MEASURES AND FORECASTS OF AGRICULTURAL

LAND VALUES

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Stillwater, Oklahoma

2010

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 2010

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LAND VALUES

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ACKNOWLEDGMENTS

Partial funding from the Oklahoma Agricultural Experiment Station is gratefully acknowledged. Appreciation is extended to Federal Reserve Economist Brian Briggeman and Regional Affairs Assistant Economist Maria Akers for their help in obtaining and using the data from the Federal Reserve's 10th District *Survey of Agricultural Credit Conditions*. I would also like to express thanks to Mr. Roger Sahs and Dr. Damona Doye for their assistance with the Farm Credit Association of Oklahoma's land transaction data. The views expressed in the following articles may not represent the views of the Federal Reserve Bank of Kansas City or those of the Farm Credit Associations of Oklahoma.

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PREFACE

This thesis is comprised of two articles that examine farmland values and farmland value forecasts for non-irrigated cropland, irrigated cropland, and pasture. The first article considers the collection and reporting procedures each of three data sources: the United States Department of Agriculture's (USDA) annual report, the Federal Reserve's quarterly 10th District Survey of Agricultural Credit Conditions, and sales data provided by Farm Credit Services. The objective of this essay is to determine if the land value estimates from opinion based surveys are consistent with values observed from land sales. Additionally, a multi-state panel is used to compare how annual USDA values relate to quarterly Federal Reserve estimates. Time series tests are used to determine if land values published by the Federal Reserve prior to the release of the USDA report are indicators of USDA land values.

The second article uses forecasts from the Federal Reserve's survey to determine if bankers can accurately forecast land values. Various techniques are used to compare bankers' quarterly forecasts to their own reported changes in land value. Contingency tables describe how well bankers forecast land value at the individual bank level. Qualitative forecasts are made into quantitative values by aggregating bankers' qualitative forecasts for up and downward movement. These values are modeled to predict the change in quarterly land value. The forecasting model is compared to a naïve model to determine if bankers are able to forecast future land value changes.

ESSAY I

ARE LAND VALUE SURVEYS ACCURATE INDICATORS OF FARMLAND VALUE?

Abstract

This study determines how consistent land values from opinion surveys are with respect to actual sales prices. Three sources of land value data are considered; United States Department of Agriculture, Federal Reserve Bank, and transaction prices. In Oklahoma, all of the data sources considered are highly correlated, but state averages computed from sales data are higher for irrigated and pasture land. USDA land values are intended to represent land values on January first, but instead they more closely represent first and second quarter land values according to a multi-state comparison to changes in quarterly Federal Reserve land values. Since, Federal Reserve first quarter estimates are closely related to USDA estimates and the Federal Reserve publishes first quarter estimates in advance of the USDA release, yearly changes in first quarter Federal Reserve estimates are leading indicators of USDA values.

Introduction

Farmland values are a useful way to track the overall financial strength of the agricultural sector. Accounting for approximately 85 percent of assets on farm balance sheets, farmland is the main source of wealth for agricultural producers and the primary asset held as collateral by farm lenders. As such, land values are a barometer of farm financial health; Briggeman, Gunderson, and Gloy (2009) observe that during previous periods of falling land values, farmers have shown substantial financial stress. “Understanding changes in farmland values is critical to understanding the behavior of farmers and the financial performance of the agricultural sector (Henderson 2008, p.2).” Accurate, timely information on the movement of land values helps assess the overall financial health of agriculture. However, land value data remains limited, and little is known about how consistent different land value sources are to one another.

Previous land value research has primarily focused on creating econometric models to derive determinants of land value based on capitalization theory (Alston ,1986; Burt, 1986; Mcconnen, 1979; Melichar, 1979). However, precise models require accurate data. Past econometric models of agricultural land prices do not match theory (Falk 1998), and poor data is one possible cause of weak models. Further, many past econometric models have used data from the United States Department of Agriculture and there are uncertainties as to what point in time this data series represents.

This paper compares three land value sources. Data from two survey sources are considered: the United States Department of Agriculture's (USDA) annual report and the Federal Reserve Bank of Kansas City's quarterly 10th District Survey of Agricultural Credit Conditions. The annual USDA survey is an area-based survey comprised of agricultural producers' reported fair market value of farmland. The quarterly Federal Reserve survey questions agricultural bankers about current farmland values. Additionally, Oklahoma sales data are obtained from records provided by Farm Credit Associations of Oklahoma.

One objective of this paper is to determine if survey estimates of Oklahoma land values are consistent with farmland sales prices through time. We also seek to determine what USDA values represent. Are estimates yearly averages, or do they reflect the value of farmland at a specific point in time? Preference is often given to USDA estimates; however, the Federal Reserve reports are published more frequently and are available sooner than USDA reports. Therefore, we determine if Federal Reserve estimates are leading indicators of changing USDA estimates.

The paper begins with a description of each of these data sets and identifies differences in data sampling, collection, and reporting across each respective source. The next section compares the average value of Oklahoma farmland across each of the data sources. Next, USDA estimates are compared to quarterly Federal Reserve values across multiple states to determine the point in time best represented by USDA estimates. The fourth section uses Granger causality tests to determine if USDA estimates can be anticipated by Federal Reserve surveys. The final section summarizes the results obtained in the preceding sections and addresses the relative benefits and limitations of each data source.

Land values differ slightly across different sources, but are all highly correlated. Oklahoma transaction data show higher land prices than survey estimates for irrigated cropland and pasture. The USDA report has a thorough area-based sampling procedure and should provide a precise estimate of average farmland values at the state level if producer survey responses are unbiased. The Federal Reserve survey collects land value estimates from bankers that are similar to estimates provided by USDA. In Oklahoma, lower Federal Reserve land value averages are not representative due to low survey response rates in the eastern half of the state. Over a multi-state panel, annual land value changes in Federal Reserve reports lead similar USDA estimates due to the timeliness and frequency of the Federal Reserve publication.

Data Sources

This section outlines the basic collection, revision and reporting procedures for each of the three data sources considered in this paper.

United States Department of Agriculture

The USDA report has traditionally been the gold standard for land valuation and has gained public trust by using statistical sampling methods. The USDA estimates are based primarily on the June Area survey conducted during the first two weeks of June. This annual survey uses a probability-based land-area sampling frame which is stratified by land use. The survey is assumed to provide complete coverage of farm and ranch operations because the area-based frame covers all land in the U.S. The national survey includes approximately 11,000 land areas (segments), averaging approximately one square mile in size.

Enumerators collecting data for the June Area Survey contact all agricultural producers operating land within the boundaries of the sampled land segments and record land value information for cropland and pasture within these segments. Specifically, producers are asked to estimate the fair market value for various tracts of their farmland. Survey reported data are reviewed for reasonableness and consistency by comparing with other data reported in the survey and with data reported within the segment the previous year. Land value estimates are subject to periodical revision based on information from the Census of Agriculture (United States Department of Agriculture 2010).

The table titles in the USDA land value reports consistently refer to their land value estimates as the value of land on January 1st (United States Department of Agriculture 2010). This reference date is used to match the estimated acreage of land in farms on January 1st. The actual survey, however, which is included in Appendix A, refers to current market conditions. USDA data are limited to a single annual report, which is only available at the state level since 1997. The data are published during the first week of August.

Oklahoma Transaction Data

Sales data are alluring because they provide a true measure of land value rather than opinion based estimates. However, transaction data are difficult to collect. Thousands of farmland transactions are completed every year, and while information regarding land sales may be public record, it is rarely compiled into an easily accessible database. For this paper, transaction data are from a database of Oklahoma land sales made available by Farm Credit Services through the Oklahoma State Cooperative Extension Service. Data are updated annually at the end of July. The sales data represents 53,423 transactions from 1971 to 2009.

Deriving precise land values from transaction data can also be challenging. Transactions often include acreage in both cropland and pasture which causes difficulties in determining which portion of the purchase price should be allocated to each tract. Sales prices also include the value of any improvements, mineral rights, buildings, or home sites. To overcome these challenges, hedonic land values are derived from a regression that accounts for land utilization, size, and location. For detailed explanation of the regression procedures, refer to Appendix B.

Federal Reserve Bank Tenth District Survey

The Federal Reserve *Survey of Agricultural Credit Conditions* is a survey of commercial banks with a high volume of agricultural loans (approx. 14% or more of total loan volume) within the Federal Reserve's 10th District. The 10th District includes the states of Kansas, Nebraska, Oklahoma, Wyoming, Colorado, the northern half of New Mexico, and the western third of Missouri. This region contains almost 30 percent of the nation's agricultural banks, and of these approximately 650 agricultural banks, over 250 respond to the survey each quarter. Each qualifying bank receives only one survey which is typically completed by the same respondent each period.

The Federal Reserve aggregates responses at both state and District levels and summarizes information into a quarterly report. To prevent the survey being used as a benchmark for land sales, the Federal Reserve does not publicly report the nominal level of average land values. Instead, year over year percent changes in each state's average land values are published. Only banks that have responded in previous periods are included in the calculation of yearly changes. Bank responses are subject to an additional validation procedure that removes outliers. The Federal Reserve's unpublished land value data are at the state level since 1976.

In 2002, the Federal Reserve expanded the survey and created an online database to track individual bank responses. Though Federal Reserve economists use the disaggregated data for internal research, the Bank does not publicly release disaggregate responses due to confidentiality agreements with respondent banks. This paper uses the unpublished disaggregate to create state level land price changes.

