ISSN 1936-5330

kcFED Research Working Papers

The Supply and Demand of Agricultural Loans

Francisco Scott, Todd H. Kuethe, Ty Kreitman, and David Oppedahl

July 2022
RWP 22-06
http://doi.org/10.18651/RWP2022-06

Federal Reserve Bank of Kansas City

The Supply and Demand of Agricultural Loans

Francisco Scott[1], Todd H. Kuethe[2], Ty Kreitman[1], and David Oppedahl[3]

[1] Federal Reserve Bank of Kansas City
[2] Purdue University
[3] Federal Reserve Bank of Chicago
July 8, 2022

Abstract

Credit plays a critical role in the agricultural sector, but many studies suggest that farmers are credit constrained. We examine the degree to which changes in non-real-estate agricultural loans at commercial banks are driven by changes in supply and demand, using information provided by agricultural lending surveys conducted by the Federal Reserve Banks of 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 1,024 banks across 191 quarters (2002:Q1–2021:Q2). The survey responses provide instruments of "pure" supply and demand changes that allow us to examine fluctuations in bank-level agricultural loan volumes. We find that changes in the volume of non-real-estate farm loans at commercial banks are principally driven by changes in excess demand for loans. In addition, we demonstrate that excess loan demand is countercyclical to aggregate farm income.

Keywords: agricultural lending, credit demand, credit supply, bank lending survey
JEL Codes: E51, G21, Q14

The views expressed here are the opinions of the authors only and do not necessarily represent those of the Federal Reserve Bank of Kansas City or the Federal Reserve System. All remaining errors are our responsibility.

1 Introduction

Credit plays a critical role in the agricultural sector. Farmers rely on external debt capital, in combination with owners' equity, 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). Credit rationing may limit farmers' ability to accumulate capital and suppress aggregate farm output (Barry et al., 2000; Briggeman et al., 2009). Blancard et al. (2006) outlines a number of reasons why credit constraints and rationing may be severe in the agricultural sector: (i) there is a substantial lag between purchasing inputs and selling outputs, (ii) farm-specific capital is inflexible, (iii) the direct link between private wealth and farm capital limits the possibilities of providing collateral, and (iv) most farms are relatively small.

Credit rationing occurs because the market for loans is not like the market for physical commodities. 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. 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 a result, loan rates do not behave the same way as "prices" in standard markets. Loan rates may fail to equate supply and demand for loans, and credit may be allocated independent of interest rates (Laffont and Garcia, 1977; Stiglitz and Weiss, 1981). Previous research suggests that credit rationing, independent of interest rates, may be particularly pronounced in sectors like agricultural production, where borrowers have limited access to other forms of debt capital, such as bonds (Khwaja and Mian, 2008). As such, Hubbs and Kuethe (2017) demonstrate that agricultural credit markets fluctuate between periods of excess supply and excess demand.

Given the prominent role of credit in the agricultural sector and prior evidence that farmers may be credit constrained, this study examines the degree to which agricultural loan volumes are driven by changes in supply and demand. Our empirical approach builds on recent studies of credit market supply and demand that rely on information from 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). Loan officer opinion surveys provide information to central banks on the supply and demand of credit to assist monetary policy decisions.

In a similar fashion, we exploit the unique advantages of an unbalanced panel of responses from surveys of agricultural bankers conducted by three Federal Reserve Banks: Chicago, Kansas City, and Minneapolis. We match these survey responses to administrative data on agricultural loan volumes and bank characteristics obtained from the Federal Financial Institutions Examination Council (FFIEC) quarterly "call reports."

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. As Turvey and Weersink (1997, pp. 202) note, "a meaningful portrayal of loan demand cannot be viewed in isolation of lender supply, and *vice versa*." Loan officer opinion surveys collect qualitative information of respondents' perception of changes in the demand for credit, as well as changes in the supply for credit, as captured by changes in credit standards. Given that loan rates do not act in the same way as prices in standard markets, lenders compete through credit standards (Jaffee and Stiglitz, 1990). As outlined by Lown and Morgan (2006, pp. 1577) credit standards refer to "any of the various non-price lending terms specified in the typical bank business loan or line of credit: collateral, covenants, loan limits, etc." Credit standards are important for general economic activity, as banks systematically tighten or ease credit standards over a business cycle to reflect changes in lending policies (Asea and Blomberg, 1998).

Loan officer surveys collect qualitative information on the degree to which lending conditions have tightened or eased. Aggregate responses to loan officer opinion surveys, therefore, provide "a reasonable index for the full vector of non-price lending terms" (Lown and Morgan, 2006, pp. 1577). As such, aggregate responses to 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). More recent studies rely on individual responses to loan officer surveys to create orthogonal measures of both credit supply and demand through instrumental variable techniques (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).

Given credit's role in the agricultural economy, a number of studies examine credit market frictions in farm lending. Early studies use structural models of the agricultural sector to estimate the demand and/or supply of credit (Hesser and Schuh, 1962; Melichar, 1973; Boyette and White, 1987). More recent studies use measures of credit constraints obtained from surveys of farmer-borrowers (Petrick, 2004; Foltz, 2004; Briggeman et al., 2009). Most recently, Kandilov and Kandilov (2018) exploit the variation caused by changes in interstate banking regulation to captures changes in the supply of agricultural credit.

This study makes a number of contributions to our understanding of agricultural credit markets. First, we show that changes in the volume of non-real estate farm loans at commercial banks are principally driven by changes in excess loan demand. Contrary to prior findings of credit rationing, we find no empirical evidence that agricultural lending volumes are linked to changes in supply conditions. These findings are robust to a number of modeling choices. Second, through counterfactual analysis, we estimate the expected change in non-real estate loan volume if demand were to remain constant. The periods of excess demand are consistent with prior structural models (Hubbs and Kuethe, 2017). The counterfactual analysis suggests particularly high demand for loans when aggregate farm income declines, which suggests the demand for debt capital is counter-cyclical to farm income. The counter-cyclical relationship between farm income and loan demand is consistent with prior findings of income and investment smoothing in the agricultural sector (Whitaker, 2009) and the inverse relationship between income and credit use (Prager, Burns, and Miller, Prager et al.; Fiechter and Ifft, 2022).

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 summary of our data. Section 4 describes our estimation approach. Section 5 summarizes our key findings. Section 6 concludes with a discussion of policy implications, limitations of our study, and suggestions for future research.

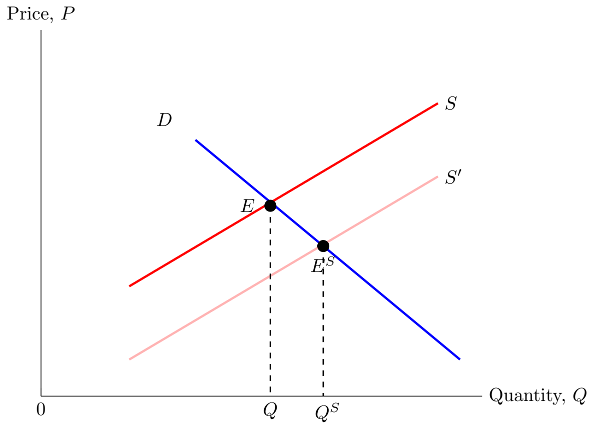
2 Conceptual Model

Identifying the effect that supply and demand have on the changes in agricultural loan volumes requires (i) a measure of changes in supply independent of demand and (ii) a measure of changes in demand independent of supply. Identifying the impact of supply and demand on different outcomes has been central to applied economics since, at least, Haavelmo (1943). The traditional approach to identify a demand curve based on observed prices and quantities relies on exogenous shocks that shift or rotate the supply curve, such as shocks on marginal costs of production. Similarly, a supply curve can be identified by exogenous shocks that shift or rotate the demand curve, such as income shocks (see Wright, 1915; Berry and Haile, 2014; Lewbel, 2019, for a discussion).

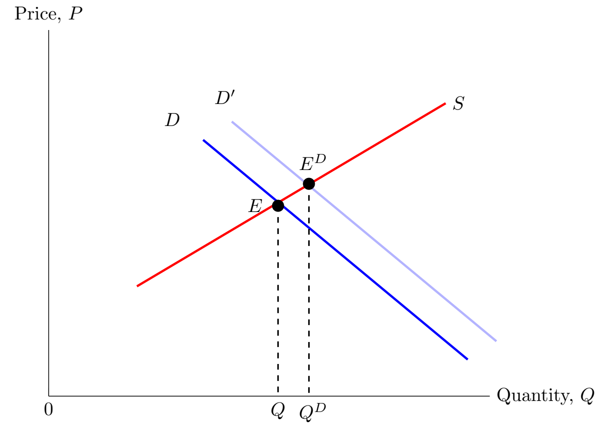
A different approach can be employed if the goal is to understand the degree to which changes in demand and supply impact an outcome. The effect of demand changes on an outcome can be identified by holding the effect of supply changes constant. Similarly, the effect of supply changes in an outcome can be identified by holding the effect of demand changes constant. This is depicted in figure 1. In the absence of changes in demand between two periods in time, as shown in panel 1(a), a rightward shift in supply moves equilibrium from point E to point E', and the change in amount of loan $Q^S - Q$ can be solely attributed to a supply shock. From a modelling perspective, panel 1(a) implies that projecting the change in loan quantities on the change in supply identifies the "pure" effect of supply change on loan change, conditional on steady demand. The same argument applies for "pure" changes in demand conditions, as shown in panel 1(b). Projecting the change in loan quantity ($Q^D - Q$) on demand changes (D to D') identifies the "pure" effect of demand changes on the growth of loans, conditional on a steady supply .

