banks | Avg. growth non-real op. loans |
|---|---|---|---|
| Chicago | 76 | 482 | 4.3 |
| Minneapolis | 74 | 166 | 3.5 |
| Kansas City | 78 | 380 | 3.0 |

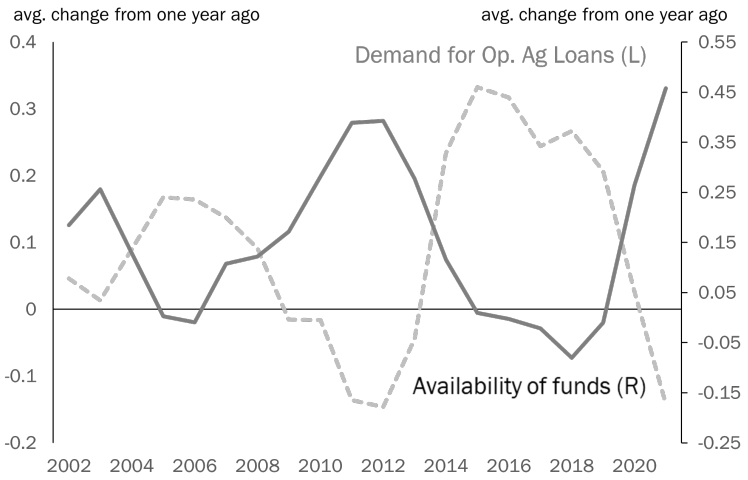
**The dynamics of availability of funds** Throughout the main text we made reference to correlations between availability of funds and changes in deposits. Change in availability of funds co-moves with changes in deposit, but it is countercyclical to the growth rate of non-real-estate agricultural loans and demand for agricultural operational loans.




(a) Δ funds and % change in deposits




(b) Δ funds and % change in non-real-estate ag loans




(c) Δ funds and Δ Demand

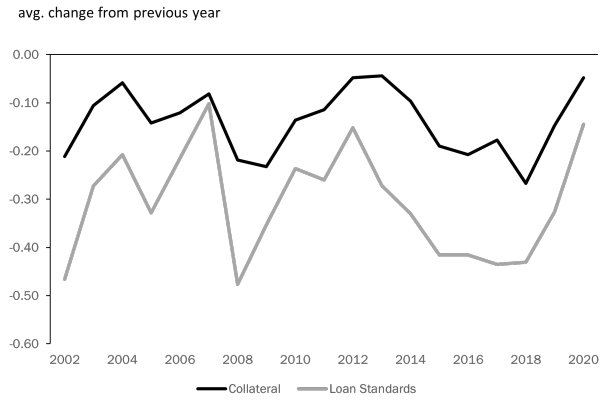
Figure A1: Change in availability of funds and other variables

**Alternative measures of supply lead to theoretical inconsistent movements in agricultural loan volume** Figure A2 plots each of the candidate proxies along with the mean changes in loan standards using the fourth quarter responses to the Federal Reserve Bank of Chicago's *Land Values and Credit Conditions* survey. The variation in the availability of funds also exhibit a similar pattern as changes in loan standards (panel A2b), yet the average bank reports higher availability of funds since 2002. As shown in Figure A1a, changes in the availability of funds are highly correlated with year-over-year changes in total deposits. While changes in total deposits may be related to the supply of agricultural credit, the relationship is likely muted. Deposits may be used to provide short-run liquidity to mitigate a bank's financial risks or may be used to fund projects and investments outside of the agricultural sector. For example, quarterly call report data suggest that commercial real estate has become a large portion of the asset portfolio of agricultural banks over recent decades (Scott, 2023). In fact, Figure A1c suggests that agricultural banks' availability of funds is countercyclical to changes in the demand for agricultural loans, indicating that this higher availability of funds may be deployed to other sectors of the economy.

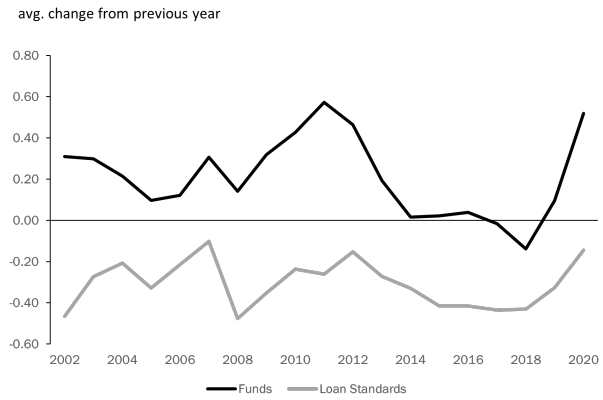
Finally, changes in loan repayment also mirror changes in loan standards (panel A2c), yet loan repayment rates were positive for a number of years. Repayments fell most drastically after 2012, alongside a steep decline in commodity prices.

Alternative measures (funds available, repayment rates, and the average of possible supply measures) suggest that the growth in loan volumes are negatively associated with higher availability of funds and loan repayment rates. These coefficient estimates are counter to the relationships suggested by the banking literature, yet the counterintuitive finding is supported by the means depicted in figure 1. First, the availability of funds does not vary in the same direction as changes in loan standard, the *status quo* measure of loan supply in previous studies. Instead, the availability of funds is correlated (correlation coefficient of 0.7) with changes in overall bank deposits (as shown in figure A1a). Thus, the availability of funds likely reflects the perception of funds available that are *not necessarily committed* to new non-real-estate agricultural loans. In addition, the estimated coefficient on "pure" changes in supply is smaller in absolute value than the estimated coefficient on "pure" changes in demand. Thus, conditioned on demand, bank characteristics, and macroeconomic conditions, an expansion in the availability of funds acts as a drag on the growth in non-real-estate agricultural loans. A similar argument can be made for the impact of repayment rates, which have a similar moderating effect on loan growth. Intuitively, the additional funds from timely or early repayment represent a flow of new funds to the banks, but, on the margin, these funds may not be allocated to agricultural non-real-estate loans. Altogether, these are not measures that likely reflect changes in supply conditions. Collateral requirements are more correlated with the Chicago's Fed measure of changes in standard of loans, and have the same directional variation across time. That is why collateral requirements is our preferred specification.