The Federal Reserve Bank of Kansas City survey process is straightforward with respect to the timing of the survey collection, reference, and publication dates. Surveys are distributed during the last month of each quarter, and respondents are asked to fill out the survey at month's end. Over the next two weeks, surveys are returned to the 10th District office and the public report is published during the first week of the second month of the new quarter. In this way, reports include recent land value information with an approximate one month lag for publication. An example survey question is included in Appendix A.

Methods

Three procedures are used. First various statistics and graphical analysis are used to compare the relative levels of land value across the three data sources. Second, a regression is used to test if the values reported by USDA represent yearly averages or point in time estimates. Third, Granger causality tests are used to determine the lead lag relationship between Federal Reserve and USDA land values.

Comparing Agricultural Land Value Sources

The correspondence between each series may be measured using various techniques. Graphical presentations show the overall trends in the data. Correlation coefficients are used to determine how well the levels of each land value series relate to one another. The means of the differences between the land value estimates of each of the data sources are calculated. The standard deviations of the differences are also calculated. If two data sources provide similar land value estimates, their respective land values will be highly correlated, and the difference between the series will have a small mean and standard deviation.

USDA Time Series

The USDA collects land value information during the first two weeks of June with a reference date of January 1st. This information is included in a report which is released in August. The timing of the survey collection and interpretation of the January 1st reference date create questions about what point in time the USDA report actually represents. If USDA values represent a yearly average centered at January 1, estimates should reflect the average level of land values from July of the previous year through June, when the survey is taken. The January reference date suggests that USDA estimates may represent a point in time estimate, representing the value of land on January 1st.

One solution to verify the information in the USDA survey is to compare a multiple-state panel of USDA estimates to a similar panel of Federal Reserve survey responses. Using the following equation, USDA estimates may be expressed as an average of recently observed quarterly prices:

(1) $$USDA_{it} = (Q2_{it} + Q1_{it} + Q4_{i(t-1)} + Q3_{i(t-1)})/4$$

where $Q1_{it}$ and $Q2_{it}$ represent average land values in quarter one and two of year *t*, $Q4_{i(t-1)}$ represents the *i*-th state's average land value during fourth quarter of the previous year, and $Q3_{i(t-1)}$ is the *i*-th state's average land value during the third quarter of the previous year.

To better reflect information published by the Federal Reserve, quarterly prices are redefined as functions of quarterly changes over the last year:

(2) $$Q3_{i(t-1)} = Q2_{i(t-1)} + \Delta Q3_{i(t-1)};$$

$$Q4_{i(t-1)} = Q2_{i(t-1)} + \Delta Q3_{i(t-1)} + \Delta Q4_{i(t-1)};$$

$$Q1_{it} = Q2_{i(t-1)} + \Delta Q3_{i(t-1)} + \Delta Q4_{i(t-1)} + \Delta Q1_{it};$$

$$Q2_{it} = Q2_{i(t-1)} + \Delta Q3_{i(t-1)} + \Delta Q4_{i(t-1)} + \Delta Q1_{it} + \Delta Q2_{it};$$

Using equation (2), USDA values are represented as changes in quarterly prices:

(3) $$USDA_{it} = \left(\frac{1}{4}\right)\Delta Q2_{it} + \left(\frac{1}{2}\right)\Delta Q1_{it} + \left(\frac{3}{4}\right)\Delta Q4_{i(t-1)} + \Delta Q3_{i(t-1)} + Q2_{i(t-1)}$$

Repeating the procedures outlined above, lagged USDA values are defined as the summation of price changes since $Q2_{i(t-2)}$ produces:

(4) $$USDA_{it} = \left[\left(\frac{1}{4}\right)\Delta Q2_{it} + \left(\frac{1}{2}\right)\Delta Q1_{it} + \left(\frac{3}{4}\right)\Delta Q4_{i(t-1)} + \Delta Q3_{i(t-1)} + \Delta Q2_{i(t-1)} + \Delta Q1_{i(t-1)} + \Delta Q4_{i(t-2)} + \Delta Q3_{i(t-2)} + Q2_{i(t-2)}\right]$$

$$USDA_{i(t-1)} = \left[\left(\frac{1}{4}\right)\Delta Q2_{i(t-1)} + \Delta\left(\frac{1}{2}\right)Q1_{i(t-1)} + \left(\frac{3}{4}\right)\Delta Q4_{i(t-2)} + \Delta Q3_{i(t-2)} + Q2_{i(t-2)}\right]$$

Differencing the data makes the series stationary and yields a form suitable for estimation. First differencing $USDA_{it}$ simplifies to:

(5) $$\Delta USDA_{it} = \left(\frac{1}{4}\right)\Delta Q2_{it} + \left(\frac{1}{2}\right)\Delta Q1_{it} + \left(\frac{3}{4}\right)\Delta Q4_{i(t-1)} + \Delta Q3_{i(t-1)} + \left(\frac{3}{4}\right)\Delta Q2_{i(t-1)} + \left(\frac{1}{2}\right)\Delta Q1_{i(t-1)} + \left(\frac{1}{4}\right)\Delta Q4_{i(t-2)}$$

where $\Delta USDA_{it} = USDA_{it} - USDA_{i(t-1)}$ is the first difference of USDA land value estimates. As noted by Working (1960), using first differences of averages introduces correlations not present in the original series.

Federal Reserve Bank estimates are used as a proxy for quarterly land value changes, and the following equation is estimated:

(6) $$\Delta USDA_{it} = \beta_0 + \beta_1\Delta FQ2_{it} + \beta_2\Delta FQ1_{it} + \beta_3\Delta FQ4_{i(t-1)} + \beta_4\Delta FQ3_{i(t-1)} + \beta_5\Delta FQ2_{i(t-1)} + \beta_6\Delta FQ1_{i(t-1)} + \beta_7\Delta FQ4_{i(t-2)} + \varepsilon_{it}$$

where $\Delta FQ1_{it}$ is the change in the *i*-th state's land value in the first quarter of year *t* as estimated by the Federal Reserve Bank's first quarter Survey of Agricultural Credit Conditions. The variables $\Delta FQ2, \Delta FQ3$, and $\Delta FQ1$ are the quarterly changes in the Federal Reserve Bank's second, third, and fourth quarter estimates respectively.

The null hypothesis that actual coefficient values equal the expected weights placed on the lagged quarterly changes is formally tested. Using the expected coefficient values derived in equation (5), the following null hypothesis is tested to determine if USDA estimates are a true yearly average of land values:

(7) H_0: $\beta_4 = 0.25\,\beta_1 = 0.50\,\beta_2 = 0.75\,\beta_3 = 0.75\,\beta_5 = 0.50\,\beta_6 = 0.25\,\beta_7$

H_A: At least one equality does not hold.

If the null hypothesis is rejected, then USDA estimates do not represent a true yearly average. Observing the relative levels of the beta coefficients will suggest which quarters are more heavily weighted by survey respondents.

Alternatively, USDA reports suggest that estimates provide a point in time estimate for the market value of land on January 1st. Since bankers are asked to complete the Federal Reserve survey on the last day of December, Fourth Quarter Federal Reserve and annual USDA land value estimates would be only one day apart if producers are reporting land values on January 1. In this case one may expect that USDA estimates are best represented by the Federal Reserve's fourth quarter estimates:

(8)
$$USDA_t = Q4_{t-1} = \Delta Q2_{it} + \Delta Q1_{it} + \Delta Q4_{i(t-1)} + \Delta Q3_{i(t-1)} + \Delta Q2_{i(t-1)} + \Delta Q1_{i(t-1)} + \Delta Q4_{i(t-2)} + \Delta Q3_{i(t-2)} + Q2_{i(t-2)}$$
$$USDA_{t-1} = Q4_{t-2} = \Delta Q2_{it} + \Delta Q1_{it} + \Delta Q4_{i(t-1)} + \Delta Q3_{i(t-1)} + \Delta Q2_{i(t-1)} + \Delta Q1_{i(t-1)} + \Delta Q4_{i(t-2)} + \Delta Q3_{i(t-2)} + Q2_{i(t-2)}.$$

Defining USDA estimates in this fashion produces the first difference equation:

(9)
$$\Delta USDA_t = \Delta Q1_{it} + \Delta Q4_{i(t-1)} + \Delta Q3_{i(t-1)} + \Delta Q2_{i(t-1)}$$

This relationship may be tested using equation (6) and the null hypothesis of

(10) H_0: $\beta_3 = \beta_4 = \beta_5 = \beta_6 = 1,\ \beta_1 = \beta_2 = \beta_7 = 0$

H_A: At least one equality does not hold.

Granger Causality

Granger causality may be used to determine if the USDA and Federal Reserve surveys are leading indicators of one another. A variable *X* is said to Granger-cause variable *Y* if the variable *Y* may be better predicted using lagged values of both *X* and *Y* than if only lagged values of *Y* itself were used. The causality model is useful in exploring the linear linkages between two economic series and determining if they are indicators of one another (Sanders et al. 2003). We want to determine if the annual changes in land value reported by agricultural bankers are indicators of similar information in future USDA reports. The corresponding Granger causality model regresses recent USDA values on annual lagged USDA and Federal Reserve Bank estimates of annual percentage changes. Separate regressions are estimated for each quarter. The following equation is estimated to determine the predictive power of each quarterly Federal Reserve survey:

(11) $$\%\Delta\, USDA_{it} = \beta_0 + \sum_{j=1}^{J} \beta_j \,\%\Delta\, USDA_{i(t-j)} + \sum_{k=1}^{K} \gamma_k \,\%\Delta\, Fed_{i(t-k)} + \varepsilon_t$$

where $\%\Delta USDA_{it}$ is the percent change in the *i*-th state's USDA land values, and $\%\Delta\, Fed_{i(t-k)}$ is the yearly percent change reported using quarter *i* land values for year *t-k*. The equation is estimated four times, using the annual change in each of the four quarterly Federal Reserve values as estimates of $\%\Delta\, Fed_{i(t-k)}$. The value ε_t is the white noise error term.