But we seldom observe steady demand or supply conditions over a significant period in the market for agricultural loans. The supply and demand for agricultural credit changes as the result of shifts in monetary policy (Barnett, 2000), agricultural policy (Ifft et al., 2015), and farm incomes (Katchova, 2005). Panel 1(c) shows the consequences for identification. The total change in the volume of agricultural loans when both supply and demand move can be represented by the change in equilibrium from E to E^{SD}. This movement, for which the total change in loan volume is $Q^{SD} - Q$, does not correspond to the "pure" demand change (E to E^D) nor to the "pure" supply change (E to E^S). Rather, a demand change has a direct and an indirect effect on equilibrium displacement. The direct effect corresponds to the movement from E to E^D, as in the "pure" movement represented in panel 1(a). The indirect effect corresponds to the movement from E^S to E^{SD}, which represents the indirect impact of demand after a change in supply. Similarly, the direct impact of supply corresponds to the displacement E to E^D and the indirect impact from E^D to E^{SD}.

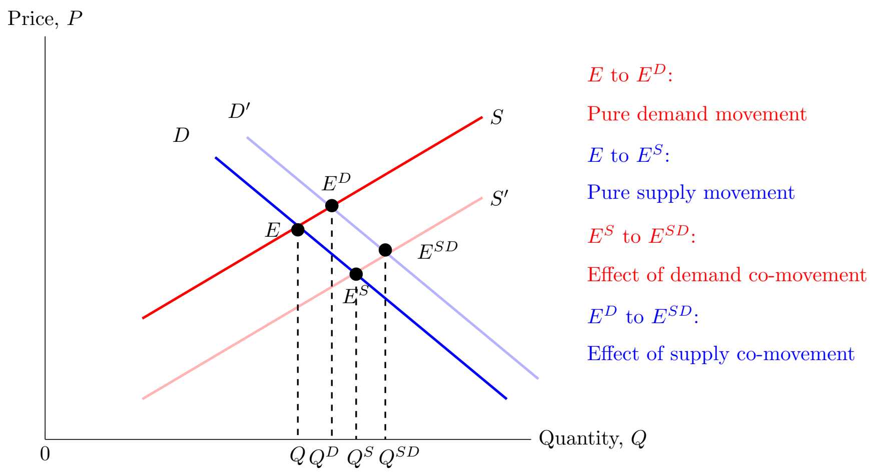
Capturing the *direct* effect of changes in supply or demand requires partialling out the *indirect* effect from the total effect. As formalized by Bassett et al. (2014), our identification strategy first captures the co-movement between supply and demand, the movement from Q^D to Q^{SD} for demand and the movement from Q^S to Q^{SD} for supply. We then partial out the effects of that co-movement from the observed changes in supply and demand. Finally, we regress observed changes in agricultural loan volumes on our estimates of the "pure" effect of supply and demand. Specific features of our data and empirical approach are discussed in detail in the following sections.



(a) Effect of supply shift



(b) Effect of a demand shift



(c) Effect of a demand and supply shift

Figure 1: Effects of Supply or Demand changes

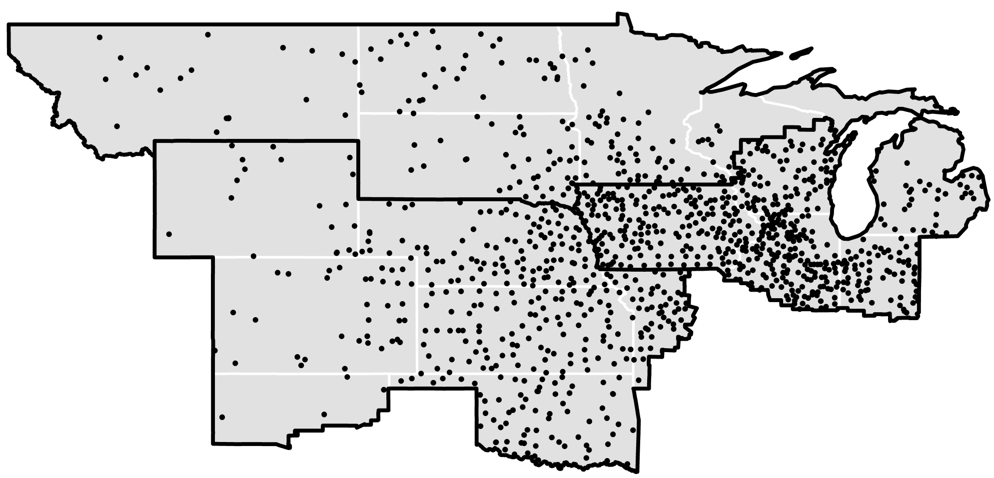
3 Data

Our empirical approach builds on recent studies of credit market supply and demand that exploit information from 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). We obtain data pertaining to bank defined levels of loan demand and credit supply from quarterly surveys of agricultural credit conditions at commercial banks conducted by the Federal Reserve Banks of Kansas City, Minneapolis and Chicago. As shown in Figure 2, our study area spans the entirety of 12 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.

The Federal Reserve Bank of Kansas City's Survey of Agricultural Credit Conditions

(Kansas City Survey), Federal Reserve Bank of Minneapolis's Agricultural Credit Conditions Survey (Minneapolis Survey), and Federal Reserve Bank of Chicago's Land Values and Credit Conditions Survey (Chicago Survey) collect information on current and expected credit market conditions and agricultural land values from agricultural bankers throughout each respective District. As of June 30, 2021, approximately 80 percent of commercial banks with agricultural loans representing at least 25% of total loans were headquartered in these three Districts (Federal Financial Institutions Examinations Council, 2021).

The surveys are conducted each quarter and include a set of questions that remain constant and a series of special questions that vary over time. The responses are gathered via a link to an online surveying tool or through the mail. Each survey is completed by an executive officer, loan officer, or an equivalent position. The three surveys differ in the specific topics covered, the wording of questions, and set of banks covered. Since the second quarter of 2002, the Kansas City and Minneapolis Surveys are identical in topics and wording of all questions, while the Chicago Survey differs in certain aspects. Importantly, the source question for the data employed in this research are identical. The surveys also differ in sample size and the characteristics of the banks responding to the survey and these factors have changed over time as a result of bank consolidation and other factors.



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

Figure 2: Study Area and Respondent Banks

The population of each of the three surveys include all member banks with a presence in their respective districts that could be classified as "agricultural banks." The definition of agricultural banks, however, varies slightly across the three surveys and through time. A detailed description of the differences in both survey and respondent characteristics across the three surveys is presented in subsections 3.1 – 3.3. The surveys include a number of branch locations of banks that are headquartered outside of each respective district. The dots in Figure 2 represent the approximate location of each respondent in our sample, as defined by the centroid of the zip code of each respondent bank office.

3.1 Chicago Survey

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. The initial survey population included all member banks at which farm loans as a share of total loans exceeded a threshold that was established in 1972 (Federal Reserve Bank of Kansas City, 2019). A threshold of 25 per cent was applied in all states except Michigan, where a threshold of 10 per cent was applied. The sample has undergone periodic review and, since 2015, has included approximately 550 banks with about 150 banks responding in each quarter. As of June 30, 2021, approximately 28% 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).

3.2 Kansas City Survey

The Federal Reserve Bank of Kansas City is the Federal Reserve's Tenth District and includes western Missouri, northern New Mexico, and the complete states of Nebraska, Kansas, Oklahoma, Wyoming, and Colorado. The survey was revised in the second quarter of 2002 with changes to wording and removal of certain questions and has since remained consistent. Currently, about 70 percent of responses are gathered via a link to an online surveying tool sent by email and 30 percent are gathered via mail. The original sample chosen in 1976 had 181 banks selected from banks at which farm loans constituted 50 percent or more of total loans, with appropriate representation of all farm areas. The sample was redrawn and significantly expanded in 1987, with agricultural banks defined as having more than approximately 15 percent of their total loans in farm loans. Given further concentration of commercial banks in recent years, the sample is currently not defined by a percentage threshold of farm loans and now includes any commercial bank or branch of a commercial bank that has an operational presence of agricultural lending that allows an executive officer or senior loan officer to accurately assess the conditions described in the survey. In some instances, multiple branches of a single bank with distinct lending territories respond separately to the survey. The sample has undergone periodic review and, since 2015, has included approximately 275 banks, with about 150-200 banks responding in each quarter. As of June 30, 2021, approximately 30%

of commercial banks with agricultural loans representing at least 25% of total loans were headquartered in the Tenth District (Federal Financial Institutions Examinations Council, 2021).

3.3 Minneapolis Survey

The Federal Reserve Bank of Minneapolis is the Federal Reserve's Ninth District and includes Minnesota, Montana, North and South Dakota, 26 counties in northwestern Wisconsin, and the Upper Peninsula of Michigan. Currently, about 70 percent of responses are gathered via a link to an online surveying tool sent by email and 30 percent are gathered via mail. Before 1987, the sample provided a cross-section of banks of all sizes that were engaged in farm lending. Members of the Upper Midwest Agricultural Credit Council formed the core of the survey panel. In 1987, the sample was redrawn to include only banks at which farm loans represented 25 percent or more of total loans.

The Minneapolis survey changed considerably beginning in the first quarter of 1994 and was again revised in the second quarter of 2002. The changes included wording and removal of certain questions, but it has since remained consistent. Given further concentration of commercial banks in recent years, the sample is no longer defined by a percentage threshold of farm loans and now includes any commercial bank or branch of a commercial bank that has an operational presence of agricultural lending that allows an executive officer or senior loan officer to accurately assess the conditions described in the survey. In some instances, multiple branches of a single bank with distinct lending territories respond separately to the survey. The sample has undergone periodic review and, since 2015, has included approximately 130 banks, with about 60-75 banks responding in each quarter. As of June 30, 2021, approximately 20 percent of commercial agricultural banks (banks with agricultural loans representing at least 25% of total loans) were headquartered in the Ninth District (Federal Financial Institutions Examinations Council, 2021).