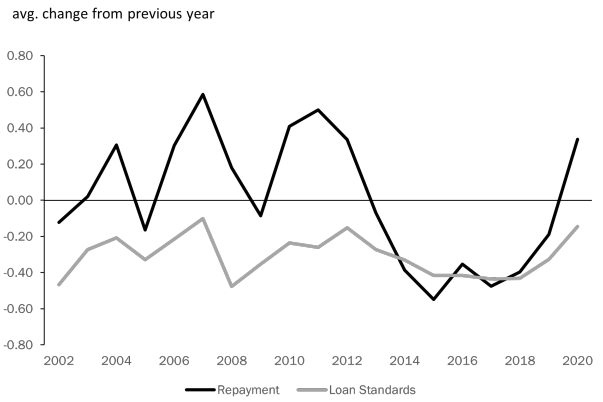
We also construct a measure of excess demand by subtracting banks reported changes in collateral requirements from their reported changes in demand. For example, a bank that reported an increase in demand (encoded in our dataset as 1) and tighter supply conditions (encoded in our dataset as –1), would have "excess demand" encoded as $1-(-1)=2$ in our dataset. Conversely, a bank that reported a decline in demand and looser supply conditions, would not have an "excess demand" as $-1-(1)=-2$. As expected, these measures largely




(a) $\Delta$ collateral and $\Delta$ in loan std.




(b) $\Delta$ availability of funds and $\Delta$ in loan std.




(c) $\Delta$ repayment and $\Delta$ in loan std.

Figure A2: Possible proxies for loan standard based on Chicago Survey data

agree with the main conclusion of the paper.

For each specification, the residuals from our first stage estimates provide a measure of "pure" supply and demand changes and are plugged into the second-stage regression that also contains the same control variables.

Table A6: Changes in Demand, 1st stage

| | S = Funds | S = Repay | S = Avg. | Excess Demand |
|---|---|---|---|---|
| Change Demand, lag | 0.1132*** | 0.1174*** | 0.1085*** | |
| | (0.0085) | (0.0084) | (0.0082) | |
| Change Supply | -0.2795*** | -0.2330*** | -0.5500*** | |
| | (0.0144) | (0.0130) | (0.0246) | |
| Change Excess Demand, lag | | | | 0.1304*** |
| | | | | (0.0081) |
| Asset Size, log | -0.0527** | -0.0626*** | -0.0700*** | -0.0388 |
| | (0.0208) | (0.0212) | (0.0210) | (0.0279) |
| Liquid Asset Ratio | 0.0018** | 0.0018** | 0.0026*** | 0.0012 |
| | (0.0008) | (0.0008) | (0.0008) | (0.0013) |
| Equity to Capital Ratio | 0.0063* | 0.0054 | 0.0063* | 0.0012 |
| | (0.0035) | (0.0034) | (0.0034) | (0.0049) |
| Share of Ag Loans | -0.0015 | -0.0023** | -0.0026*** | -0.0013 |
| | (0.0009) | (0.0010) | (0.0009) | (0.0014) |
| Branch answered (1/0) | 0.1651*** | 0.1550*** | 0.1662*** | 0.1412* |
| | (0.0576) | (0.0564) | (0.0544) | (0.0755) |
| g.r. Fed Funds | -0.2823*** | -0.2152*** | -0.2173*** | -0.3038*** |
| | (0.0397) | (0.0414) | (0.0390) | (0.0584) |
| Change Vix | 0.0081 | 0.0021 | 0.0018 | 0.0130** |
| | (0.0052) | (0.0051) | (0.0050) | (0.0066) |
| Change GDP expec. | -0.0001*** | $-3.52 \times 10^{-5}$ | $1.38 \times 10^{-5}$ | -0.0004*** |
| | $(4.84 \times 10^{-5})$ | $(4.86 \times 10^{-5})$ | $(4.84 \times 10^{-5})$ | $(7.57 \times 10^{-5})$ |
| Change U.S. Treasury expec. | 0.7201*** | 0.4091*** | 0.3395** | 1.164*** |
| | (0.1519) | (0.1534) | (0.1484) | (0.2232) |
| Observations | 31,720 | 31,720 | 31,720 | 31,720 |
| $R^2$ | 0.23571 | 0.23088 | 0.25106 | 0.24373 |
| Adjusted $R^2$ | 0.20794 | 0.20294 | 0.22385 | 0.21628 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Each column refers to a potential measure of supply. $S = average$ refers to an average of collateral, funds, and repayment in the surveys. *Excess demand* refers to the measures of demand in surveys minus the measures of supply. All models estimated as linear square dummy variables (LSDV) model and include bank fixed-effects (FE) and year-quarter FE. *Branch answered* controls for the answers that given by loan officers at branches rather than headquarters.