The number of lags (*j* and *k*) are determined using the Akaike Information Criterion (AIC) with the optimal lags being *J*=2 and *K*=1. Non-causality, which implies that Federal Reserve estimates are not leading indicators of USDA estimates corresponds to the null hypothesis, $H_0\!: \gamma_1 = 0$, which is tested using a t-test. If the coefficient for lagged Federal Reserve estimates (γ_1) is significant, then the percent change in USDA land values can be partially anticipated by the observed yearly changes in Federal Reserve estimates.

Likewise, we may want to know if USDA land values anticipate Federal Reserve estimates. To examine this, the reverse of the above equation is used, placing the change in Federal Reserve estimates as the dependent variable:

(12) $$\%\Delta\, Fed_{it} = \beta_0 + \sum_{j=1}^{J} \beta_j \,\%\Delta\, Fed_{i(t-j)} + \sum_{k=1}^{K} \gamma_k \,\%\Delta\, USDA_{i(t-k)} + \varepsilon_t$$

where $\%\Delta Fed_{it}$ is the yearly percent change in the Federal Reserve's quarterly estimate for the *i*-th state. Again, the equation is estimated four times, using the annual change in each of the four quarterly Federal Reserve values for the variable $\%\Delta\, Fed_{it}$. Non-causality is tested using the null hypothesis, $H_0: \sum \gamma_k = 0$. By testing both series as leading indicators of one another, we can better understand the relationship between USDA and Federal Reserve estimates.

Results

This section summarizes the results obtained from each of the methods described in the previous section.

Comparing Agricultural Land Value Sources

For non-irrigated cropland in Oklahoma, the fourth quarter Federal Reserve estimates and the estimated transaction prices track extremely closely since 2000 (Figure I.1). Over this period, there was less than a 1% difference in the average land values between the Federal Reserve survey estimates and the estimated transaction price for non-irrigated land. The Federal Reserve survey and transaction data have the lowest mean difference and the lowest standard deviation of differences (Table I.1). USDA values were near transaction prices through the late 1990's but averaged $80/acre higher (10.2% over transaction prices) since 2002. All series were highly correlated, with the two surveys (Fed and USDA) having a correlation coefficient over 99 percent.

The Federal Reserve's survey also tracks closely with USDA estimates of irrigated cropland (Figure I.2). Again USDA and Federal Reserve estimates were highly correlated with USDA estimates slightly higher (5.8%) than those given by the Federal Reserve Bank. Both Federal Reserve and USDA data fell well under transaction prices for irrigated cropland. Whereas normally we may assume that the transaction price is the most accurate indication of the true value of farmland, it should be noted that the number of transactions for irrigated cropland was low, and, in many periods, did not provide enough observations to form an accurate estimate. The result is large quarter-to-quarter volatility in irrigated transaction values. Survey responses, such as those provided by the USDA and the Federal Reserve Bank, are not as sensitive to limited data and may be better indicators as to the true value of irrigated cropland. In 2009, neither the Federal Reserve nor USDA publicly reported irrigated land values for Oklahoma because of inadequate sample size.

Ranchland values were highly correlated across each source (Table I.1), but the nominal levels varied (Figure I.3). Notably, transaction price estimates were significantly higher than those of either the Federal Reserve Bank or USDA. Since the mid 1990's, ranchland transaction prices have increased at a rate greater than what was reported by either survey. From 1997 to 2007, transaction estimates averaged $280/acre higher than Federal Reserve estimates and were $200/acre more than USDA reports. Federal

Reserve land values followed USDA estimates closely until 2005, when the USDA began reporting increasing rates similar to what was being shown in the transaction data. Since 2005, USDA land values have averaged $100/acre higher than Federal Reserve estimates.

Deviation in the level of Federal Reserve ranchland estimates from that of USDA values may be attributed to the sampling differences in the data sources. Land values tend to be lower in western Oklahoma, and low ranchland values from the Federal Reserve survey are likely due to respondents being concentrated in the western half of the state. Recall that the Federal Reserve's survey respondents are banks that have a high proportion of agricultural loan volume. The majority of these banks are located in western Oklahoma. Of the banks in eastern Oklahoma that qualify for the survey, few choose to respond. Consequently, the Federal Reserve samples more banks in western Oklahoma. Plotting survey respondents by county confirms that the Federal Reserve Survey is not a representative sample of all agricultural land in Oklahoma (Figure I.4). The non-representative sample provides justification for the Federal Reserve's practice of reporting changes in land values rather than land values themselves.

USDA Time Series

The regression of USDA estimates against quarterly changes in Federal Reserve land values are in table I.2. Much of the variation in differenced USDA land values can be explained by quarterly changes in Federal Reserve estimates. Restricting the coefficients to represent yearly averages results in high F-statistics and so the null hypothesis that USDA land values represent a true yearly average is rejected for each land type. Likewise, the null hypothesis that USDA values represent the price of land on January 1^{st} is also rejected.

Examining the coefficients in table I.2 shows that variation in the USDA estimates is best explained by changes in land values occurring in the first and second quarters. The highest and most statistically significant quarterly estimates occurred in the three quarters prior to USDA's June sampling. Specifically, first quarter changes received the highest weight for irrigated and ranchland while Federal Reserve Bank's second quarter changes best explained changes in USDA's non-irrigated cropland estimates. These results suggest that USDA land values are more representative of recent (first and second quarter) prices than they are of land values on January 1^{st} (end of quarter 4).

Granger Causality

The tests of annual changes in each of the four Federal Reserve quarterly estimates as leading indicators of USDA changes are in table I.3. Annual changes in Federal Reserve land values show the ability to predict land value information later reported by USDA with first quarter changes explaining the most variation in USDA estimates as shown by high $\%\Delta Fed$and R^2coefficients. For each land type, the lagged Federal Reserve coefficients are significant at the one percent level for first quarter changes. For non-irrigated cropland, lagged Federal Reserve estimates have highly significant coefficients for each of the three quarters preceding USDA sampling. For irrigated cropland, coefficients were most significant in the first two quarters of the year. USDA pasture values were best explained by the annual changes in Federal Reserve ranchland from the first quarter of the same year and the fourth quarter of the previous year. The levels of the lagged Federal Reserve coefficients were fairly constant; those significant at $\alpha = .05$ ranged between 0.361 and 0.509. Though coefficients near one are desired, the statistical significance of lagged Federal Reserve estimates indicates that yearly changes in Federal Reserve land values contain information similar to that of USDA.

For each land type, annual changes in first quarter estimates are the best indicator of annual USDA changes as shown by high lagged Federal Reserve coefficients. This is not surprising considering that the previous section showed that changes in USDA land values are represented by first and second quarter changes in Federal Reserve land values. Considering that the first quarter Federal Reserve publication is released during the first week of April, those interested in tracking land values would have information concerning probable land value movement four months in advance of the USDA release. In this way, the Federal Reserve survey may benefit those interested in a timely indicator of farmland value movement.

The estimated equations for testing USDA values as indicators of annual Federal Reserve estimates are found in table I.4. Although bankers report third quarter prices in September, the yearly percent changes in these prices do not seem to be related to the USDA changes earlier reported in August. Previous USDA numbers also partially predict annual changes in the Federal Reserve's fourth quarter land prices, while fourth quarter estimates also take into account recent USDA numbers. In quarters one and two, yearly percent changes in Federal Reserve estimates show some relation to previous USDA data, but little variation in Federal Reserve estimates was explained by lagged land values from either source.

Conclusion

Transaction data are the most direct measure of farmland value. Transaction data, however, are often difficult to obtain, are noisy, and are sensitive to occasional outliers. Some years there are few sales, and the quality and location of sales tracts vary by year. In Oklahoma, transaction prices are highly correlated with both Federal Reserve and USDA land value estimates. Non-irrigated cropland prices closely matched USDA and Federal Reserve farmland value estimates. Irrigated and pasture transaction prices were higher than land values of both USDA and Federal Reserve. These relatively high land values are consistent with past research using Oklahoma transaction data (Guiling, et al., 2009), and may indicate that highly valued irrigated and ranchland is more likely to be sold or the surveys may simply underestimate land prices.

In Oklahoma, all the data series are highly correlated since 1997. The two surveys produced by the Federal Reserve and the USDA track extremely well together. For each land type, the correlation coefficient for USDA and Federal Reserve land values is over 98 percent. The lower correlation with transaction data may reflect noise in the transaction data or may reflect smoothing or gradual adjustment in the survey series.

The thorough, area-based sampling procedure allows the USDA to provide precise estimates of producer beliefs about farmland value. This paper regresses annual changes produced by the USDA against quarterly values of the Federal Reserve to determine the time period represented by the USDA data. The USDA estimates are more representative of first and second quarter land values than they are of yearly averages or January 1st point estimates.

Through the Federal Reserve's 10th District survey, bankers provide land value estimates based on observed land values within their local areas. Average land values are consistent with similar land values estimated by the USDA, but due to a dearth of agricultural banks, some areas are not represented in the survey. In Oklahoma, this effect is most problematic when considering ranchland values that are highly concentrated in eastern counties. Since most crop acreage is in western counties, cropland values are less affected. The unrepresentative sample for specific areas may contribute to the Federal Reserve Bank's hesitancy to publicly report land value estimates from the survey. However, the 10th District Bank does publish annual changes which are shown to closely follow USDA values.