3.4 Sample Characteristics

Drawing from the three surveys, we construct a quarterly, unbalanced panel of responses that greatly exceeds those of prior studies, in terms of both time period and number of respondents. Our unbalanced panel includes responses from 1,024 banks across the three surveys and spans quarter 1 of 2002 to quarter 2 of 2021 (191 quarters). Del Giovane et al. (2011) examine an unbalanced panel of 11 banks in Italy over 29 quarters (2002Q4 – 20009Q4), Van der Veer and Hoeberichts (2016) an unbalance panel of 8 banks in the Netherlands over 42 quarters (2003Q1 – 2013Q2), Pintaric (2016) an unbalance panel of 27 banks in Croatia over 14 quarters (2012Q3 – 2015Q4), Altavilla et al. (2021) an unbalance panel of 116 Euro-area banks across 13 countries over 61 quarters (2002Q4 – 2017Q4), and Hogg et al. (2021) an unbalanced panel of an unreported number of banks in Canada for 10 quarters (2007Q3 – 2009Q4). Our panel consists of 32,143 bank-quarter observations, compared to Vojtech et al. (2020), which examine 4,600 bank-quarter observations from U.S. mortgage lending institutions over 94 quarters (1990Q3 – 2013Q4).

Our measures of supply and demand conditions for agricultural loans are taken from a common set of questions across the three surveys, that are similar to the qualitative questions in loan officer opinion surveys examined by previous studies (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). Changes in supply and demand condition are obtained from the questions: *What changes occurred in non-real-estate farm loans at your bank in the previous three months compared to the same months a year ago?* for which the respondents answer whether *Demand for loans* was *Higher*, *No change*, or *Lower* and then whether *Amount of collateral required* was *Higher*, *No change*, or *Lower.* The Chicago survey question is slightly different. It asks *What changes occurred in non-real-estate farm loans at your bank in the past three months relative to a year earlier?* and the respondents chooses between *Higher*, *Same*, or *Lower*. The minor differences are assumed to have no meaningful impact on the differences of responses. It is important to note that the question is limited to "non-real-estate" lending, which is better characterized as a flow variable when compared to the long-term nature of mortgage credit, which is more appropriately characterized as a stock variable (Hubbs and Kuethe, 2017).

Figure 3 plots the share of respondents for each qualitative response for both our measures of farm loan demand (a) and supply (b). Within quarters, most lenders indicate demand and supply conditions to be unchanged in relation to the same quarter in the previous year. The proportion of respondents reporting unchanged conditions for demand corresponds to 50% of the total, while respondents reporting unchanged conditions for supply varies between 75% to 90% of the total. Lenders report changes in demand conditions more often than changes in supply conditions, and only a small proportion of lenders report lower collateral requirements.

It is important to note, that in contrast to prior studies, our measure of loan supply is determined by changes in a single measure of lending standards – the amount of collateral required. Loan officer opinion surveys, such as SLOOS or BLS, generally ask about changes in credit standards more broadly to include "any of the various non-price lending terms specified in the typical bank business loan of line of credit: collateral, covenants, loan limits, etc. (Lown and Morgan, 2006, pp. 1577)." Thus, the amount of collateral required is a

(a) Variation of demand change

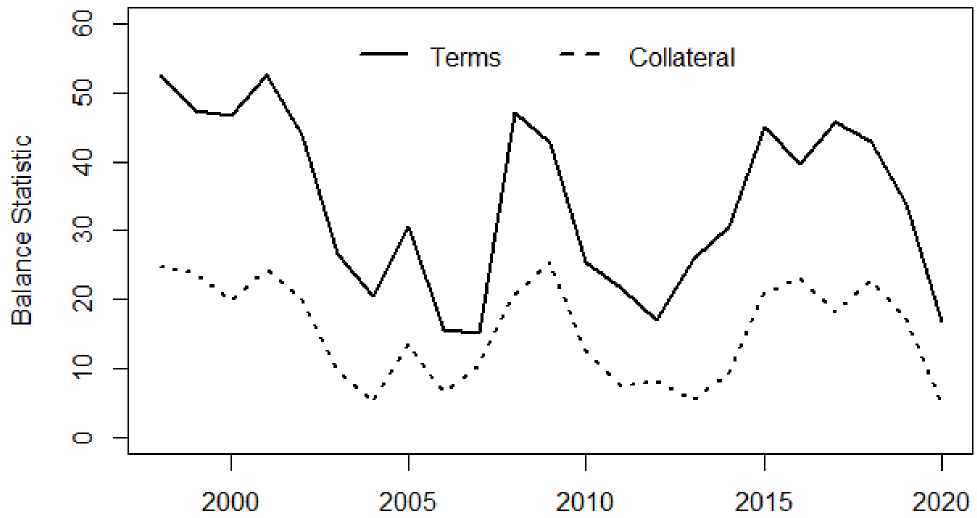
(b) Variation of supply change

Figure 3: Proportion of Banks' answers regarding demand and supply conditions

subset of the terms considered in previous studies. We argue that this difference should not substantially impact our empirical estimates, given the prevalence of collateralized lending in the agricultural sector. According to a survey of a representative sample of commercial agricultural lenders, approximately 96% of agricultural loans made by commercial banks from 2001 to 2021 were secured with collateral (Federal Reserve Bank of Kansas City, 2021).

To ensure that our results are not influenced by our definition of lending standards, we conduct a battery of robustness checks which are discussed in greater detail later and in an appendix. We explore two alternative definitions of credit supply. First, we exploit the unique characteristics of the Chicago survey. The Chicago survey includes a special question that is asked once a year that is similar to the more general credit standards questions common in loan officer opinion surveys. Lenders are asked *How have your credit standards for approving agricultural loans during the past three months changed relative to a year earlier?* and they can choose from five options: *Tightened considerably*, *Tightened somewhat*, *Remained basically unchanged*, *Eased somewhat*, *Eased considerably*. The Chicago Survey includes the question 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 both the amount of collateral required and "credit standards" more generally.

Figure 4 plots the balance statistic for both measures of credit supply from 1998 to 2020. For the more general terms question (solid line), the balance statistic is calculated as the share of respondents who report tightened considerably or tightened somewhat less the share of respondents who report eased somewhat or eased considerably (% tightened – % eased). For the amount of collateral required (dotted line), the balance statistic is calculated as the share of respondents reporting higher less the share of respondents reporting lower (% higher – % lower). For both series, a positive balance statistic represents tighter credit standards.



Source: Federal Reserve Bank of Chicago

Figure 4: Balance Statistics for Lending Terms and Collateral Requirement, 1998–2020

Figure 4 suggests that the two measures show similar patterns. The Pearson correlation coefficient for the two series is 0.92 and is statistically significant at 1%. However, the balance statistic for terms generally exceeds that of the amount of collateral required, which may suggest a tighter credit market. To ensure that our primary findings are robust to our definition of credit standards, we replicate our empirical analysis but limit our observations to responses to the Chicago survey that answer both questions. As shown in the the appendix, the empirical results are qualitatively similar with minor quantitative differences across the two sets of questions.

Our second alternative measure of credit supply follows Castro et al. (2022). One major concern with the use of collateral required as a measure of supply is limited variability of responses, as shown in figure 3, compared measures of supply reported in previous studies of more broadly defined loan markets. Following Castro et al. (2022), we use the principal component of several measures associated with supply: repayments, renewals and extensions, amount of collateral, and availability of funds. As shown in detail in our appendix, the principal component measure also suggests that demand is the primary driver of the growth rate of agricultural loans.

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. Table 1 details a description of each variable and also includes the corresponding identifier(s) utilized by the Federal Reserve Board of Governors Micro Data Reference Manual (MDMR).

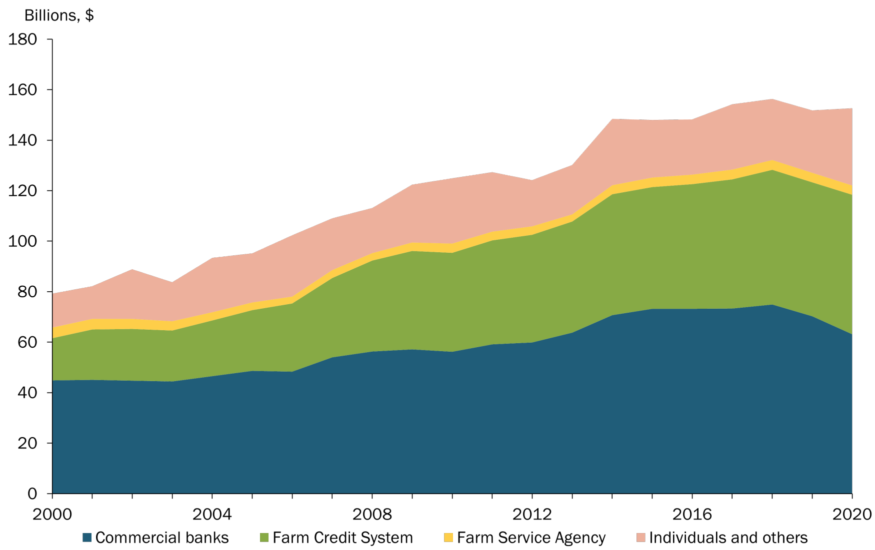
Table 1 summarizes the key variables considered in our empirical model of agricultural loan supply and demand. Our primary variable of interest is the volume of quarterly bank-specific non-real estate agricultural loans. Changes in supply and demand are encoded on a numerical scale varying from 1 to 3. On the demand side, tightening of demand conditions takes the value of 1, while loosening of demand conditions takes the value of 3. No changes take the value of 2. On the supply side, tightening of supply conditions takes the value of 3, loosening takes the value of 1, and no changes takes the value of 2. The encoding reflects the fact that higher collateral requirements implies tightening conditions. Our analysis also includes important bank characteristics that may impact lending activity. These variables show that our sample consists of small banks with relatively liquid balance sheets and whose loan activity is largely focused on agriculture.