Table A7: Changes in Demand, 1st stage

| | S = Funds | S = Repay | S = Avg. |
|---|---|---|---|
| Change Demand | -0.1552*** | -0.1600*** | -0.1131*** |
| | (0.0085) | (0.0092) | (0.0053) |
| Change Supply, lag | 0.1335*** | 0.1100*** | 0.1492*** |
| | (0.0098) | (0.0083) | (0.0089) |
| Asset Size, log | -0.0218 | -0.0626*** | -0.0394*** |
| | (0.0135) | (0.0165) | (0.0087) |
| Liquid Asset Ratio | 0.0010 | 0.0019*** | 0.0018*** |
| | (0.0007) | (0.0007) | (0.0004) |
| Equity to Capital Ratio | 0.0048* | 0.0014 | 0.0026 |
| | (0.0029) | (0.0031) | (0.0016) |
| Share of Ag Loans | -0.0006 | -0.0037*** | -0.0020*** |
| | (0.0006) | (0.0008) | (0.0004) |
| Branch answered (1/0) | 0.0449 | 0.0196 | 0.0294 |
| | (0.0342) | (0.0475) | (0.0229) |
| g.r. Fed Funds | -0.0679** | 0.2447*** | 0.0864*** |
| | (0.0285) | (0.0314) | (0.0180) |
| Change Vix | -0.0008 | -0.0283*** | -0.0123*** |
| | (0.0033) | (0.0037) | (0.0021) |
| Change GDP expec. | 0.0002*** | 0.0007*** | 0.0004*** |
| | $(3.88 \times 10^{-5})$ | $(4.05 \times 10^{-5})$ | $(2.31 \times 10^{-5})$ |
| Change U.S. Treasury expec. | -0.1477 | -1.614*** | -0.7397*** |
| | (0.1151) | (0.1199) | (0.0696) |
| Observations | 31,720 | 31,720 | 31,720 |
| $R^2$ | 0.28494 | 0.31860 | 0.37262 |
| Adjusted $R^2$ | 0.25896 | 0.29384 | 0.34982 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Each column refers to a potential measure of supply. $S = average$ refers to an average of collateral, funds, and repayment in the surveys. *Excess demand* refers to the measures of demand in surveys minus the measures of supply. All models estimated as linear square dummy variables (LSDV) model and include bank FE and year-quarter FE. *Branch answered* controls for the answers that given by loan officers at branches rather than headquarters.

Table A8: Changes in non-real-estate farm loans, 2nd stage

| | S = Funds | S = Repay | S = Avg. | Excess Demand |
|---|---|---|---|---|
| Change Demand, res. | 0.0317*** | 0.0313*** | 0.0323*** | |
| | (0.0034) | (0.0034) | (0.0035) | |
| Change Supply, res. | -0.0294*** | -0.0226*** | -0.0526*** | |
| | (0.0038) | (0.0040) | (0.0074) | |
| Change Excess Demand, res. | | | | 0.0248*** |
| | | | | (0.0022) |
| Change Op. Loans, lag | -0.0979*** | -0.0984*** | -0.0982*** | -0.0978*** |
| | (0.0203) | (0.0203) | (0.0203) | (0.0203) |
| Asset Size, log | -0.2183*** | -0.2182*** | -0.2183*** | -0.2184*** |
| | (0.0295) | (0.0295) | (0.0295) | (0.0295) |
| Liquid Asset Ratio | 0.0018*** | 0.0018*** | 0.0018*** | 0.0018*** |
| | (0.0005) | (0.0005) | (0.0005) | (0.0005) |
| Equity to Capital Ratio | 0.0017 | 0.0017 | 0.0017 | 0.0017 |
| | (0.0023) | (0.0023) | (0.0023) | (0.0023) |
| Share of Ag Loans | -0.0041*** | -0.0041*** | -0.0041*** | -0.0041*** |
| | (0.0006) | (0.0006) | (0.0006) | (0.0006) |
| Branch answered (1/0) | 0.5311*** | 0.5303*** | 0.5305*** | 0.5314*** |
| | (0.0733) | (0.0728) | (0.0730) | (0.0732) |
| g.r. Fed Funds | 7.078*** | 6.149*** | 7.702*** | 6.963*** |
| | (0.9628) | (0.8354) | (1.046) | (0.9466) |
| Change Vix | -0.4379*** | -0.3834*** | -0.4716*** | -0.4304*** |
| | (0.0597) | (0.0522) | (0.0641) | (0.0586) |
| Change GDP expec. | 0.0143*** | 0.0126*** | 0.0152*** | 0.0140*** |
| | (0.0019) | (0.0017) | (0.0021) | (0.0019) |
| Change U.S. Treasury expec. | -36.27*** | -31.84*** | -38.96*** | -35.66*** |
| | (4.921) | (4.313) | (5.278) | (4.834) |
| Observations | 24,914 | 24,914 | 24,914 | 24,914 |
| $R^2$ | 0.23639 | 0.23606 | 0.23633 | 0.23632 |
| Adjusted $R^2$ | 0.20439 | 0.20404 | 0.20433 | 0.20435 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Each column refers to a potential measure of supply. $S = average$ refers to an average of collateral, funds, and repayment in the surveys. All models estimated from linear square dummy variables (LSDV) model and include bank FE and year-quarter FE. Branch answered controls for the answers that given by loan officers at branches rather than headquarters. Standard errors from cluster-bootstrap estimation of residual demand and supply produce qualitatively identical results. The inclusion of state-year-quarter FE instead of year-quarter FE leads to qualitatively identical results

# B Sensitivity of results to different choices

**Sensitivity of results to the lag structure of controls** Here we examine the sensitivity of our results to the time-varying observed bank characteristics. Instead of using a 4-period lag ($x_{it-4}$) for controls in equations 1a-2, we use 1-period lag ($x_{it-1}$). Results below show robustness of our conclusion to the choice.