USDA data are presently only published once a year. Federal Reserve data offer more frequent information. In addition, first quarter annual changes reported by the Federal Reserve are highly correlated with USDA estimates. Since the Federal Reserve publishes first quarter estimates in advance of the USDA release, yearly changes in first quarter Federal Reserve estimates are leading indicators of USDA values.

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TABLES

Table I.1. Correlation and Differences among Data Sources (1997-2008)

Land Type	Statistic	Trans-Fed	Trans-USDA	USDA-Fed
Non-irrigated	Correlation	0.935	0.962	0.993
	Mean Difference	14.929	-45.967	60.896
	SD	65.521	70.602	24.257
Irrigated	Correlation	0.826	0.784	0.984
	Mean Difference	137.474	89.301	48.446
	SD	166.088	181.078	38.207
Ranchland	Correlation	0.918	0.920	0.993
	Mean Difference	429.700	344.856	84.844
	SD	118.620	121.127	81.403

Table I.2. USDA Annual Land Value Changes as a Function of Past Quarterly Federal Reserve Land Values

	Land Type		
Independent Variable	Non-irrigated	Irrigated	Pasture
Intercept	-0.232	9.997	5.552
$\Delta Q2_t$	0.821***	0.543***	0.544***
$\Delta Q1_t$	0.779***	0.865***	1.138***
$\Delta Q4_{t-1}$	0.677***	0.463***	0.600***
$\Delta Q3_{t-1}$	0.283	-0.017	0.016
$\Delta Q2_{t-1}$	0.477**	0.121	0.400
$\Delta Q1_{t-1}$	0.587***	0.139	0.404**
$\Delta Q4_{t-2}$	0.172	0.467***	0.241
$\Delta Q3_{t-2}$	-0.352	-0.038	0.119
R^2	0.682	0.782	0.716
F-stat: Yearly Average	10.20***	9.58***	9.34***
F-stat: Jan 1st	9.91***	20.54***	10.48***

Note: Asterisk (*), double asterisk (**), and triple asterisk (***) denote coefficients significant at 10%, 5%, and 1% respectively.

Table I.3. Granger Causality Test: Annual Percent Change in Federal Reserve Land Values as Indicators of Annual Percent Change in USDA Land Values

		RHS: Quarterly Federal Reserve Report			
Land Type	Independent Variable	2nd Qtr	1st Qtr	4th Qtr	3rd Qtr
Non-irrigated	Intercept	1.175	0.594	2.748*	5.072***
	$\%\Delta\ USDA_{i(t-1)}$	0.640***	0.467**	0.470*	0.728***
	$\%\Delta\ USDA_{i(t-2)}$	-0.390*	-0.268	-0.411*	-0.416
	$\%\Delta\ Fed_{i(t-1)}$	0.4097***	0.509***	0.361***	-0.125
	R^2	0.356	0.373	0.260	0.165
Irrigated	Intercept	2.272	2.418*	3.387**	4.930***
	$\%\Delta\ USDA_{i(t-1)}$	0.546**	0.492**	0.584***	0.763***
	$\%\Delta\ USDA_{i(t-2)}$	-0.419*	-0.419*	-0.556**	-0.403
	$\%\Delta\ Fed_{i(t-1)}$	0.388***	0.400***	0.277*	-0.213
	R^2	0.331	0.347	0.217	0.193
Ranch	Intercept	4.211***	2.733***	3.398**	5.916***
	$\%\Delta\ USDA_{i(t-1)}$	0.846***	0.735***	0.750***	0.987***
	$\%\Delta\ USDA_{i(t-2)}$	-0.516***	-0.457***	-0.550***	-0.559***
	$\%\Delta\ Fed_{i(t-1)}$	0.149	0.394***	0.378***	-0.170
	R^2	0.441	0.626	0.521	0.429

Note: Asterisk (*), double asterisk (**), and triple asterisk (***) denote coefficients significant at 10%, 5%, and 1% respectively.

Table I.4. Granger Causality Test: Percent Change in Annual USDA Values as Indicators of Annual Percent Change in Federal Reserve Land Values

		LHS: Quarterly Federal Reserve Report			
Land Type	Independent Variable	2nd Qtr	1st Qtr	4th Qtr	3rd Qtr
Non-irrigated	Intercept	7.575***	6.517***	2.921*	5.355***
	$\%\Delta\ Fed_{i(t-1)}$	0.054	0.299*	-0.098	-0.249
	$\%\Delta\ USDA_{i(t-1)}$	0.089	0.1353*	0.360**	-0.086
	$\%\Delta\ USDA_{i(t-2)}$	-0.135	-0.238	0.491**	0.729***
	R^2	0.014	0.147	0.318	0.184
Irrigated	Intercept	5.839***	5.115***	3.521**	4.093***
	$\%\Delta\ Fed_{i(t-1)}$	-0.260*	-0.217	-0.160	-0.268*
	$\%\Delta\ USDA_{i(t-1)}$	0.349*	0.452**	0.176	-0.176
	$\%\Delta\ USDA_{i(t-2)}$	0.054	0.075	0.540***	0.840***
	R^2	0.089	0.122	0.237	0.333
Ranch	Intercept	8.386***	7.771***	5.008***	4.968***
	$\%\Delta\ Fed_{i(t-1)}$	-0.278*	-0.292	-0.293	-0.276*
	$\%\Delta\ USDA_{i(t-1)}$	0.227	0.473**	0.324**	-0.120
	$\%\Delta\ USDA_{i(t-2)}$	-0.081	-0.175	0.314**	0.755***
	R^2	0.081	0.082	0.312	0.358

Note: Asterisk (*), double asterisk (**), and triple asterisk (***) denote coefficients significant at 10%, 5%, and 1% respectively.