Finally, it is important to note that our analysis of agricultural loan volumes is, by definition, limited to loans supplied by commercial banks. Agricultural producers, however, obtain non-real estate loans from a variety of lenders. According to the USDA, commercial banks provide between 41.4% to 56.6% of all non-real estate loans between 2000 and 2020 (USDA Economic Research Service, 2021). As shown in Figure 5, non-real estate debt from commercial banks increased by 40.7%, from $40.7 billion to $63.1 billion between 2000 and 2020.[1]

[1]It is important to note that USDA changed its definition of lender categories in 2012. Beginning in 2012, farm sector debt held by savings associations is classified under commercial banks instead of the "individuals and others" category.

Table 1: Summary statistics of key variables

Variable	Mean	Std. Dev.	Description	MDMR Identifier
Non-Real Estate Ag. Loans ($ mil.)	38	186	Loans to finance agricultural production and other loans to farmers	rcfd1590
ΔDemand	2.095	0.683	Encoded survey answers where 1 means lower 2 means no change, and 3 means higher	–
ΔSupply	2.142	0.358	Encoded survey answers where 1 means lower 2 means no change, and 3 means higher	–
Asset Size ($ mil.)	2,036	28,336	Sum of all asset items	rcfd2170
Ratio Liquid Asset to Total Asset	20.931	13.860	Earning assets minus net loans and leases and pledged securities divided by the sum of all asset items	ubpre123 less ubpre119 less ubpr0416 divided by ubpr2170
Ratio Equity Capital to Assets	11.284	3.329	Total equity capital as a percent of the sum of all asset items	rcfd3210 divided by rcfd2170
Ratio Ag. Loans to Total Loans	39.236	21.085	Sum of real estate loans secured by farmland and loans to finance agricultural production and other loans to farmers as a percent of total loans and leases, net of unearned income	sum of rcon1420 and rcfd1590 divided by rcfd2122
Fed Funds Rate	1.442	1.611	Target interest rate	–



Source: USDA Economic Research Service (2021)

Figure 5: Farm non-real estate debt by lender type, 2000–2020

4 Methods

The conceptual model presented in section 2 informs the ways we can leverage the data discussed in section 3 to identify the impact of changes in demand and supply on changes in agricultural loans. Figure 1 shows that the impact of supply on agricultural loans cannot be disentangled from effects of demand, unless one accounts for the co-movement between supply and demand. The same is true for the effects of demand on loans, as it can only be determined after we take into account the co-movement between supply and demand. The first stage of our identification strategy, then, is to partial out (i) the co-movement of demand from supply and (ii) the co-movement of supply from demand. The second stage of our identification strategy uses the measures of supply and demand resulting from the first stage and examines their impact on agricultural loans.

The panel we constructed using the Federal Reserve agricultural lending surveys allows us to measure the degree to which bank-specific movements in supply vary with demand. To do so, we follow the literature and assume a model in which supply changes linearly with changes in demand, bank characteristics, and macroeconomic conditions (Del Giovane et al., 2011; Bassett et al., 2014; Altavilla et al., 2021), as shown in the reduced-form equation:

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

where i indexes a bank, and t indexes a year-quarter pair. Besides changes in demand, the model captures the general path of supply in a quarter by including a one year lag of change in supply. We include the year lag (captured by the index $t-4$) instead of a quarter lag since the surveys ask banks specifically about the changes in supply conditions in relation to the same quarter of the previous year. Equation (1), then, assumes that the realization of the change in supply conditions over a quarter can be influenced by the change in conditions of the same quarter during the previous year. The 4-quarter lag is justified under the assumption that respondents use the same quarter of the previous year as reference point when answering the survey questions. Since these reference points impact the answers of both the current quarter and the same quarter during the previous year, we include the lag as described in the equations. All of the bank-specific control variables are also lagged.[2]

We control for several observable bank characteristics (x^k_{it-4})and time-invariant bank characteristics by adding bank fixed effects. We also include macroeconomic conditions (x^w_t) by adding the growth rate of the Federal Funds Rate (averaged over the quarter) over the same quarter of the previous year, a quarter fixed effects to control for seasonality, and a year-quarter fixed effect. The remaining variation, therefore, is capture by ε_{it}.

The parameter α_1 describes the co-movement between supply and demand. Empirically, we use changes in collateral requirement as the supply measure (see section 3), such that higher values of this measure implies leftward shifts in supply. Because of that, $\alpha_1 < 0$ implies that a positive shift in demand leads to a shift in the same direction in supply, implying a cyclical behavior between supply and demand. But if $\alpha_1 > 0$, a positive shift in demand leads to a shift of supply in the opposite direction, implying a countercyclical behavior between supply and demand. Notice also that ε_{it} is the share of demand that, conditional on bank characteristics and macroeconomic conditions, cannot be explained by changes in demand. That would be the "pure" shift in supply as described by figure 1(a).

Similarly, we can compute how movements in supply impact movements in demand by estimating:

$$\Delta Demand_{it} = \alpha_1 \Delta Supply_{it} + \sum_k \theta_k^{demand} x^k_{it} + \sum_w \theta_w^{demand} x^w_t + \gamma_i + \gamma_t + \nu_{it}. \tag{2}$$

Equation (2) follows a similar specification as (1) as we project changes in demand conditions onto the same changes in supply, a year lag of changes in demand conditions, and the same control variables $\{x^k, x^w\}$. Again, $\alpha_2 < 0$ reflects cyclical behavior between demand and supply, and $\alpha_2 > 0$ a countercyclical behavior between them. The residual ν_{it} represents the part of demand that cannot be explained by changes in supply, and thus the "pure" demand

[2]The supplemental appendix shows that results on the parameters of interest remains largely unchanged when we consider 1-quarter lag structure.

as described in figure 1b.

Armed with measures of the change in supply ($\hat{\varepsilon}_{it}$) and demand ($\hat{\nu}_{it}$) that have taken into account the co-movement between them, we estimate the impact of changes in demand and supply in the growth rate of agricultural loans. More specifically, we regress the growth rate of agricultural loans, y_{it}, on $\hat{\varepsilon}_{it}$ and $\hat{\nu}_{it}$ and the same macroeconomic conditions and bank specific variables in (1) and (2). We include the 4-quarter lag in equation 3 because we assume that changes in demand and supply conditions are part of the data generating process of agricultural loans, as are their 4-quarter lag. Conditional on this assumption, agricultural loans of same quarter during the previous year influence agricultural loans of the current quarter. The model is expressed:

$$y_{it} = \omega_1 \hat{\nu}_{it} + \omega_2 \hat{\epsilon}_{it} + \sum_k \theta_k^{loan} x_{it}^k + \sum_w \theta_w^{loan} x_t^w + \gamma_i + \gamma_t + \xi_{it} \tag{3}$$

where the parameters of interest are ω_1 and ω_2, and ξ refers to the structural residual. We now turn to the results.

5 Results

The estimation results of our first-stage supply and demand equations (1) and (2) are reported in tables 2 and 3, respectively.[3] As discussed previously, the primary goal of the first-stage regressions is to obtain measures of "pure" shifts in supply or demand, or the share of supply or demand that, conditional on bank characteristics and macroeconomic conditions, is independent of the co-movement between supply and demand. Previous microeconomic studies of loan officer opinion surveys generally suggest a positive correlation between loan supply and demand in the general economy (Bassett et al., 2014; Altavilla et al., 2021). The positive correlation between loan supply and demand is driven by fluctuations in broader economic conditions. During business cycle expansions, the balance sheet of potential borrowers improve, and banks tend to ease lending standards, as consumers and firms demand more credit (Dell'Ariccia and Marquez, 2006; Rodano et al., 2018). The inverse happens during business cycle contractions.

The first-stage coefficient estimates, however, suggest that the supply and demand for non-real estate farm loans at commercial banks are negatively correlated. The coefficient estimates in the first row of table 2 suggest that collateral requirements are positively associated with the demand for loans. Similarly, the coefficient estimates in the first row of table

[3]The Supplemental Appendix shows results are robust to other definitions of supply, as discussed in Section in section 3.4, robust to subsampling, and robust to a dynamic panel setting.

3 suggest that loan demand is positively associated with increasing collateral requirements. Thus, lending terms are expected to tighten as loan demand increases. In both first-stage regressions, the estimated coefficients are robust to conditioning on path of supply change for the quarter (i.e., lagged supply change), to conditioning on bank characteristics and branch status of the Survey respondent (columns 1), to conditioning on bank characteristics, branch status, and interactions that capture the importance of agriculture to the bank (column 2), and to conditioning on bank characteristics and macroeconomic conditions, as captured by the growth rate of the Federal Funds Rate in relation to the same quarter of the previous year (column 3).