Table B1: Changes in Demand, 1st stage, 1-period lag

| | S = Collateral | S = Funds | S = Repay | S = Avg. | Excess Demand |
|---|---|---|---|---|---|
| Change Demand, lag | 0.2925*** | 0.2731*** | 0.2783*** | 0.2659*** | |
| | (0.0101) | (0.0102) | (0.0099) | (0.0099) | |
| Change Supply | -0.0869*** | -0.2461*** | -0.2074*** | -0.4883*** | |
| | (0.0180) | (0.0146) | (0.0126) | (0.0244) | |
| Change Excess Demand, lag | | | | | 0.2860*** |
| | | | | | (0.0088) |
| Asset Size, log | -0.0599*** | -0.0609*** | -0.0721*** | -0.0791*** | -0.0552** |
| | (0.0194) | (0.0192) | (0.0194) | (0.0196) | (0.0259) |
| Liquid Asset Ratio | -0.0018** | -0.0005 | -0.0014* | $-8.16 \times 10^{-5}$ | -0.0040*** |
| | (0.0008) | (0.0008) | (0.0008) | (0.0008) | (0.0011) |
| Equity to Capital Ratio | 0.0058* | 0.0055* | 0.0052* | 0.0056* | 0.0046 |
| | (0.0031) | (0.0031) | (0.0030) | (0.0030) | (0.0042) |
| Share of Ag Loans | -0.0017** | -0.0017** | -0.0023*** | -0.0026*** | -0.0020* |
| | (0.0008) | (0.0008) | (0.0008) | (0.0008) | (0.0012) |
| Branch answered (1/0) | 0.1515*** | 0.1656*** | 0.1544*** | 0.1667*** | 0.1272* |
| | (0.0564) | (0.0570) | (0.0553) | (0.0549) | (0.0688) |
| g.r. Fed Funds | -1.006*** | -1.092*** | -1.114*** | -1.175*** | -0.7927*** |
| | (0.1892) | (0.1877) | (0.1882) | (0.1848) | (0.2447) |
| Change Vix | 0.0565*** | 0.0566*** | 0.0528*** | 0.0527*** | 0.0562*** |
| | (0.0100) | (0.0099) | (0.0098) | (0.0098) | (0.0124) |
| Change GDP expec. | 0.0020*** | 0.0021*** | 0.0022*** | 0.0023*** | 0.0017*** |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0005) |
| Change U.S. Treasury expec. | 1.159*** | 1.210*** | 1.151*** | 1.170*** | 1.056*** |
| | (0.1866) | (0.1849) | (0.1844) | (0.1820) | (0.2376) |
| Observations | 26,938 | 26,938 | 26,938 | 26,938 | 26,938 |
| $R^2$ | 0.27057 | 0.29533 | 0.29261 | 0.30761 | 0.32718 |
| Adjusted $R^2$ | 0.24090 | 0.26666 | 0.26384 | 0.27944 | 0.29983 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Each column refers to a potential measure of supply. $S = average$ refers to an average of collateral, funds, and repayment in the surveys. *Excess demand* refers to the measures of demand in surveys minus the measures of supply. All models estimated as linear square dummy variables (LSDV) model and include bank FE and year-quarter FE. Branch answered controls for the answers that given by loan officers at branches rather than headquarters.

Table B2: Changes in Supply, 1st stage, 1-period lag

| | S = Collateral (1) | S = Funds (2) | S = Repay (3) | S = Avg. (4) |
|---|---|---|---|---|
| Change Demand | -0.0214*** | -0.1346*** | -0.1370*** | -0.0946*** |
| | (0.0041) | (0.0085) | (0.0091) | (0.0051) |
| Change Supply, lag | 0.4059*** | 0.3158*** | 0.3051*** | 0.3694*** |
| | (0.0140) | (0.0117) | (0.0109) | (0.0104) |
| Asset Size, log | -0.0304*** | -0.0221 | -0.0596*** | -0.0357*** |
| | (0.0114) | (0.0140) | (0.0156) | (0.0077) |
| Liquid Asset Ratio | 0.0018*** | 0.0028*** | 0.0012* | 0.0017*** |
| | (0.0004) | (0.0006) | (0.0006) | (0.0003) |
| Equity to Capital Ratio | 0.0012 | 0.0018 | -0.0011 | 0.0007 |
| | (0.0017) | (0.0025) | (0.0028) | (0.0014) |
| Share of Ag Loans | -0.0017*** | -0.0004 | -0.0025*** | -0.0014*** |
| | (0.0005) | (0.0006) | (0.0007) | (0.0004) |
| Branch answered (1/0) | 0.0150 | 0.0570* | 0.0304 | 0.0320 |
| | (0.0347) | (0.0326) | (0.0445) | (0.0208) |
| g.r. Fed Funds | -0.1919* | -0.4494*** | -0.5043*** | -0.3601*** |
| | (0.1078) | (0.1361) | (0.1474) | (0.0741) |
| Change Vix | -0.0014 | 0.0094 | -0.0157** | -0.0029 |
| | (0.0047) | (0.0067) | (0.0078) | (0.0041) |
| Change GDP expec. | 0.0004* | 0.0008*** | 0.0010*** | 0.0007*** |
| | (0.0002) | (0.0003) | (0.0003) | (0.0001) |
| Change U.S. Treasury expec. | 0.0127 | 0.3241** | -0.0492 | 0.0808 |
| | (0.0978) | (0.1319) | (0.1461) | (0.0765) |
| Observations | 26,938 | 26,938 | 26,938 | 26,938 |
| $R^2$ | 0.42276 | 0.35493 | 0.37822 | 0.45233 |
| Adjusted $R^2$ | 0.39928 | 0.32869 | 0.35293 | 0.43005 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. $S = average$ refers to an avearage of the different measures of supply in the surveys. *Excess demand* refers to the measures of demand in surveys minus the measures of supply. All models estimated as linear square dummy variables (LSDV) model and include bank FE and year-quarter FE. Branch answered controls for the answers that given by loan officers at branches rather than headquarters.