FIGURES

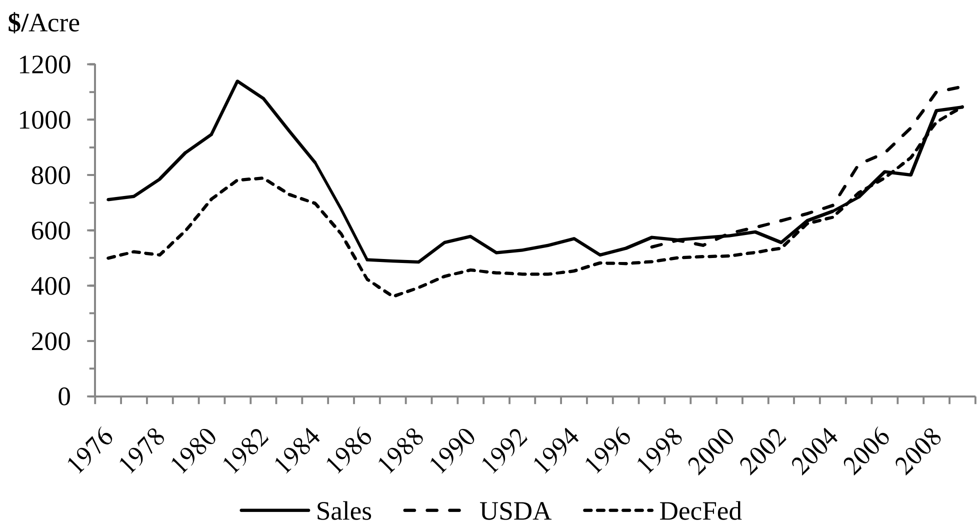

Figure I.1. Estimated Oklahoma non-irrigated cropland value

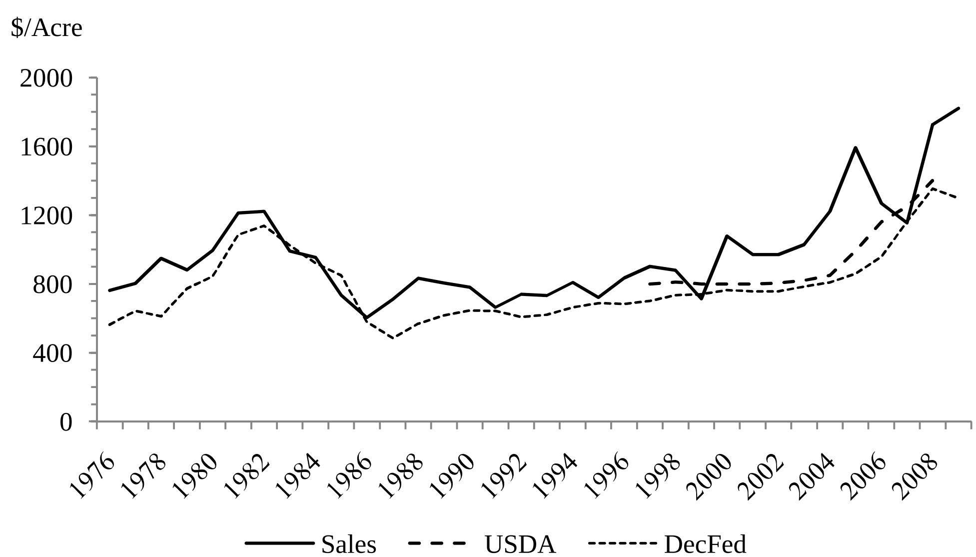

Figure I.2. Estimated Oklahoma irrigated cropland value

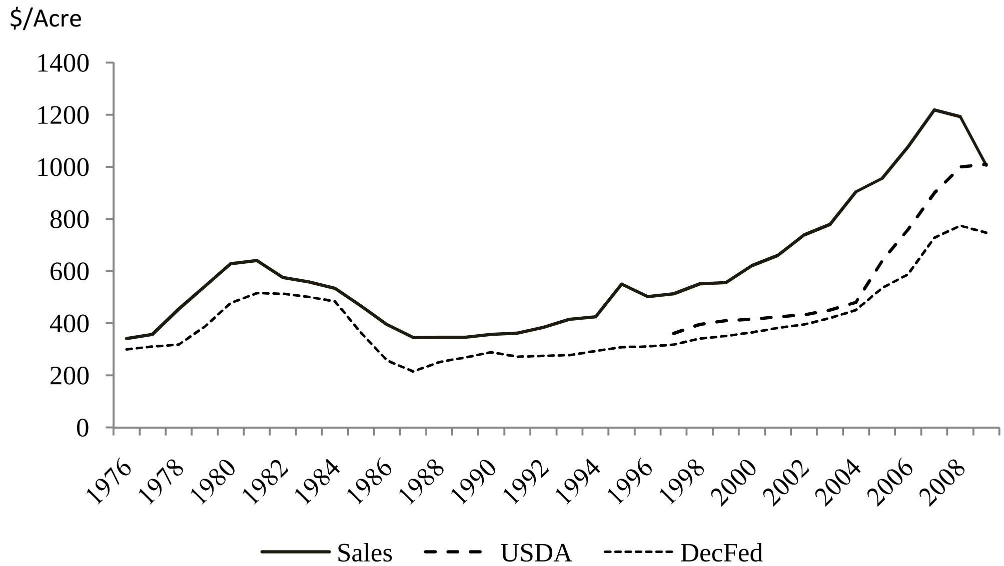

Figure I.3. Estimated value of Oklahoma ranchland

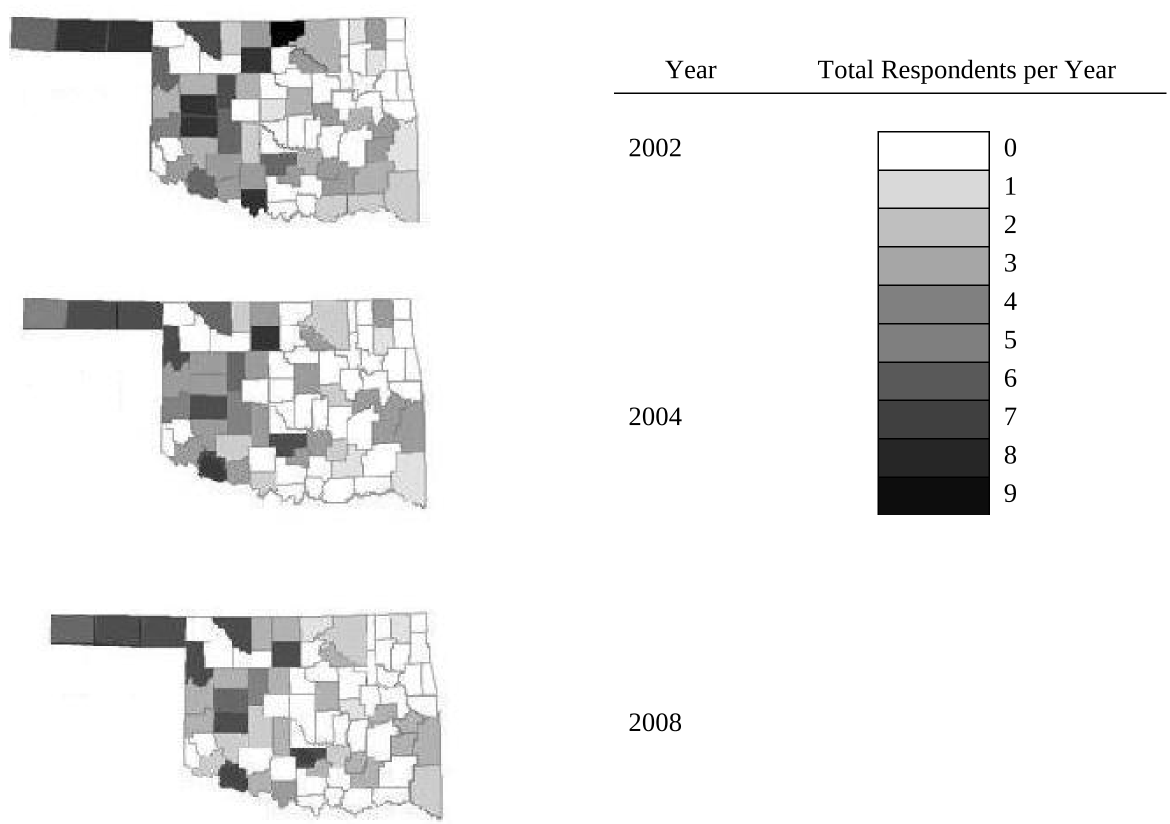

Figure I.4 Distribution of Federal Reserve Oklahoma survey respondents

APPENDICES

Appendix A:

USDA and Federal Reserve Bank Survey Questions

This appendix includes the specific questions included in the USDA and Federal Reserve surveys. The questions asked by the USDA and Federal Reserve Bank are noted.

United States Department of Agriculture (USDA):

Now I would like to ask about the market value of the land **inside** the blue tract boundary. By "market value," I mean the value at which the land could be sold under current market conditions.

[*Show photo and refer to fields recorded in Section D.*]

1. For the **(Section D)** acres reported within this **blue boundary**, I need your best estimate of the market value of these acres by type of land. This value should exclude the value of all dwellings and buildings.

[*check if reported in Section D.*]

b. Non-irrigated cropland? (*Include fruit, nut, berry, vineyard, and nursery land*)…

c. Irrigated cropland? (*Include fruit, nut, berry, vineyard, and nursery land*)…

d. Permanent pasture, grazing, or grassland…

Federal Reserve Bank's 10th District Survey of Agricultural Credit Conditions:

What is the current average value of good quality farmland in your lending area?

Farmland Values:	Good quality farmland	____ ($/acre)
	Irrigated Cropland	____ ($/acre)
	Ranchalnd or pastureland	____ ($/acre).

Appendix B:

Deriving Land Values from Sales Data

Regression Equation

Land values from sales data are estimated using the equation:

(13)
$$y_{it} = \beta_{0t} + \beta_{1t}Acres_{it} + \beta_{2t}Acres^2{}_{it} + \beta_{3t}Pcrop_{it} + \beta_{4t}Pirrig_{it} + \beta_{5t}Ppast_{it}$$
$$+\beta_{6t}Ptimber_{it} + \beta_{7t}Longitude_{it} + \beta_{8t}Ppast_{it} * Longitude_{it} + \varepsilon_{it}$$

where the dependent variable y_{it} is the transaction price (less improvements) per acre for the *i*-th transaction in time period *t*. Previous research has shown that land value per acre decreases with increasing tract size (Guiling et al., 2009; Tsoodle et al., 2007) prompting the inclusion of explanatory variables representing the total acreage sold (*Acres*) and the acreage squared ($Acres^2$). Other explanatory variables include the percent of land assigned to each land use (*Pcrop, Pirrig, Ppast*, *Ptimber*) which is assigned based on assessors' judgments. The percent of land that did not fall into one of the above categories forms the variable *Pother* which is removed from the equation to prevent collinearity. The variable *Longitude* is calculated for each parcel based on the legal description of the sale and is included to distinguish regional differences between eastern and western Oklahoma. An interaction term between *Ppast* and *Longitude* is also included. Longitude interaction terms with other land types were estimated, but none were significant at the five percent level and many coefficients took unexpected signs. The equation was then reduced to its current form which separates regional variations in cropland from changes in ranchland. Using the model specified in equation (13), coefficients for the variable *Longitude* take expected signs and are statistically significant at the ten percent level every year and are significant at the five percent level in all but one year. Coefficients for the interaction term are statistically significant at the five percent level 40 percent of the time and statistically significant at the 10 percent level 51% of the time.

Categorizing Land Sales Based on Assessors Judgments

For each sale, an assessor provides a description and the estimated acreage of the type of land. The descriptions are listed below according to the land utilization best represented. The acreage corresponding to each description is used in the calculation of the variables *Pcrop, Pirrig, Ppast, Ptimber,* and *Pother*. The number of different descriptions identifying the same land use is notable. Standardizing land descriptions would eliminate many seemingly redundant descriptions. From a research perspective, fewer descriptions would improve the data by allowing the researcher to better assign land to appropriate categories.