While this finding is counter to previous studies of credit supply and demand in the broader economy, it is consistent with prior studies of the role of non-real estate loans in the agricultural economy. When commodity prices fall, financially vulnerable farms seek to increase non-real estate debt, increasing the demand for credit (Prager, Burns, and Miller, Prager et al.; Fiechter and Ifft, 2022). To agricultural lenders, a decrease in commodity prices may signal an increase probability of default, which may encourage increasing collateral requirements. Also, previous studies suggest that farmers may use credit to smooth consumption over time, which implies that as farm income increases, the demand for agricultural loans decreases (Whitaker, 2009). Together, the responses of agricultural sector borrowers to business cycle fluctuations can lead to a negative correlation between demand and supply in a given quarter, in contrast to the positive correlation between supply and demand for credit found in the broader economy.

Table 2: Supply regression

	Change in Supply		
	(1)	(2)	(3)
Change in Demand	0.026***	0.027***	0.026***
	(0.005)	(0.005)	(0.005)
Change in Supply, Lag	0.194***	0.193***	0.194***
	(0.012)	(0.012)	(0.012)
Log Asset Size	0.033***	0.026*	0.033***
	(0.011)	(0.014)	(0.012)
Ratio Liquid-Total Asset	–0.003***	–0.003***	–0.003***
	(0.0005)	(0.001)	(0.0005)
Ratio Equity-Captial	–0.001	–0.004	–0.001
	(0.002)	(0.004)	(0.002)
Ratio Ag-Total Loans	0.002***	–0.002	0.002***
	(0.001)	(0.004)	(0.001)
Growth rate mean Fed Funds			–0.166***
			(0.023)
Branch	–0.022	–0.022	–0.022
	(0.035)	(0.035)	(0.035)
Asset Size × Ratio AgLoans		0.0002	
		(0.0003)	
Liquid-Total × Ratio AgLoans		0.00001	
		(0.00002)	
Equity-Capital × Ratio AgLoans		0.0001	
		(0.0001)	
Constant			1.135***
			(0.165)
Bank FE	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Observations	32,143	32,143	32,143
Between R^2	0.66	0.66	
Within R^2	0.06	0.06	
R^2			0.319
F Statistic	225.986***	158.682***	13.067***

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. The first 2 columns are estimated via two-way within estimator. The third model is estimated via a linear dummy model to preserve the Fed Funds Rate variable.

In summary, banks overwhelmingly perceive changes in supply and demand for agricultural loans as moving in opposite directions. If the supply and demand for agricultural loans move in opposite directions, the effects of supply and demand shifts on agricultural loan volumes is unpredictable. A positive demand change in a quarter corresponds to a rightward shift in the demand curve and an increase in the volume of loans for that quarter, all else constant (Figure 1a). But the negative correlation between changes in supply and demand implies that the rightward shift in demand is accompanied by a leftward shift in supply, which decreases the volume of loans, all else constant. The growth in agricultural loans, therefore, will be determined by the relative intensity of the supply shift in comparison to the demand shift.

Table 3: Demand regression

	Change in Demand		
	(1)	(2)	(3)
Change in Supply	0.104***	0.105***	0.104***
	(0.019)	(0.019)	(0.019)
Change in Demand, Lag	0.129***	0.128***	0.129***
	(0.008)	(0.008)	(0.008)
Log Asset Size	–0.054***	–0.025	–0.054**
	(0.021)	(0.025)	(0.021)
Ratio Liquid-Total Asset	0.002**	0.002	0.002**
	(0.001)	(0.002)	(0.001)
Ratio Equity-Captial	0.006*	0.017***	0.006*
	(0.003)	(0.007)	(0.004)
Ratio Ag-Total Loans	–0.002*	0.013*	–0.002*
	(0.001)	(0.007)	(0.001)
Growth rate mean Fed Funds			-0.157***
			(0.050)
Branch	0.162***	0.170***	0.162***
	(0.055)	(0.056)	(0.056)
Asset Size × Ratio AgLoans		–0.001*	
		(0.001)	
Liquid-Total × Ratio AgLoans		–0.00000	
		(0.00003)	
Equity-Capital × Ratio AgLoans		–0.0003**	
		(0.0001)	
Constant			2.672***
			(0.301)
Bank FE	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Observations	32,143	32,143	32,143
Between R^2	0.47	0.48	
Within R^2	0.03	0.03	
R^2			0.20
F-Statistic	90.405***	64.983***	7.111***

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. The first 2 columns are estimated via two-way within estimator. The third model is estimated via a linear dummy model to preserve the Fed Funds Rate variable.

The results of the first-stage regressions presented in tables 1 and 2 do not aim to explain all of the factors driving changes in supply and demand. The goal of the first-stage regressions is to partial out factors that would prevent identification of the effects of change in demand and supply on changes in total loans. We do not offer a structural interpretation of the results presented in table 1 and in table 2. Rather, we interpret the results in a similar fashion to results of the first-stage of a Two-Stage Least Squares estimator in the presence of valid instruments.

The estimation results of our second-stage model of agricultural loan volumes, equation (3) are reported in table 4. The model residuals from our measures of "pure" supply and demand changes, columns 1-3 in tables 2 and 3, are plugged into the second-stage regression model that contains the same set of control variables used in the first-stage. Across the three specifications, the estimated coefficient on "pure" demand changes are statistically significant and positive, yet the estimated coefficient on "pure" supply changes are indistinguishable from zero. The result, therefore, indicate that the growth rate of non-real estate agricultural loans are mainly driven by changes in demand, rather than by changes in supply.

The estimated coefficients suggest that, when the demand for loans in a particular quarter are higher than the same quarter a year before, non-real estate farm loans are expected to increase, on average, by 3%. The finding is robust across specifications. Point estimates for supply, 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 agricultural loans. These findings contradict prior studies that suggest farmers are credit constrained. Our results suggest that loan volumes respond more, on average, to perceived changes in demand than to changes from changes in supply.

Table 4: Loan growth rate regression

	Growth rate of ag loans		
	(1)	(2)	(3)
Change in Demand, residual	0.030***	0.030***	0.030***
	(0.003)	(0.003)	(0.003)
Change in Supply, residual	–0.0001	0.0001	–0.0001
	(0.007)	(0.007)	(0.007)
Growth rate of ag loans, Lag	–0.096**	–0.098**	–0.096**
	(0.020)	(0.019)	(0.020)
Growth rate mean Fed Funds			0.186***
			(0.082)
Controls	Yes	Yes	Yes
+ Interactions	No	Yes	No
Bank FE	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Observations	25,457	25,457	25,457
Between R^2	0.23	0.24	
Within R^2	0.06	0.06	
R^2			0.23
F-Statistic	282.631***	211.092***	7.306***

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. The first 2 columns are estimated via two-way within estimator. The third model is estimated via a least squares linear dummy model to preserve the Fed Funds Rate variable. Controls and interactions are the same as first stage regressions.

5.1 Counterfactual

The dominance of demand factors over supply factors has implications for agricultural policy. Our results suggest that supply-side policies that increase loan volume (e.g., increases in competition, loose monetary policy, lower levels of regulations) would have limited impact on the the volume of farm loans offered by commercial banks. Factors that affect the demand, on the other hand, would influence the growth rate of loans. To identify periods in our sample when demand changes drove growth rate of loans, we conduct a counterfactual exercise in which, conditional on the parameters shown in table 4, we artificially hold demand constant.

A counterfactual exercise estimates the outcome of a variable of interest under a state of the world that differs from what was observed. The exercise assumes that the the parametric solutions of our model would hold under a different set of demand and supply conditions. That is, our model approximates the true data generating process of the growth rate of agricultural loans. In the period of our sample, bankers reported several changes in demand for agricultural loans. In fact, our second-stage regression (table 4) suggests that demand changes drove the observed changes in non-real estate agricultural loan volumes. Our counterfactual exercise estimates what the growth rate of agricultural loan volumes would have been if demand had remained unchanged.

The counterfactual exercise is conducted in two steps. First, we take the parametric solution of column 2 in table 4, our preferred specification, and estimate the fitted values of growth rate in loans under no change in demand — but holding everything else constant. The fitted values reveal the bank-specific growth rate of loans had the banks' perceived demand were always "No Change" throughout the observation period. Second, we subtract the counterfactual values from the bank-specific fitted values of growth rate under the factual demand changes. The result of this exercise are plotted in figure 6. The values above zero in the figure indicate periods of strong demand for loans, whereas the values below zero indicate periods of weak demand for loans.[4]

Figure 6 suggests that the effect of demand changes on the growth rate of non-real estate agricultural loans can be substantial. The USDA Economic Research Service (2021) calculates the average growth rate of non-real estate loans in commercial banks at about 6% over the period, while our sample presents a more modest average of 3.4% growth rate. These values could have been substantially different without demand changes. For example, the counterfactual exercise reveals that lack of strong demand around the the period 2002 – 2007 could have decreased the volume of agricultural loans by almost 0.5 percentage points on a quarter-over-quarter basis from an observed 3.3% growth rate during the period. The loss in volume of loans could had been even higher during the 2012 – 2018 period, with losses in agricultural volume around 0.75 percentage points from the observed 5.4% growth rate.

[4]Notice that we compute the difference between the fitted growth rate of the factual demand changes and the "No Change" counterfactual to identify years with strong demand for agricultural loans by looking at values above zero: negative values are observed in quarters in which the factual demand change is lower than the counterfactual "No Change" scenario. Negative values are observed in quarters in which the factual demand is lower than the counterfactual.