Table B3: Changes in non-real-estate farm loans, 2nd stage, 1-period lag

| | S = Collateral (1) | S = Funds (2) | S = Repay (3) | S = Avg. (4) | Excess Demand (5) |
|---|---|---|---|---|---|
| Change Demand, res. | 0.0168*** | 0.0174*** | 0.0170*** | 0.0177*** | |
| | (0.0019) | (0.0020) | (0.0020) | (0.0020) | |
| Change Supply, res. | 0.0024 | -0.0158*** | -0.0108*** | -0.0270*** | |
| | (0.0032) | (0.0023) | (0.0021) | (0.0042) | |
| Change Excess Demand, res. | | | | | 0.0140*** |
| | | | | | (0.0013) |
| FarmProductionLoans_gr_real_lg | 0.7312*** | 0.7312*** | 0.7313*** | 0.7314*** | 0.7311*** |
| | (0.0237) | (0.0237) | (0.0236) | (0.0237) | (0.0237) |
| Asset Size, log | -0.0175** | -0.0175** | -0.0176** | -0.0175** | -0.0175** |
| | (0.0083) | (0.0083) | (0.0084) | (0.0084) | (0.0083) |
| Liquid Asset Ratio | 0.0004** | 0.0004** | 0.0004** | 0.0004** | 0.0004** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Equity to Capital Ratio | 0.0027** | 0.0027** | 0.0027** | 0.0027** | 0.0027** |
| | (0.0012) | (0.0012) | (0.0012) | (0.0012) | (0.0012) |
| Share of Ag Loans | -0.0013*** | -0.0013*** | -0.0013*** | -0.0013*** | -0.0013*** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Branch answered (1/0) | 0.0600*** | 0.0599*** | 0.0600*** | 0.0599*** | 0.0600*** |
| | (0.0190) | (0.0190) | (0.0191) | (0.0191) | (0.0190) |
| g.r. Fed Funds | -0.0211 | -0.0210 | -0.0210 | -0.0210 | -0.0202 |
| | (0.0417) | (0.0421) | (0.0422) | (0.0424) | (0.0418) |
| Change Vix | 0.0027** | 0.0027** | 0.0027** | 0.0027** | 0.0027** |
| | (0.0012) | (0.0012) | (0.0013) | (0.0013) | (0.0012) |
| Change GDP expec. | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Change U.S. Treasury expec. | -0.1521*** | -0.1528*** | -0.1530*** | -0.1530*** | -0.1520*** |
| | (0.0487) | (0.0489) | (0.0490) | (0.0491) | (0.0485) |
| Observations | 23,334 | 23,334 | 23,334 | 23,334 | 23,334 |
| $R^2$ | 0.59289 | 0.59334 | 0.59307 | 0.59330 | 0.59334 |
| Adjusted $R^2$ | 0.57493 | 0.57540 | 0.57511 | 0.57536 | 0.57541 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Each column refers to a potential measure of supply. $S = average$ refers to an average of collateral, funds, and repayment in the surveys. All models estimated from linear square dummy variables (LSDV) model and include bank FE and year-quarter FE. Branch answered controls for the answers that given by loan officers at branches rather than headquarters.

**Sensitivity of results to choice of fixed effects** The results below replace year-quarter fixed effects with state × year-quarter fixed effects. Results remain qualitatively the same, as shown by tables B4 to B6.

Table B4: Changes in Demand, 1st stage with the inclusion of State-Year-Quarter fixed effects

| | Change Demand | | | | Excess Demand |
|---|---|---|---|---|---|
| | S = Collateral | S = Funds | S = Repay | S = Avg. | |
| Change Demand, lag | 0.1195*** | 0.1062*** | 0.1095*** | 0.1013*** | |
| | (0.0087) | (0.0085) | (0.0084) | (0.0084) | |
| Change Supply | -0.0958*** | -0.2678*** | -0.2297*** | -0.5416*** | |
| | (0.0191) | (0.0142) | (0.0130) | (0.0248) | |
| Change Excess Demand, lag | | | | | 0.1223*** |
| | | | | | (0.0082) |
| Constant | 0.5542 | 0.3249 | 0.5837 | 0.3497 | 1.499* |
| | (0.5168) | (0.4937) | (0.5378) | (0.5134) | (0.8191) |
| Asset Size, log | -0.0544** | -0.0554** | -0.0622*** | -0.0702*** | -0.0389 |
| | (0.0226) | (0.0220) | (0.0223) | (0.0222) | (0.0297) |
| Liquid Asset Ratio | 0.0019** | 0.0021** | 0.0021** | 0.0028*** | 0.0014 |
| | (0.0009) | (0.0008) | (0.0009) | (0.0008) | (0.0013) |
| Equity to Capital Ratio | 0.0033 | 0.0043 | 0.0030 | 0.0042 | -0.0026 |
| | (0.0036) | (0.0036) | (0.0035) | (0.0035) | (0.0052) |
| Share of Ag Loans | -0.0018* | -0.0018* | -0.0022** | -0.0025*** | -0.0015 |
| | (0.0010) | (0.0010) | (0.0010) | (0.0009) | (0.0014) |
| Branch answered (1/0) | 0.1753*** | 0.1784*** | 0.1657*** | 0.1754*** | 0.1728** |
| | (0.0608) | (0.0600) | (0.0595) | (0.0578) | (0.0785) |
| g.r. Fed Funds | 0.3200 | 0.4596** | 0.4417** | 0.5776*** | -0.2498 |
| | (0.2114) | (0.2109) | (0.2159) | (0.2146) | (0.3133) |
| Change Vix | 0.0899*** | 0.0947*** | 0.1096*** | 0.1129*** | 0.0752** |
| | (0.0246) | (0.0247) | (0.0245) | (0.0247) | (0.0296) |
| Change GDP expec. | 0.0015 | 0.0021** | 0.0020* | 0.0027** | -0.0012 |
| | (0.0011) | (0.0011) | (0.0011) | (0.0011) | (0.0017) |
| Change U.S. Treasury expec. | -1.042 | -1.965 | -1.595 | -2.493 | 2.655 |
| | (1.561) | (1.480) | (1.601) | (1.528) | (2.524) |
| Observations | 31,720 | 31,720 | 31,720 | 31,720 | 31,720 |
| Adjusted $R^2$ | 0.19001 | 0.22085 | 0.21662 | 0.23581 | 0.23288 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Each column refers to a potential measure of supply. $S = average$ refers to an average of collateral, funds, and repayment in the surveys. *Excess demand* refers to the measures of demand in surveys minus the measures of supply. All models estimated as linear square dummy variables (LSDV) model and include bank FE and state × year-quarter FE. Branch answered controls for the answers that given by loan officers at branches rather than headquarters.