Table I.5 Land Use Categories

Crop	Irrig. Crop	Pasture	Timber	Other
(bottom)	CROP IRRG	(& brushy past.	& timber	DRAINAGE/ROAD
(Bottomland)	Irr Crop, R & W	(and pasture)	(scattered tmb)	R & W
(Btmld-creek)	Irr Cropland	(Bermuda-bottom	(small amt.timb	R/W
(mostly upld)	Irr. Cropland	(Bluestem, some	(some timber)	R/W/RIVER
(some crop)	Irr.crop	(improved/mdw)	(timb along cre	R/W=2.5AC
(upld,homesite)	Irrg Crop	(mostly native)	(timb.on creek)	Raods and Waste
ACCESS CROP	Irrg Land	(Native)	(Timber along	ROAD & WASTE
ACREAGE	Irrigated crop	(Native,Cl.6)	(timber along c	Road/ Waste
Alfalfa	Irrigated crop/	(Native,rollng)	(timber along d	Roads
Bates Loam III	IRRIGATED CROPL	(Native/Fescue)	acres of timber	ROADWAYS
Bates Loam IV	IRR. CROP	(scattered brus	and timber	RR/Waste
Bluestem (Crop)	Irrg. Crop	(small amt mead	BTM LAND TIMBER	RW
Bodine Cherty L	Irrig Crop	(Some meadow)	Btm Timber	RW
Bodine ChertyLa	Irrigated Cropland	(Spot bermuda)	clear cut tm/pa	UTILITIES
Bodine Stony Lo	Irrigated land	BER	CUTOVER TIMBER	Waste
BOTTOM CROP		BERMUDA	front timber	WASTE
BOTTOM LAND		Bermuda and Fes	MTN TIMBER	WASTE AND ROADS
Bottomland		Bermuda Past.	NO ACCESS TIMBE	Waste and Water
Bottomland crop		Bermuda Pasture	NP AND TIMBER	WASTE RIVER
Bottomland/		BERMUDA/CREEK B	POOR ACCESS TIM	WASTE RRROW
BTM CROP		Bermuda/pasture	ROUGH TIMBERED	WATER WAYS
BTM CROP LAND		Bermuda/R&W	RR/Waste/Timb	Water/ Old RR
Btm Crop/Pastur		BOTTOM LAND PAS	Semi-Timber	Water/Waste
Choska Loam I		Bottom past/pec	Small Amt.Tmb	Waterway
Class II		BOTTOM PAST/TIM	THICK TIMBER/PA	WW/
Class IV		BOTTOM PASTURE	TIM./PASTURE	WW/DRAINAGE
Class VII		Bottom. Pasture	Tim/Pas	CREEK/R&W
CROP		Brome Past	Timb/Rough Past	Creek
Crop (Imp.past.		BTM IMPR PASTUR	Timber	Creek, R&W
CROP 2ND BOTTOM		BTM LAND BERMUD	Timber & Brush	SITE

Table I.5 Land Use Categories

Crop	Irrig. Crop	Pasture	Timber	Other
CROP I,II,IV,V		BTM.PAST/PECANS	Timber & Lakes	(2) Home Sites
CROP LAND		Clear Cut Pas.	Timber & Semi-T	Building Lot
CROP LAND-HOME		CLEARED PASTURE	TIMBER & WASTE	building site
CROP LOW BOTTOM		CRP	Timber (btmland	Building Site(T
CROP -PASTURE		CRP Land	TIMBER AND BRUS	HOME LOT
CROP(FAIR- ACCE		CRP/Bluestem	TIMBER AND CREE	HOME SITE
Crop(Imp.P)		CRP/Imp.Past	Timber and Semi	HOME SITE & PAS
CROP(SM.AMT.TIM		CRP/Imp.pasture	TIMBER BRUSH	Home Site R&W
Crop, R&W		CRP/Improved pa	TIMBER HOMESITE	Home site/Imp.
CROP/BERMUDA		CRP/Pasture	Timber Pas(1/2	HOME STIE-LAKE
Crop/bluestem		Fair Pasture	Timber Pasture	Homesite
Crop/Bottom lan		fescue)	TIMBER- REGROWT	HOMESITE(EASE
Crop/BS		Good Pasture	Timber(upld)	HOMESITE/LOT
Crop/CRP		HAY MEADOW	Timber/Borrow p	HOMESITE/PAST
CROP/HOMESITE		Highway Pasture	TIMBER/BRUSH/CR	HOMESITE/SEPTI
CROP/IDLE CROP		Imp Pas	TIMBER/BRUSH/PI	Homesite/upland
Crop/Imp Past		Imp Pas & Site	TIMBER/BRUSHY P	Residential
CROP/MEADOW		Imp Past	Timber/Creek	Rural Res
CROP/MEADOW/PAS		Imp Past/Crop	TIMBER/CREEK/B.	Site for Dwelli
Crop/Pas. Land		imp past/crop/t	TIMBER/CREEK/GR	
Crop/Pasture		IMP PASTURE	TIMBER/FLOODS	
Crop/R&W		Imp. Pas & Site	Timber/Grasslan	
Crop/Tillable		Imp. Pas. Gate	TIMBER/GRAVEL P	
Crop/Timber		Imp. Pas./site	TIMBER/HILL	
CROPABLE LAND		Imp. Pas.-Crk B	TIMBER/HOMESIT	
CROPABLE PASTUR		Imp. Pas/Homesi	Timber/Hunting	
Cropland		Imp. Past.- CRP	Timber/Lake Vie	
Cropland A		Imp. Pasture	TIMBER/LOT	
Cropland B		Imp. Pasture/ H	TIMBER/NATIVE P	
Cropland Bttm		Imp. Pasture/Me	TIMBER/PASTUR/C	
Cropland/CRP		Imp. Pas-Upld	Timber/Pasture	
Cropland/Meadow		IMP.& NAT.PASTU	TIMBER/PECANS	
Cropland/Pastur		IMP.PAST/HOMESI	TIMBER/POOR ACC	
Cropland/R&W		IMP.PAST/MEADOW	TIMBER/RECLAIME	
Cropland/RW		IMP.PASTURE/MEA	TIMBER/REGROWTH	
Croplantd		Imp.pasture/R&W	TIMBER/RIVER	
CROP-PAST		Improved	Timber/rocky bl	
Crop-Ryegrass		IMPROVED BERMUD	TIMBER/ROCKY HI	
CROP-TIMBER		IMPROVED BTM PA	Timber/Site	
Crop--Tract 1		Improved Pas(Bt	TIMBER/SPT.TIMB	
CULT.		Improved Pas(Up	TIMBER/STRIP MI	
CULT. CROP		Improved Pas-Cr	TIMBER/TIM.PAST	
CULT. CROPLAND		Improved Pas-Re	TIMBER/UNRECLAI	
CULT. LAND		IMPROVED/NATIVE	TIMBER/WASTE	
CULT. PEACH ORC		Improvement Sit	TIMBER/WATERWAY	
CULT.CREEK BOTT		LOST PASTURE	TIMBER/WETLAND	
Cultivatable		Maedow	Timber/Wetlands	
Cultivatable/RW		Mead/homesite	TIMBER-BRUSH	

Table I.5 Land Use Categories

Crop	Irrig. Crop	Pasture	Timber	Other
CULTIVATED		Meadow	Timber-Btm land	
CULTIVATION		MEADOW (POOR AC	TIMBER-CREEK	
CULTIVATION - C		MEADOW/CROP	TIMBER-DRAWS	
Dennis Loam		Meadow/Hmsite	Timbered	
Dennis Loam II		MEADOW/HOMESITE	TIMBERED HILL	
Dennis Loam III		MEADOW/IDLE CRO	TIMBERED HOMESI	
Dennis Loam VI		MEADOW/IMP.PAST	TIMBERED LOT	
Dennis Verdigri		Meadow/Past	TIMBERED NATIVE	
Dickson Cherty		MEADOW/PASTURE	Timbered Past	
Dry Land		Meadow/Site	Timber-upld	
Dry crop		Meadow/timber)	Timbir	
Dry crop/CRP/R&		Meadow/upland/	timbr on creek	
Dry crop/Pastur		Meqadow	TIMER	
Dry crop/R&W		NAT BRUSH	TMBER	
Dry crop/RW		Nat Past	Tmber/p.access	
Dry Cropland		Nat Past/Develo	trees- Mostly P	
DRYLAND		NAT. & SCT BERM	Trees/Creek	
Eram VII		Nat. Past	Trees/Creek/R&W	
Etowah silt loa		NAT./BLSTM PAST	Trees/Creeks/R&	
IDLE CROP		NAT.PASTURE/BRU	WET LANDS-TIMBE	
Linker Loam II		NAT.PASTURE/HIL	Woods	
LOW BOTTOM		NAT/BLSTM PASTU	Woods/PASTURE	
Mason Loam I		NAT/BRUSH		
Orchard A		Nat/Brushy Past		
Parsons Loam		NATIVE & BERMUD		
Parsons Loam II		Native / Timber		
Pasrons Loam I		NATIVE AND BERM		
Pecan orchard		NATIVE AND TIMB		
Pecan orchardsB		NATIVE BRUSH		
Pecan trees		NATIVE BRUSH PA		
PECANS		Native Grass		
PECANS/PASTURE		NATIVE MEADOWS		
PECANS/TIMBER		NATIVE PAST&TIM		
ROCKY OUTCROP		Native/ brush p		
Roebuck Loam II		NATIVE-TIMBER		
Severn Loam I		NO ACCESS PAST/		
SMALL ACREAGE		NO ACCESS PASTU		
Sod		Old Fld. Pastur		
Stigler Loam II		Open Nat. Pas.		
Taloka Loam		Open Nat. Pastu		
Taloka Loam II		Open Pas		
Taloka Loam III		Open Pas & Peca		
Tract #1-Imp Pa		Open Pas.(1/2 I		
Tract #2-Native		OPEN PASTURE-SC		
Tract #2-Timber		Open Upld Pastu		
Tract 1		PAST.& PEACH OR		
Upland Crop		Past/Homesites		
UPPER BOTTOM		PAST/MEADOW		