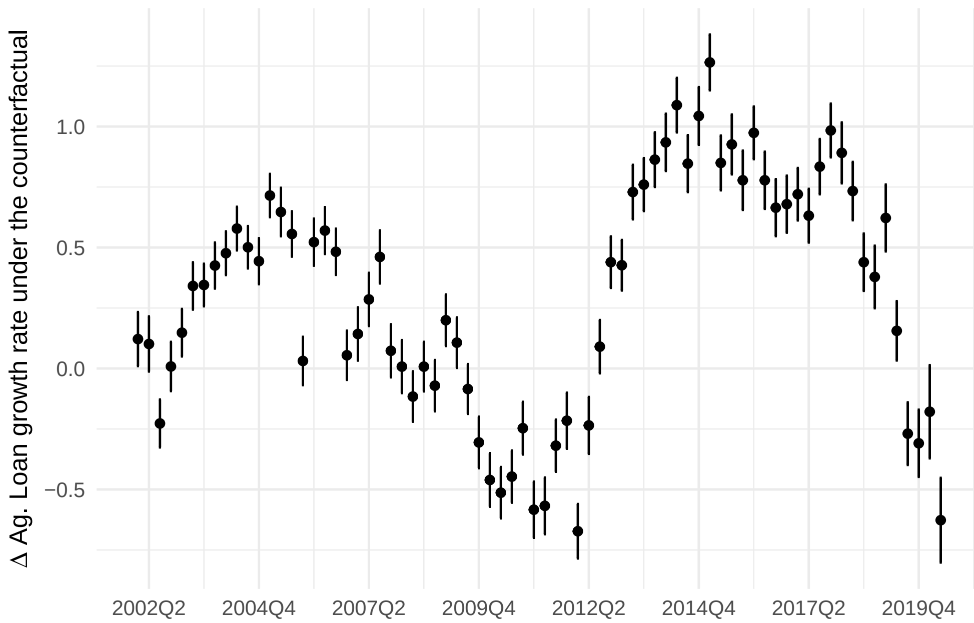


Figure 6: Average of the percentage change in agricultural loan under the counterfactual.
Notes: Values above 0 represent years under which change in demand was perceived as strong in relation to the previous year. Bars represent 95% confidence interval around the mean of the difference.

Figure 6 suggests a cyclical behavior in the counterfactual. The period 2003 – 2007 suggests strong positive changes in demand for agricultural loans, which is followed by a period of negative demand changes in 2009 – 2013. The cycle repeats itself for the period 2013 – 2019, when we see positive changes in demand, which ends before 2020. The periods of positive demand tend to be periods when real farm income was weak, and periods of weak demand changes tend to be periods when real farm income was strong.

We explore the relationship between demand for loans and farm income using the measure of pro-cyclicality developed by Harding and Pagan (2002). Their measure compares the co-movements between two series by computing their degree of concordance across cycles. Intuitively, the test computes the fraction of time that two series are jointly at the expansive phase of a cycle or jointly at the contractions phase of a cycle. The test assigns the value of 1 for each period under which a series is at the expansive phase and 0 otherwise. For series S_j (the benchmark series) and S_r (the comparison series) during time $t = 1, \ldots, T$, the test assumes the form $I_{jr} = n^{-1} \{\sum S_{jt} S_{rt} + (1 - S_{jt})(1 - S_{rt}\}$. Two series are independent if the test approaches the fraction of time that the reference series is at the expansive phase.[5] If the test is higher than this fraction, the two series behave cyclically and otherwise they

[5] The result is found over the expectation of index, $E[I_{jr}]$, and assuming both series are independent.

behave countercyclically. The test is always bounded between 0 and 1.

We use USDA's *Net Farm Income* series as our reference measure and the counterfactual[6] as the comparison series. The farm income data is reported yearly and measured in levels, while our counterfactual is computed quarterly and measured in growth rate of a year's quarter in relation to the same quarter of the previous year. To compare the two series, we average the quarterly growth rate by year to obtain the average growth over the year. Next, we convert the average yearly growth rate to an index for which 2001 equals 100. We also index net farm income in 2001 to 100. As a result, we have two series in levels for which the test is readily applicable.

Next, we have to define what constitutes a "cycle." We do so following three rules. The literature defines a cycle as a set of defined peaks and troughs (rule 1) that alternate (rule 2), over a certain duration (rule 3) (see Harding and Pagan, 2002). For quarterly data, the authors cite an algorithm that a potential peak can only happen after 2 quarters of expansion, and a potential trough can only happen after 2 quarters of contraction (rule 1). For rule number 3, the duration of a cycle would have to be at least 6 quarters. We adapt these numbers for our yearly data by defining a potential peak as happening after 1 year of expansion and a potential trough as happening after 1 year of contraction. The peaks and troughs have to alternate, and they must have a duration of at least 2 years. With the algorithm that defines the cycle selected, and both series in levels, we compute our test.

The test takes the value of 0.42. The fraction of time that farm income stays in an expansive phase is 0.63, suggesting that the two series are counter-cyclical. The counter-cyclicality of the series survives other definitions of cycle. For example, if we eliminate rule number 3, effectively rendering the test more sensitive to short term fluctuations in both series, the test still suggests counter-cyclicality between series as we compute the test value to be 0.42 and the share of farm income in an expansive cycle to be 0.53. The counter-cyclicality between demand for loans and income supports the theory that farmers also use loans as a consumption smoothing tool (Whitaker, 2009), as well as prior findings of the inverse relationship between farm income and debt use (Prager, Burns, and Miller, Prager et al.; Fiechter and Ifft, 2022). While beyond the scope of this study, future research should examine the degree to which the counter-cyclical relationship between farm income and farm loan demand is causal. Such research would better inform policy design.

Finally, we refrain from conducting a counterfactual on supply. The models presented in the *Results* section attribute most of the change in agricultural loans to changes in demand. Other measures of supply presented in the appendix suggest that the magnitude of the impact

[6]Factual fitted values minus the counterfactual fitted values. We use the inverse of the counterfactual used in Altavilla et al. (2021) for ease of exposition.

of supply on farm loans is small or not statistically distinguishable from zero. The fact that supply has a relatively limited effect on the growth rate of agricultural loans renders the counterfactual over the supply side of the market uninteresting and potentially misleading, as the point estimate for supply may not be estimated precisely in our preferred specification.

6 Conclusions

Equity and debt are central to agricultural production. But credit markets are plagued with market imperfections that may limit the scope of supply responses to demand for credit (e.g., imperfect information), or restrain demand in face of large credit availability (e.g., high liquidity in the hands of farmers). As such, this paper quantifies the impact of changes in demand and supply, individually, on the volume of non-real estate agricultural loans. We do so by constructing a novel data set that gathers measures of the changes in demand and supply conditions from surveys conducted by 3 regional Federal Reserve Banks and joins these measures with administrative data from banks' "call reports."

We use a 2-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 obtains what we call a "pure measure" of supply and demand. The second-stage regresses the growth rate of agricultural loans on these "pure measures." The first-stage of our main specification finds that demand and supply of loans are negatively correlated. The second-stage of our main specification shows that demand impacts growth rate of loans much more than supply. Specifically, the growth rate of agricultural loans would increase 3 percentage points (or 300 basis points) on average if conditions for demand improves at the margin. A marginal change in collateral requirements would decrease the growth rate of loans by 0.01 percentage point (or 1 basis point). The change in supply is imprecisely estimated.

Importantly, most studies that try to disentangle supply and demand for credit in the broader economy find that demand and supply move together with the business cycle (e.g., Altavilla et al., 2021). We show evidence that this not true for the agricultural sector. Instead, the demand for credit and farm income move counter-cyclically, and supply has a much more muted impact on the growth rate of loans than demand. Banks with a larger share of loan activity in agricultural loans, then, may benefit from cost pressures on farm production but may face challenges when agricultural prices increase.

This paper shows that demand for agricultural credit deserves a central place in future research on the economics of agricultural loans. We briefly propose a few ways to carry out this research agenda. First, we provided evidence of the counter-cyclicality between demand for loans and farm income. We have not provided evidence of the magnitude of different shocks on farm income, especially when shocks affect the costs (e.g., shock on the price of fertilizer) or revenue (e.g., shock on the price of grains) of businesses. Second, we have not provided evidence of the attributes of loans that attract and retain farmers to banks. This is of great importance, particularly with competitive pressures coming from the Farm Credit System and non-traditional lenders (Kuethe et al., 2022). Third, policies that impact farm income may have direct consequences for agricultural lenders. The efficiency and distribution implications of such policies must be better studied. We hope that these questions return to the forefront of agricultural production and financial economics.

Appendix

This supplementary appendix provides estimation results of alternative specifications of the relationship between supply and demand and the volume of non-real real estate farm loans. The additional estimates are provided to demonstrate that our key empirical findings are robust to a number of modeling choices.

As outlined in Section 4, our baseline specification includes a one year lag to capture the general path of supply and demand in each quarter. The one year lag was chosen in our preferred specification to match the frequency used in the Fed Surveys (current quarter compared to a year earlier). Table A1, alternatively, estimates the three equations of our two-stage model using a one quarter lag, instead of a one year lag. The magnitude and significance of the coefficients are largely unchanged from our baseline specification.

Table A1: Supply and demand of agricultural loans under a quarter-over-quarter lag structure

	Demand	Supply	Growth Rate Ag Loan
Change in Supply	0.088***		–0.002
	(0.017)		(0.003)
Change in Demand		0.022***	0.017***
		(0.004)	(0.002)
Change Lag	0.294***	0.405***	0.732***
	(0.010)	(0.014)	(0.024)
Controls	Yes	Yes	Yes
+ Interactions	No	No	No
Bank FE	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Observations	27,500	27,500	24,007
R^2	0.27	0.42	0.178
F statistic	9.35***	18.42***	33.43***

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. The difference between the models presented here and the ones in the main text relates to the structure of the lags added as dependent variables. The main text variables uses the quarter of the previous year lag (4-quarters), while results here use quarter-over-quarter lags (1-quarter lag).