Table B5: Changes in Supply, 1st stage with the inclusion of State-Year-Quarter fixed effects

| | S = Collateral | S = Funds | S = Repay | S = Avg. |
|---|---|---|---|---|
| Change Demand | -0.0246*** | -0.1504*** | -0.1526*** | -0.1086*** |
| | (0.0046) | (0.0085) | (0.0090) | (0.0052) |
| Change Supply, lag | 0.1922*** | 0.1302*** | 0.1002*** | 0.1407*** |
| | (0.0124) | (0.0100) | (0.0084) | (0.0090) |
| Constant | -0.2527** | -0.8285* | 0.2319 | -0.2808 |
| | (0.1086) | (0.4278) | (0.4854) | (0.2552) |
| Asset Size, log | -0.0337*** | -0.0236* | -0.0528*** | -0.0367*** |
| | (0.0120) | (0.0143) | (0.0177) | (0.0095) |
| Liquid Asset Ratio | 0.0024*** | 0.0010 | 0.0019*** | 0.0017*** |
| | (0.0005) | (0.0007) | (0.0006) | (0.0004) |
| Equity to Capital Ratio | 0.0015 | 0.0059* | 0.0007 | 0.0028* |
| | (0.0019) | (0.0030) | (0.0031) | (0.0016) |
| Share of Ag Loans | -0.0015** | -0.0006 | -0.0027*** | -0.0016*** |
| | (0.0006) | (0.0007) | (0.0008) | (0.0004) |
| Branch answered (1/0) | 0.0230 | 0.0320 | -0.0086 | 0.0156 |
| | (0.0384) | (0.0350) | (0.0509) | (0.0250) |
| g.r. Fed Funds | 0.2403*** | 0.5880*** | 0.5778*** | 0.4661*** |
| | (0.0929) | (0.1542) | (0.1793) | (0.0935) |
| Change Vix | 0.0171 | 0.0266 | 0.0977*** | 0.0474*** |
| | (0.0108) | (0.0176) | (0.0205) | (0.0096) |
| Change GDP expec. | 0.0011** | 0.0028*** | 0.0026*** | 0.0022*** |
| | (0.0005) | (0.0008) | (0.0009) | (0.0005) |
| Change U.S. Treasury expec. | -1.383** | -3.764*** | -2.579* | -2.568*** |
| | (0.6401) | (1.229) | (1.392) | (0.7662) |
| Observations | 31,720 | 31,720 | 31,720 | 31,720 |
| $R^2$ | 0.34904 | 0.31477 | 0.37789 | 0.42095 |
| Adjusted $R^2$ | 0.29978 | 0.26293 | 0.33083 | 0.37714 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. $S = average$ refers to an avearage of the different measures of supply in the surveys. *Excess demand* refers to the measures of demand in surveys minus the measures of supply. All models estimated as linear square dummy variables (LSDV) model and include bank FE and state × year-quarter fixed effects. Branch answered controls for the answers that given by loan officers at branches rather than headquarters.

Table B6: Changes in non-real-estate farm loans, with the inclusion of State-Year-Quarter fixed effects