Table I.5 Land Use Categories

Crop	Irrig. Crop	Pasture	Timber	Other
Verdigris II		Past/overflow		
Verdigris Loam		Past/Timber		
wheat		Past/timber/wwa		
Bottomland Cultivation		PAST-TIMBER		
Crop/Past		Pastur/Creek		
Cropalnd		Pasture & Creek		
Cropland/Bottom land		PASTURE & HOME		
Cultivable Past		Pasture & Lake		
CULTIVATABLE PA		Pasture & Site		
Dry crop/CRP		PASTURE & TIMBE		
Dry crop/CRP/R&W		PASTURE (BRUSHY		
Dry crop/Pasture/RW		Pasture (btmlan		
Dryland Cultivation		Pasture (facili		
Till. Past./CRP		PASTURE (IMPROV		
Tillable Past		PASTURE (NATIVE		
Upld Crop		PASTURE (PECANS		
Upld Cropland		Pasture (upland		
Upldn Crop		Pasture / Timbe		
		Pasture / Woods		
		Pasture A		
		PASTURE AND CRE		
		PASTURE AND TIM		
		PASTURE AND WAS		
		PASTURE AROUND		
		Pasture B		
		PASTURE BERMUDA		
		Pasture C		
		PASTURE- CULTIV		
		PASTURE CULTIVA		
		PASTURE LAND		
		PASTURE LAND LO		
		Pasture r/w		
		PASTURE TIMBER		
		Pasture w/Brush		
		PASTURE W/REGRO		
		PASTURE W/TIMBE		
		PASTURE WITH MI		
		PASTURE& SCAT.B		
		Pasture&Timber		
		Pasture(2nd gro		
		PASTURE(50'ACCE		
		PASTURE(AND MEA		
		Pasture(Ber)		
		PASTURE(BRUSHY)		
		PASTURE(NAT-FES		
		Pasture(Native)		
		Pasture(Open)		
		Pasture(Pine)		

Table I.5 Land Use Categories

Crop	Irrig. Crop	Pasture	Timber	Other
		Pasture(Semi-Op		
		Pasture(Spt Ber		
		Pasture(Timber)		
		PASTURE, NAT.		
		Pasture, R&W		
		PASTURE/ HOMESI		
		Pasture/ R&W		
		Pasture/ R&W/ W		
		Pasture/ Timber		
		Pasture/B		
		Pasture/bottoml		
		PASTURE/BRUSH		
		PASTURE/BRUSH/C		
		ASTURE/BRUSHY		
		Pasture/Build.		
		Pasture/Buildin		
		Pasture/cedar		
		pasture/creek		
		PASTURE/CREEK B		
		Pasture/Creek/T		
		Pasture/Crop		
		Pasture/CRP		
		Pasture/Cultiva		
		PASTURE/DEVELOP		
		Pasture/Devlpmt		
		PASTURE/EXEC.HM		
		PASTURE/FACIL.S		
		Pasture/Facilit		
		Pasture/Hay		
		PASTURE/HDQRTER		
		PASTURE/IDLE CR		
		PASTURE/LOT		
		PASTURE/MAEDOW		
		Pasture/Mead-Bt		
		PASTURE/MEADOW		
		PASTURE/NATIVE		
		PASTURE/ORCHARD		
		Pasture/Pecans		
		Pasture/Ponds		
		Pasture/R&W		
		Pasture/R&W/WW		
		Pasture/R&W--Tr		
		pasture/river		
		Pasture/RW		
		PASTURE/SCT. TI		
		Pasture/site		
		Pasture/Swamp		
		Pasture/Timber		

Table I.5 Land Use Categories

Crop	Irrig. Crop	Pasture	Timber	Other
		PASTURE/WATERWA		
		Pasture/Woods		
		Pasture/WW		
		Pasture\Crop		
		PASTURE\TIMBER		
		PASTURE-BRUSH		
		PASTURE-CULTIVA		
		PASTURE-HOME SI		
		Pastureland		
		Pastureland/RW		
		Pasture-Lot		
		PASTURE-NATIVE		
		Pasture-Sprouty		
		Pasture-Tillabl		
		PASTURE-TIMBERE		
		PASTURE-UNIMPRO		
		PASTUREW/TIMBER		
		Pasutre/RW		
		Pature/River ar		
		Semi Open Pastu		
		Semi-Improved P		
		Semi-open		
		Semi-Open Pas		
		Spt Ber		
		Spt Ber Pasture		
		TAME PASTURE		
		TILLABLE PASTUR		
		unimproved pasture		
		UNMINED PASTURE		
		UPLAND PASTURE		
		UPLD BER/NAT/TI		
		UPLD IMP.PASTUR		
		UPLD NATIVE PAS		
		UPLD PASTURE		
		Upld Pasture/Si		
		UPLD, PASTURE I		
		w/bermuda grass		
		Improvd Past		
		Improved Pa		
		Improved Pas		
		Improved Past		
		Native Past Sit		
		Native Past.		
		Native Pasture		
		Native Pasture/Brushy		
		Past R&W		
		Pasture		

Assigning Longitude Based on Legal Description

The legal descriptions of sold parcels are listed in the sales record using the federal township and range system. The basic units of this system are sections, which are equivalent to one square mile and include 640 acres. Townships are 36 sections arranged in a 6x6 array. The range measures the distance east to west a given township is against a principle meridian. Oklahoma has two principal meridians. The Cimarron Meridian is used for counties in the Oklahoma panhandle while the Indian Meridian is used for the remaining counties.

Longitudinal values are assigned to each land tract in the sales database based on the defined range. Table I.6 shows the assigned longitude based on the range specified in the legal description.

Table I.6. Longitude Value Corresponding to Legal Description

Indian Meridian				Cimarron Meridian	
West Range	Longitude	East Range	Longitude	Range	Longitude
R1W	97.30	R1E	97.19	R1E CM	102.95
R2W	97.41	R2E	97.08	R2E CM	102.84
R3W	97.52	R3E	96.97	R3E CM	102.73
R4W	97.63	R4E	96.87	R4E CM	102.62
R5W	97.73	R5E	96.76	R5E CM	102.52
R6W	97.84	R6E	96.66	R6E CM	102.41
R7W	97.95	R7E	96.56	R7E CM	102.30
R8W	98.05	R8E	96.45	R8E CM	102.19
R9W	98.16	R9E	96.33	R9E CM	102.04
R10W	98.27	R10E	96.23	R10E CM	101.98
R11W	98.37	R11E	96.12	R11E CM	101.87
R12W	98.48	R12E	96.02	R12E CM	101.76
R13W	98.59	R13E	95.92	R13E CM	101.65
R14W	98.70	R14E	95.81	R14E CM	101.55
R15W	98.80	R15E	95.70	R15E CM	101.44
R16W	98.91	R16E	95.60	R16E CM	101.33
R17W	99.02	R17E	95.49	R17E CM	101.22
R18W	99.12	R18E	95.38	R18E CM	101.12
R19W	99.23	R19E	95.27	R19E CM	101.00
R20W	99.33	R20E	95.17	R20E CM	100.90
R21W	99.44	R21E	95.06	R21E CM	100.79
R22W	99.55	R22E	94.05	R22E CM	100.68
R23W	99.66	R23E	94.85	R23E CM	100.58
R24W	99.77	R24E	94.74	R24E CM	100.47
R25W	99.87	R25E	94.63	R25E CM	100.36
R26W	99.96	R26E	94.52	R26E CM	100.25
				R27E CM	100.15

Note: Ranges are taken from the legal description of sold tracts using the federal township and range system

Deriving Land Value Estimates of Sales Data

Hedonic values for each land type (non-irrigated cropland, irrigated cropland, pasture), were obtained using equation (13). To obtain state average land value estimates for each type of land utilization, the percentage of land assigned to the desired land type is 100 percent while the remaining land uses are assigned zero percent. Estimates for variables $Acres$ and $Acres^2$ are constant across time and are obtained using the regression equation:

(14) $$Acres = \alpha_0 + \alpha_1 Pcrop + \alpha_2 Pirrig + \alpha_3 Ppast + \alpha_4 Ptimber + \varepsilon.$$

The results of the regression equation are:

(15) $$\underset{(37.15)}{Acres = 116.21} + \underset{(39.30)}{39.29\ Pcrop} + \underset{(45.01)}{118.11\ Pirrig} + \underset{(37.49)}{115.43\ Ppast} + \underset{(42.14)}{310.37\ Ptimber}.$$

where the values in parentheses represent the standard error of the estimated coefficient values. The appropriate acreages are obtained by setting the desired land type to 100 percent and the other land types to zero percent such that the estimates of *Acres* for each farmland type are as follows:

non-irrigated cropland $= \alpha_0 + \alpha_1$ =155.50 acres,

irrigated cropland $= \alpha_0 + \alpha_2$ =234.31 acres, and

pasture and ranchland $= \alpha_0 + \alpha_3$ =231.64 acres.

The estimates of $Longitude$ are held constant through time and are obtained using the average longitude of sold tracts weighted by the acreage designated to each land type. For example, pasture land is estimated using:

(16) $$Longitude_{Pasture} = [\sum_t \sum_i Longitude_{it} * PastureAcres_{it}]/[\sum_t \sum_i PastureAcres_{it}]$$

where $Longitude_{Pasture}$ is the weighted average longitude for pasture land, and $PastureAcres_{it}$ is the total number of acres in pasture for the *i*-th transaction in time *t*. Alternatively, $PastureAcres_{it} = Acres_{it} * Ppast_{it}$. The resulting longitudinal values are 98.85, 100.43, and 96.71 for non-irrigated, irrigated and pasture respectively. These values are used to remove the noise created when more transactions are in eastern or western Oklahoma in a given year.

The average values for each of the land types are estimated:

(17) $$Crop_t = \hat{\beta}_{0t} + \hat{\beta}_{1t}\,(155.50) + \hat{\beta}_{2t}\,(24180.25) + \hat{\beta}_{3t}\,(1) + \hat{\beta}_{7t}\,(98.85)$$

$$Irrig_t = \hat{\beta}_{0t} + \hat{\beta}_{1t}\,(234.31) + \hat{\beta}_{2t}\,(54901.18) + \hat{\beta}_{4t}\,(1) + \hat{\beta}_{7t}\,(99.56)$$

$$Past_t = \hat{\beta}_{0t} + \hat{\beta}_{1t}\,(231.64) + \hat{\beta}_{2t}\,(53657.09) + \hat{\beta}_{5t}\,(1) + \hat{\beta}_{7t}\,(97.45) + \hat{\beta}_{8t}\,(97.45)$$

where $Crop_t$ is the estimated average value for Oklahoma non-irrigated cropland in time t, $Irrig_t$ is the value of irrigated cropland, and $Past_t$ is the estimated average value for Oklahoma pasture land.