In addition, our baseline estimation measures changes in lending standards based on the amount of collateral required. As outlined in Section 4, previous studies of loan officer opinion surveys use more general definitions of lending standards, to include “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). The Chicago Land Values and Credit Conditions Survey uses a similar broad definition of standards in an question collected in the fourth quarter of each year. Once a year, during the fourth quarter of the year, the Chicago Survey asks bankers specifically about changes in credit standards for approving loans during the last quarter of the year in relation to the same period an year earlier. We group the 5 possible answers (tightened considerably, tightened somewhat, remained basically unchanged, eased somewhat, eased considerably) to 3 categories (tightened, no change, eased). Regressions under (Collateral) use the measure of collateral we used for the regressions in the main text and regressions under (Standards) use the alternative measure of supply. Table A2 and A3 below show first and second stage regressions as described in equations 1, 2, and 3 using the information provided by the Chicago Survey collected for the fourth quarter of every year. Again, the empirical findings are largely consistent with our preferred specification.

Table A2: Chicago 1st stage regressions

	Change in Demand		Change in Supply	
	(Collateral)	(Standards)	(Collateral)	(Standards)
Co-movement (demand or supply)	0.069	–0.004	0.017	0.0001
	(0.066)	(0.041)	(0.016)	(0.017)
Change in Dependent Lag	0.029	0.028	0.090**	0.075***
	(0.026)	(0.026)	(0.037)	(0.028)
Log Asset Size	–0.033	–0.028	0.059	0.105*
	(0.101)	(0.101)	(0.037)	(0.058)
Ratio Liquid-Total Asset	0.002	0.002	-0.002	-0.003
	(0.003)	(0.003)	(0.002)	(0.002)
Ratio Equity-Capital	0.005	0.005	-0.004	-0.012
	(0.015)	(0.015)	(0.008)	(0.010)
Ratio Ag-Total Loans	–0.008**	–0.008**	0.003*	0.002
	(0.004)	(0.003)	(0.002)	(0.003)
Growth rate Mean Fed Funds	0.024	0.032	0.094***	0.160***
	(0.060)	(0.061)	(0.025)	(0.037)
Branch	0.130	0.140	0.048	0.019
	(0.104)	(0.104)	(0.050)	(0.071)
Constant	2.692**	2.784**	1.074**	0.851
	(1.304)	(1.290)	(0.451)	(0.753)
Bank FE	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes
Observations	2,492	2,492	2,492	2,492
R^2	0.312	0.311	0.392	0.407
F Statistic	2.169***	2.162***	3.077***	3.274***

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. The first 2 columns are estimated via two-way within estimator. The third model is estimated via a linear dummy model to preserve the Fed Funds Rate variable.

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 in the two-way within estimator. 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 the bias, we employ the strategy of first-differencing our data and instrumenting with higher-order lags, as in Arellano and Bond (1991). We present these results in table A4.

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

Table A3: Chicago loan regression

	Growth rate of ag loans	
	(Collateral)	(Standards)
Residual Demand	0.020**	0.020**
	(0.011)	(0.011)
Residual Supply	0.021	0.033
	(0.024)	(0.021)
Ag Loans gr Lag	–0.160*	–0.160**
	(0.092)	(0.081)
Growth rate mean Fed Funds	–0.042	–0.042
	(0.054)	(0.054)
Controls	Yes	Yes
+ Interactions	No	No
Bank FE	Yes	Yes
Year-Quarter FE	Yes	Yes
Observations	1,710	1,710
R^2	0.278	0.280
F-Statistic	1.491***	1.501***

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. The first 2 columns are estimated via two-way within estimator. The third model is estimated via a linear dummy model to preserve the Fed Funds Rate variable.

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 by 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 lags when possible. This specification beats others as it provides a combination of tests results that suggest our model is well-specified. Hansen tests, AR(2) tests, and difference-in-Hansen tests are estimated to have $p-$values above 0.20 in the first-stage. Results are qualitatively and quantitatively similar to the model estimated in the main text.

Table A4: Dynamic panel

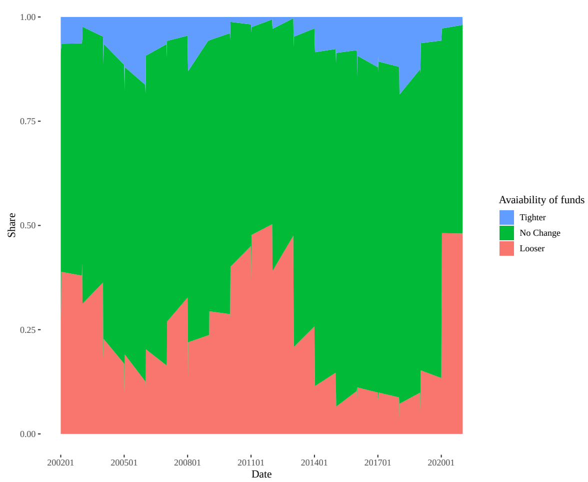
	Demand	Supply	Growth Rate Ag Loan
Change in Supply	0.095***		0.004
	(0.026)		(0.003)
Change in Demand		0.015***	0.018***
		(0.004)	(0.001)
Change Lag	0.138***	0.160***	0.391***
	(0.018)	(0.025)	(0.035)
Log Asset Size	–0.547***	–0.151***	–1.222***
	(0.153)	(0.052)	(0.149)
Ratio Liquid-Total Asset	–0.003	–0.0005	0.006***
	(0.001)	(0.00005)	(0.0006)
Ratio Equity-Capital	–0.029***	–0.005*	–0.027***
	(0.011)	(0.003)	(0.005)
Ratio Ag-Total Loans	0.010***	0.0009	–0.017***
	(0.003)	(0.0009)	(0.001)
Bank FE	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Observations	20,046	20,046	20,046
Hansen Test ($p-value$)	371.37 (0.45)	376.91 (0.39)	670.44 (0.17)
AR(1) $z-value$	-15.14***	-11.53***	-7.91***
AR(2) $z-value$	-1.53	0.95	-1.38

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. Models estimated via GMM using moment conditions over the lag of the dependent variable. We assume all other variables are exogenous.

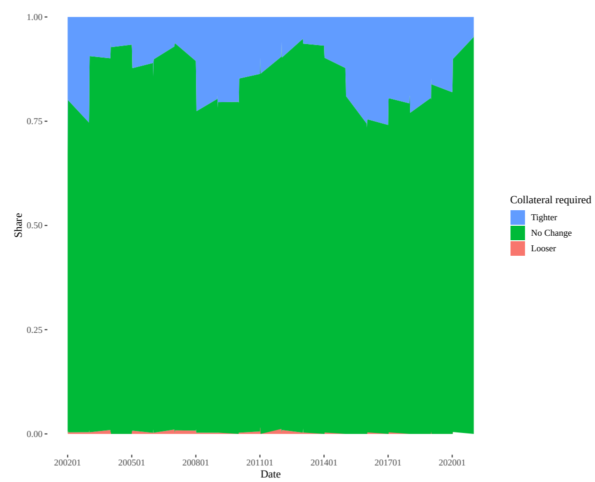
An additional concern of collateral requirement as a measure of farm loan supply is the limited variation in responses. As discussed previously, standards of loans correspond to a full vector of non-price lending terms. In similar fashion to Castro et al. (2022), we extract the principal components of a vector of non-price lending terms and use the principal component as a measure of supply to overcome the lack of variability in the amount of collateral required. The Surveys contain a few measures in addition to collateral required that we can use to measure supply, including the availability of funds, rate of loan repayment, and renewals and extensions. Figure 7 shows their variation over time. Variables are coded such that 3 represents tightening, 1 loosening, and 2 represents no change.

(a) Variation of Repayment

(b) Variation of Renewal



(c) Variation of availability of funds



(d) Variation of changes in collateral

Figure 7: Proportion of Banks' answers regarding several supply conditions

Table A5 shows the loads of the 4 principal components. The first principal component explains 52% of the variability, and it is positively related to the amount of collateral and negatively related to renewals and repayments. The second principal component explains an additional 25% of the variability. It is negatively related to availability of funds.

The fact that the first principal component has a negative load for renewals and repayment and a positive load for collateral adds difficulty to the interpretation of the use of the principal component as a supply measure. This is because a positive and marginal change in the first principal component implies that collateral is tightening the standards of lending, but renewals and repayments are loosening the standards of lending. Table A6 shows the results for the first-stage and second-stage regressions using the first principal component as a supply measure.

A marginal change in the first principal component is associated with positive change in demand. If we believe that repayment and renewals are dominating the variability of collateral in the principal component (a plausible assumption given the rate of variability of these series), then a positive change in the principal component implies loosening of standards (positive change of the principal component is related to loosening in renewals and repayment) which associates with increased demand. Similarly, loosening standards leads to a positive, but small, change in growth rate of loans, as shown in table A6. If we believe that the principal component reflects mostly variability in the collateral – a questionable assumption – then the results would be the opposite.

Either way, the difficulty of interpretation of the principal components led us to choose the model in the primary text as our preferred specification. One should be aware, though, that using different variables for standards of loans, particularly variables with higher variability than amount of collateral, can lead to statistical significant impacts of supply on the growth rate of loans. But even when we do so, the magnitude of the impact of the supply side remains a fourth of the magnitude of the impact of the demand side.