| | S = Collateral | S = Funds | S = Repay | S = Avg. | Excess Demand |
|---|---|---|---|---|---|
| Change Demand, res. | 0.0284*** | 0.0296*** | 0.0292*** | 0.0301*** | |
| | (0.0032) | (0.0033) | (0.0033) | (0.0034) | |
| Change Supply, res. | 0.0050 | -0.0281*** | -0.0215*** | -0.0492*** | |
| | (0.0071) | (0.0039) | (0.0039) | (0.0074) | |
| Change Excess Demand, res. | | | | | 0.0234*** |
| | | | | | (0.0023) |
| Constant | 1.846*** | 1.870*** | 1.857*** | -2.314*** | -2.535*** |
| | (0.2924) | (0.2967) | (0.2957) | (0.3155) | (0.3439) |
| FarmProductionLoans_gr_real_lg | -0.0960*** | -0.0959*** | -0.0964*** | -0.0963*** | -0.0959*** |
| | (0.0203) | (0.0204) | (0.0203) | (0.0205) | (0.0204) |
| Asset Size, log | -0.2202*** | -0.2204*** | -0.2204*** | -0.2204*** | -0.2205*** |
| | (0.0296) | (0.0296) | (0.0296) | (0.0297) | (0.0296) |
| Liquid Asset Ratio | 0.0020*** | 0.0020*** | 0.0020*** | 0.0020*** | 0.0020*** |
| | (0.0005) | (0.0005) | (0.0005) | (0.0005) | (0.0005) |
| Equity to Capital Ratio | 0.0009 | 0.0008 | 0.0009 | 0.0009 | 0.0008 |
| | (0.0023) | (0.0023) | (0.0023) | (0.0023) | (0.0023) |
| Share of Ag Loans | -0.0043*** | -0.0043*** | -0.0043*** | -0.0043*** | -0.0043*** |
| | (0.0006) | (0.0006) | (0.0006) | (0.0006) | (0.0006) |
| Branch answered (1/0) | 0.5445*** | 0.5453*** | 0.5442*** | 0.5445*** | 0.5456*** |
| | (0.0708) | (0.0710) | (0.0708) | (0.0712) | (0.0709) |
| g.r. Fed Funds | 2.061*** | 2.121*** | 2.130*** | 24.26*** | 25.47*** |
| | (0.3081) | (0.3175) | (0.3186) | (3.388) | (3.539) |
| Change Vix | 0.1434*** | 0.1479*** | 0.1487*** | -1.403*** | -1.471*** |
| | (0.0246) | (0.0253) | (0.0255) | (0.1954) | (0.2040) |
| Change GDP expec. | 0.0047*** | 0.0048*** | 0.0048*** | 0.0412*** | 0.0432*** |
| | (0.0007) | (0.0007) | (0.0007) | (0.0058) | (0.0060) |
| Change U.S. Treasury expec. | -6.817*** | -6.952*** | -6.988*** | -113.3*** | -118.9*** |
| | (0.9915) | (1.011) | (1.017) | (15.85) | (16.54) |
| Observations | 24,914 | 24,914 | 24,914 | 24,914 | 24,914 |
| $R^2$ | 0.28763 | 0.28888 | 0.28829 | 0.28291 | 0.28662 |
| Adjusted $R^2$ | 0.22362 | 0.22498 | 0.22434 | 0.21848 | 0.22255 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Each column refers to a potential measure of supply. $S = average$ refers to an average of collateral, funds, and repayment in the surveys. All models estimated from linear square dummy variables (LSDV) model and include bank FE and state-year-quarter FE. Branch answered controls for the answers that given by loan officers at branches rather than headquarters.

**Sensitivity of the result to Federal Reserve Bank sample** We test the sensitivity of results by Federal Reserve Bank survey. Results qualitatively hold as shown in table B7.

Table B7: Regression results by Federal Reseerve Bank District

| Dependent variable: Change in Demand | Chicago | Kansas City | Minneapolis |
|---|---|---|---|
| Change Demand, lag | 0.1069*** | 0.1434*** | 0.1221*** |
| | (0.0136) | (0.0134) | (0.019) |
| Change Supply | -0.0884*** | -0.0808*** | -0.1974*** |
| | (0.0328) | (0.0272) | (0.0472) |
| Observations | 11,278 | 14,591 | 5,851 |
| Adjusted R2 | 0.18808 | 0.16275 | 0.19268 |
| Dependent variable : Change in supply | Chicago | Kansas City | Minneapolis |
| Change Demand | -0.0228*** | -0.0228*** | -0.0390*** |
| | (0.0078) | (0.0071) | (0.0095) |
| Change Supply, lag | 0.1746*** | 0.2146*** | 0.1812*** |
| | (0.0211) | (0.0188) | (0.0311) |
| Observations | 11,278 | 14,591 | 5,851 |
| Adjusted R2 | 0.288 | 0.290 | 0.261 |
| Dependent variable: Change in Ag. Op. Loans | Chicago | Kansas City | Minneapolis |
| Change Demand, res. | 0.0283*** | 0.0332*** | 0.0262*** |
| | (0.0064) | (0.0039) | (0.0072) |
| Change Supply, res. | -0.0082 | 0.0131 | -0.0071 |
| | (0.0124) | (0.0104) | (0.0124) |
| Observations | 8,120 | 12,043 | 4,751 |
| Adjusted R2 | 0.13277 | 0.2528 | 0.28487 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Note: All specifications include bank FE and year-quarter FE, and the controls describe in the main text: Asset Size, Liquid Asset Ratio, Equity to Capital Ratio, Share of Ag Loans, Branch, change in Fed Funds, Change in VIX, Change in GDP Expectations, Change in US Treasury Yield Expectations.

**Sensitivity of the results to inclusion of lags in the first stage** We test the sensitivity of the main results to the inclusion of different lag structures in the first-stage estimations. Results qualitatively hold as shown in tables B8 and B9.

Table B8: Regression results using Collateral Requirement Change as supply, and lag of demand and supply in the first stage

| Demand | | Supply | | Change Ag Op. Loans | |
|---|---|---|---|---|---|
| Change Demand, lag | 0.1289*** | Change Demand, lag | 0.0011 | Change Demand, res. | 0.0302*** |
| | (0.0086) | | (0.0038) | | (0.0032) |
| Change Supply, lag | 0.0454*** | Change Demand | -0.0263*** | Change Supply, res. | 0.0014 |
| | (0.0138) | | (0.0046) | | (0.007) |
| Change Supply | -0.1124*** | Change Supply, lag | 0.1933*** | | |
| | (0.019) | | (0.0127) | | |
| Observations | 31,720 | | 31,720 | | 24,914 |
| Adjusted R2 | 0.174 | | 0.292 | | 0.202 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Note: All specifications include bank FE and year-quarter FE, and the controls describe in the main text: Asset Size, Liquid Asset Ratio, Equity to Capital Ratio, Share of Ag Loans, Branch, change in Fed Funds, Change in VIX, Change in GDP Expectations, Change in US Treasury Yield Expectations.

Table B9: Regression results using Collateral Requirement Change as supply, and distributed lags in the first stage

| Demand | | Supply | | Change Ag Op. Loans | |
|---|---|---|---|---|---|
| Change Supply | -0.1136*** | Change Demand | -0.0251*** | Change Demand, res. | 0.0306*** |
| | (0.0197) | | (0.0048) | | (0.0033) |
| Change Supply, lag | 0.0338** | Change Demand, lag | -0.0036 | Change Supply, res. | 0.0013 |
| | (0.0144) | | (0.0041) | | (0.0070) |
| Observations | 31,720 | | 31,720 | 24,914 | |
| Adjusted $R^2$ | 0.161 | | 0.263 | 0.197 | |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Note: All specifications include bank FE, and year-quarter FE, and the controls describe in the main text: Asset Size, Liquid Asset Ratio, Equity to Capital Ratio, Share of Ag Loans, Branch, change in Fed Funds, Change in VIX, Change in GDP Expectations, Change in US Treasury Yield Expectations.

**Sensitivity of results to bank type.** Policymakers may be interested in the sensitivity of our results to the type of banks offering non-real-estate agricultural credit. Although we control for the share of agricultural loans in the first-stages of estimation in the main specification, we provide some evidence in table B10 that demand conditions matter more for banks with higher share fo agricultural loans.

Table B10: Regression results using Collateral Requirement Change as supply, and interacting residualized supply and demand changes with share of agricultural loans

| | Change Demand (1) | Change Supply (2) | Change Op. Loans (3) |
|---|---|---|---|
| Change Supply | -0.1033*** | | |
| | (0.0193) | | |
| Change Supply, lag | | 0.1945*** | |
| | | (0.0128) | |
| Change Demand, lag | 0.1279*** | | |
| | (0.0086) | | |
| Change Demand | | -0.0260*** | |
| | | (0.0047) | |
| Change Demand, res. | | | 0.0147 |
| | | | (0.0109) |
| Change Supply, res. | | | 0.0259 |
| | | | (0.0228) |
| Change Demand, res. × Share of Ag Loans | | | 0.0004* |
| | | | (0.0002) |
| Change Supply, res. × Share of Ag Loans | | | -0.0006 |
| | | | (0.0004) |
| Observations | 31,720 | 31,720 | 24,914 |
| Adjusted $R^2$ | 0.174 | 0.291 | 0.188 |

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Note: All specifications include bank FE, and year-quarter FE, and the controls describe in the main text: Asset Size, Liquid Asset Ratio, Equity to Capital Ratio, Share of Ag Loans, Branch, change in Fed Funds, Change in VIX, Change in GDP Expectations, Change in US Treasury Yield Expectations.

**Sensitivity of results to estimator choice** The lag structure and the possibility of too few time periods in relation to the number of banks suggest the possibility of dynamic panel bias. We know that using the within estimator to eliminate fixed effects does not solve the dynamic bias, as the lagged dependent variables correlate with the transformed errors. To deal with this issue, we employ the strategy of first-differencing the data and instrumenting the endogenous variables with higher-order lags, as in Arellano and Bond (1991). We present these results in table B11.

Dynamic panel models require assumptions regarding which variables to include in the model, and their status in relation to the error term. The lags of variables that are determined before that of the realization of the contemporaneous error term (and its first difference in time, following Arellano and Bond (1991)) are predetermined. Predetermination implies moment conditions which researchers can incorporate in to a Generalized Method of Moments (GMM) estimator. A GMM estimator can also incorporate strictly exogenous variables. Endogenous variables must be instrumented by lags of variables that are valid.

Economic theory offers little guidance for specifying dynamic panel models and researchers use assumptions and heuristics to define an appropriate model. Kiviet (2020) offers a battery of tests that practitioners can use to build a better dynamic model. We follow his advice whenever sample size permits. We start with a set of assumptions that

we believe true or are appropriate as a robustness check. We assume exogeneity of the control variables and assume a year lag structure for the dependent variable of our model. We instrument the dependent variable with 6 (demand model) and 8 (supply model) lags. This specification beats others as it provides a combination of tests results that suggest our first-stage models are well-specified. Hansen tests, AR(2) tests, and difference-in-Hansen tests are estimated to have $p-$values above or close 0.20 in the first-stage. There is some evidence of AR(2) behavior in the 2nd-stage, which is expected for outstanding loans given persistence of loans with different maturities in the balance sheet of banks. Call reports do not contain information about the average maturity in portfolios; we believe that the evidence of AR(2) behavior in the 2nd-stage does not significantly cloud the evidence for demand-driving growth of farm loans (unless growth rate of 2 years is serially correlated with contemporaneous changes in demand). Despite possible bias in the second stage, results are qualitatively and quantitatively similar to the model estimated in the main text.

Table B11: Demand, Supply, and growth in non-real-estate farm loans

| | Supply | Demand | g.r. non-real estate loans |
|---|---|---|---|
| Demand | -0.042 | | 0.048** |
| | (0.039) | | (0.019) |
| Supply, lag | 0.149*** | | |
| | (0.020) | | |
| Supply | | -0.071 | 0.004 |
| | | (0.108) | (0.037) |
| Demand, lag | | 0.180*** | |
| | | (0.015) | |
| g.r. non-real estate loans, lag | | | 0.293*** |
| | | | (0.040) |
| Observations | 19269 | 19269 | 19251 |
| AR(1) | -11.981 | -15.787 | -7.612 |
| p-value | 0.000 | 0.000 | 0.000 |
| AR(2) | 0.815 | -0.399 | -2.888 |
| p-value | 0.415 | 0.690 | 0.004 |

*p<0.1; **p<0.05; ***p<0.01. Robust Standard errors. All models estimated from GMM and include bank FE and year-quarter FE, macroeconomic controls, and bank-specific controls as in the main text, unless discarded by taking first differences in the dynamic panel setting, like branch status.