Table A5: Loads

	PC1	PC2	PC3	PC4
Collteral	0.55	0.11	0.82	–0.08
Renewals	–0.58	–0.07	0.466	0.66
Repayment	–0.59	0.01	0.32	–0.74
Funds	0.09	–0.99	0.06	–0.06

Table A6: PCA supply and demand of Agricultural loans under a quarter-over-quarter lag structure

	Demand	Supply	Growth Rate Ag Loan
Change in Supply	0.105***		0.008***
	(0.008)		(0.002)
Change in Demand		0.263***	0.030***
		(0.019)	(0.004)
Change Lag	0.114***	0.180***	–0.087***
	(0.010)	(0.012)	(0.019)
Controls	Yes	Yes	Yes
+ Interactions	No	No	No
Bank FE	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Observations	23,266	23,266	17,826
R^2	0.227	0.35	0.21
F-Statistic	6.589***	11.911***	5.187***

*p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the bank level. The difference between the models presented here and the ones in the main text relates to the structure of the lags added as dependent variables. The main text variables uses the quarter of the previous year lag (4-quarters), while results here use quarter-over-quarter lags (1-quarter lag).

References

Akerlof, G. A. (1970). The market for" lemons": Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics 84*(3), 488–500.

Altavilla, C., M. Boucinha, S. Holton, and S. Ongena (2021). Credit supply and demand in unconventional times. *Journal of Money, Credit and Banking 53*(8), 2071–2098.

Arellano, M. and S. Bond (1991). Some tests of specification for panel data: Monte carlo evidence and an application to employment equations. *The Review of Economic Studies 58*(2), 277–297.

Aron, J., J. V. Duca, J. Muellbauer, K. Murata, and A. Murphy (2012). Credit, housing collateral, and consumption: Evidence from Japan, the UK, and the U.S. *Review of Income and Wealth 58*(3), 397–423.

Asea, P. K. and B. Blomberg (1998). Lending cycles. *Journal of Econometrics 83*(1-2), 89–128.

Barnett, B. J. (2000). The U.S. farm financial crisis of the 1980s. *Agricultural History 74*(2), 366–380.

Barry, P. J., R. W. Bierlen, and N. L. Sotomayor (2000). Financial structure of farm businesses under imperfect capital markets. *American Journal of Agricultural Economics 82*(4), 920–933.

Bassett, W. F., M. B. Chosak, J. C. Driscoll, and E. Zakrajšek (2014). Changes in bank lending standards and the macroeconomy. *Journal of Monetary Economics 62*, 23–40.

Bernanke, B., M. Gertler, and S. Gilchrist (1996). The financial accelerator and the flight to quality. *The Review of Economics and Statistics 78*(1).

Bernanke, B. S. and M. Gertler (1995). Inside the black box: the credit channel of monetary policy transmission. *Journal of Economic Perspectives 9*(4), 27–48.

Berry, S. T. and P. A. Haile (2014). Identification in differentiated products markets using market level data. *Econometrica 82*(5), 1749–1797.

Bierlen, R. and A. M. Featherstone (1998). Fundamental q, cash flow, and investment: evidence from farm panel data. *Review of Economics and Statistics 80*(3), 427–435.

Blancard, S., J.-P. Boussemart, W. Briec, and K. Kerstens (2006). Short-and long-run credit constraints in French agriculture: A directional distance function framework using expenditure-constrained profit functions. *American journal of Agricultural Economics 88*(2), 351–364.

Boyette, D. K. and F. C. White (1987). Factors affecting demand and supply of agricultural real estate debt. *Western Journal of Agricultural Economics*, 174–181.

Briggeman, B. C., C. A. Towe, and M. J. Morehart (2009). Credit constraints: their existence, determinants, and implications for U.S. farm and nonfarm sole proprietorships. *American Journal of Agricultural Economics 91*(1), 275–289.

Castro, A., D. Glancy, F. Ionescu, and G. Marchal (2022). What happens when banks tighten C&I loan supply? *FEDS Notes Washington: Board of Governors of the Federal Reserve System*(February 18, 2022).

Ciccarelli, M., A. Maddaloni, and J.-L. Peydró (2015). Trusting the bankers: A new look at the credit channel of monetary policy. *Review of Economic Dynamics 18*(4), 979–1002.

Del Giovane, P., G. Eramo, and A. Nobili (2011). Disentangling demand and supply in credit developments: a survey-based analysis for Italy. *Journal of Banking & Finance 35*(10), 2719–2732.

Dell'Ariccia, G. and R. Marquez (2006). Lending booms and lending standards. *The Journal of Finance 61*(5), 2511–2546.

Federal Financial Institutions Examinations Council (2021). Reports of Condition and Income. Arlington, VA.

Federal Reserve Bank of Kansas City (2021). Survey of Terms of Lending.

Fiechter, C. and J. Ifft (2022). Trade credit and agricultural commodity prices: evidence from the us dairy industry. *European Review of Agricultural Economics forthcoming*.

Foltz, J. D. (2004). Credit market access and profitability in Tunisian agriculture. *Agricultural Economics 30*(3), 229–240.

Haavelmo, T. (1943). The statistical implications of a system of simultaneous equations. *Econometrica, Journal of the Econometric Society*, 1–12.

Harding, D. and A. Pagan (2002). Dissecting the cycle: a methodological investigation. *Journal of Monetary Economics 49*(2), 365–381.

Hesser, L. F. and G. E. Schuh (1962). The demand for agricultural mortgage credit. *Journal of Farm Economics 44*(5), 1583–1588.

Hogg, D. et al. (2021). Analyzing supply and demand for business loans using microdata from the senior loan officer survey. Technical report, Bank of Canada.

Hubbard, R. G. and A. K. Kashyap (1992). Internal net worth and the investment process: An application to U.S. agriculture. *Journal of Political Economy 100*(3), 506–534.

Hubbs, T. and T. Kuethe (2017). A disequilibrium evaluation of public intervention in agricultural credit markets. *Agricultural Finance Review 77*(1), 37–49.

Ifft, J. E., T. Kuethe, M. Morehart, et al. (2015). Does federal crop insurance lead to higher farm debt use? Evidence from the agricultural resource management survey (arms). *Agricultural Finance Review 75*(3), 349–367.

Jaffee, D. and J. Stiglitz (1990). Credit rationing. *Handbook of Monetary Economics 2*, 837–888.

Kandilov, A. M. and I. T. Kandilov (2018). The impact of bank branching deregulations on the U.S. agricultural sector. *American Journal of Agricultural Economics 100*(1), 73–90.

Katchova, A. L. (2005). Factors affecting farm credit use. *Agricultural Finance Review 65*(2), 17–29.

Khwaja, A. I. and A. Mian (2008). Tracing the impact of bank liquidity shocks: Evidence from an emerging market. *American Economic Review 98*(4), 1413–42.

Kiviet, J. F. (2020). Microeconometric dynamic panel data methods: Model specification and selection issues. *Econometrics and Statistics 13*(4), 16–45.

Kiyotaki, N. and J. Moore (1997). Credit cycles. *Journal of Political Economy 105*(2), 211–248.

Kuethe, T., C. Fiechter, and D. Oppedahl (2022). Perceived competition in agricultural lending: stylized facts and an agenda for future research. *Agricultural Finance Review 82*(2), 417–437.

Laffont, J.-J. and R. Garcia (1977). Disequilibrium econometrics for business loans. *Econometrica*, 1187–1204.

Lewbel, A. (2019). The identification zoo: Meanings of identification in econometrics. *Journal of Economic Literature 57*(4), 835–903.

Lown, C. and D. P. Morgan (2006). The credit cycle and the business cycle: new findings using the loan officer opinion survey. *Journal of Money, Credit and Banking*, 1575–1597.

Melichar, E. (1973). Financing agriculture: demand for and supply of farm capital and credit. *American Journal of Agricultural Economics 55*(2), 313–325.

Paligorova, T. and J. A. Santos (2017). Monetary policy and bank risk-taking: Evidence from the corporate loan market. *Journal of Financial Intermediation 30*, 35–49.

Petrick, M. (2004). A microeconometric analysis of credit rationing in the Polish farm sector. *European Review of Agricultural Economics 31*(1), 77–101.

Pintaric, M. (2016). What is the effect of credit standards and credit demand on loan growth? Evidence from the Croatian Bank lending survey. *Comparative Economic Studies 58*(3), 335–358.

Prager, D. L., C. B. Burns, and N. J. Miller. How do financially vulnerable farms finance debt in periods of falling prices? *Agricultural Finance Review 78*(4), 412–424.

Rodano, G., N. Serrano-Velarde, and E. Tarantino (2018). Lending standards over the credit cycle. *The Review of Financial Studies 31*(8), 2943–2982.

Stiglitz, J. E. and A. Weiss (1981). Credit rationing in markets with imperfect information. *The American Economic Review 71*(3), 393–410.

Turvey, C. G. and A. Weersink (1997). Credit risk and the demand for agricultural loans. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie 45*(3), 201–217.

USDA Economic Research Service (2021). 2021 Farm Sector Balance Sheet. United States Department of Agriculture, Economic Research Service, Washington, DC.

Van der Veer, K. J. and M. M. Hoeberichts (2016). The level effect of bank lending standards on business lending. *Journal of Banking & Finance 66*, 79–88.

Vojtech, C. M., B. S. Kay, and J. C. Driscoll (2020). The real consequences of bank mortgage lending standards. *Journal of Financial Intermediation 44*, 100846.

Weersink, A. J. and L. W. Tauer (1989). Comparative analysis of investment models for New York dairy farms. *American Journal of Agricultural Economics 71*(1), 136–146.

Whitaker, J. B. (2009). The varying impacts of agricultural support programs on us farm household consumption. *American Journal of Agricultural Economics 91*(3), 569–580.

Wright, P. (1915). Moore's economic cycles. *Quarterly Journal of Economics 29*(3), 631–412.