To limit the effect of outliers on the estimation, data are limited to sales over 40 acres. Additionally, a maximum price of $3000/acre and a minimum price of $100/acre are specified. Transactions spanning 1976-2009 are used. Estimates for the last three years 2007-2009 are included in table I.7.

Table I.7. Estimated Coefficients for Determining Land Values from Transaction Prices

		Year					
Variable	Symbol	2007		2008		2009	
Intercept	β_{0t}	16880.15	(8.77)	19188.57	(6.47)	10087.70	(2.00)
$Acres_t$	β_{1t}	-0.28	(-5.10)	-0.59	(-5.06)	-1.47	(-4.01)
Acres_t^2	β_{2t}	$1.2E^{-5}$	(4.33)	$1.4E^{-4}$	(4.19)	$9.8E^{-4}$	(2.81)
$Pcrop_t$	β_{3t}	-131.20	(-2.10)	44.85	(0.59)	-81.39	(-0.56)
$Pirrig_t$	β_{4t}	478.82	(2.74)	1008.32	(5.27)	1012.98	(3.48)
$Ppast_t$	β_{5t}	-1509.70	(-0.71)	-5457.14	(-1.73)	-1004.55	(-0.18)
$Ptimber_t$	β_{6t}	524.85	(2.64)	577.17	(0.92)	-331.31	(-0.67)
$Longitude_t$	β_{7t}	-160.89	(-8.11)	-183.07	(-6.01)	-89.25	(-1.72)
$Ppast_t * Longitude_t$	β_{8t}	16.32	(0.74)	55.72	(1.72)	9.32	(0.17)
Non-irrigated ($/acre)		802		1048		978	
Irrigated ($/acre)		1137		1681		1847	
Ranchland ($/acre)		1219		1193		1007	

Note: ( ) indicates t-statistic value; Non-irrigated Acres=155.5, Longitude=98.5;
Irrigated Acres=234.3, Longitude=100.43; Ranchland Acres=231.6. Longitude=96.41

Land value estimation is sensitive to variation in the number of sold tracts which possess features that generate premiums or discounts (Goodwin and Mishra, 2003). Past research has shown that other common factors including recreational uses, urban influences, soil productivity, interest rates, government payments, cash rents, income, and population density affect the value of farmland (Burt, 1986; Guiling et al., 2009; Henderson and Moore, 2006; Falk and Lee, 1998; Flanders et al., 2004; Tsoodle et al, 2007). While these are important determinants of farmland values, their effects are not estimated. Variables such as soil productivity are not available at the farm level. Other variables such as interest rates, government payments, and income are not constant through time and their effects are captured by estimating new parameters each year.

ESSAY II:

HOW ACCURATE ARE THE FORECASTS OF FARMLAND VALUES FROM THE FEDERAL RESERVE'S TENTH DISTRICT LAND VALUE SURVEY?

Abstract

This paper evaluates quarterly land value forecasts provided by bankers via the Federal Reserve's Tenth District *Survey of Agricultural Credit Conditions*. Bankers qualitative forecasts of up, down, or no-change are evaluated against actual, self-reported change in land values. Using disaggregate data, contingency tables show that a large percentage of bankers forecast no-change. Despite this, aggregating bankers' qualitative forecasts do help predict changing land values and forecast better than naïve models. Bankers' forecasts also satisfy conditions for optimal forecasts.

Introduction

Farmland is the primary source of wealth for many agricultural producers and its value plays an important role in farm financial planning, but the lack of publicly available land value forecasts makes future planning difficult. The Federal Reserve Bank of Kansas City provides a potential source of land value predictions via its quarterly *Survey of Agricultural Credit Conditions*. The purpose of this paper is to determine the ability of the Federal Reserve's *Survey of Agricultural Credit Conditions* to forecast land values. Specifically it will address how well qualitative land value forecasts given by bankers in the Federal Reserve's 10th District Survey of Agricultural Credit Conditions correspond to actual land values obtained in the next quarter's survey.

Previous research has addressed the importance of developing effective land value forecasts. Some of the earliest papers are summarized by Pope et al (1979). More recently, researchers have built econometric models to explain land values based on the present value of future returns (Burt 1986; Falk 1991). However, Falk (1998) later shows that land price movements are not forecasted well using the present value model. Furthermore, Goodwin et al. (2003) note empirical failure of forecasts based on econometric models due to structural shifts, changing market forces, and an uncertain policy environment.

This paper extends previous land value forecasting literature by determining if bankers' qualitative opinion forecasts provided by the Federal Reserve Bank are indicators of future land value movement. Currently, the Federal Reserve does not make its prediction data publicly available. Nonetheless, if survey predictions are shown to be indicators of land value movement, expanded distribution of the forecast results would provide a valuable resource for anyone interested in tracking agricultural land values

Data

Each quarter, the Federal Reserve Bank of Kansas City sends the *Survey of Agricultural Credit Conditions* to agricultural banks across the seven states within the Federal Reserve's 10th District. The Federal Reserve's 10th District includes the states of Colorado, Kansas, Nebraska, Oklahoma and Wyoming and includes the northern half of New Mexico and the western third of Missouri. This region contains 650 agricultural banks which is almost 30 percent of the nation's total. Of these banks, approximately 250 respond to the survey each quarter. Agricultural banks are defined as banks that have a higher volume of agricultural loans than the national average (approximately 14%). Bankers from these institutions are beneficial to survey because they are privy to unique information concerning farmland values.

Respondents answer questions concerning current land value levels and the expected directional movement of land values for the next quarter. Estimates are provided for three different classes of land values; Good quality farmland (non-irrigated), irrigated cropland, and ranchland. Each respondent provides a point estimate of local land values for each land category.

Average land values are noisy due to a survey sample that is not consistent from quarter to quarter. Banks responding in one quarter may not always respond in the next causing average land values to be sensitive to the banks included in the sample. For this reason, quarterly changes in the land values are calculated using the land value estimates for each bank that responds in back to back quarters. Only banks that have responded in the previous period are included in the calculation of percent changes. The quarterly percent change used in this paper is the average percent change reported by bankers in the Federal Reserve's Tenth District. Using this measure mitigates the effect of banks with high land values entering and exiting the sample. This smoothing effect may be observed for each land type in figures II.1-II.3.

In 2002, the survey was expanded to include forecasts of land values. Specifically, bankers reveal whether they expect land values to increase, decrease, or remain stable in the following quarter. Thus, for any quarter (q), survey respondents provide both the realized land value change from q-1 to q as well as the anticipated directional movement from q to q+1. Respondents are not asked to make seasonal adjustments. Bank responses are subject to additional validation procedures that remove outliers and data entry errors.

The Tenth District Federal Reserve Bank of Kansas City summarizes its agricultural survey information by reporting the yearly percentage change in farmland for each state as well as the yearly percent change in the 10th District average. Additionally, the quarterly percentage change from the previous quarter's District average is reported. Forecast data are not directly reported. Instead, the Tenth District Bank alludes to expectations through sentences such as, "most bankers expected farmland values to remain at current levels over the next three months (Henderson and Akers 2010)." This paper uses both disaggregate data as well as data that are aggregated at the District level. The panel contains 28 quarters from 2002:II to 2009:II.

Methods

Using disaggregated data, banker's individual prediction accuracy is determined through the use of contingency tables. Three additional methods use aggregated responses to measure out of sample forecasting accuracy for one-step-ahead forecasts. First, the percentage of banks predicting movement in each direction is interpreted as probability forecasts. These probability forecasts predict discrete outcomes that are based on observed movement in average land values. Next, continuous outcomes are defined as the percentage of bankers experiencing land value. Bankers' aggregated forecasts are tested as predictors of these outcomes. Finally, we evaluate bankers' ability to forecast land values by comparing the accuracy of their forecasts to forecasts from a naïve no change model.

Contingency tables

The overall forecasting accuracy of individual bankers may be shown using contingency tables. The tables show individual bank forecasts evaluated by their own self-reported movement in land value. Thus, the data are limited to banks that give both forecasts and land value estimates in period (*t*-1) and provide land value estimates in period (*t*). Stable movements, though not precisely defined in the survey, are assumed to occur when a banker provides the same land value estimate in two consecutive quarters.

Contingency table rows show the outcome frequency for movement in each direction. Likewise, the columns of the table show the number of banks forecasting each directional movement (up, down, or stable). Thus, each cell in the table (n_{ij}) gives the number of banks reporting outcomes categorized by their assigned forecasts. Correct forecasts are located on the main diagonal of the table in cells where $i=j$. A different table is provided for each of the three types of farmland considered (non-irrigated cropland, irrigated cropland, and ranchland).

The total number of banks reporting each directional movement is found in the far right column of the table. These are total realized outcomes over all periods, and are calculated as the sum of the *i*-th row over all *j*-columns: $\sum_{j=1}^{3} n_{ij}$. The total number of predictions are shown directly below the contingency table and are calculated as the summation of each observed *i*-th directional movement in column *j*: $\sum_{i=1}^{3} n_{ij}$. The total number of observations *N* is equal to the sum of all n_{ij}:

(18) $$N = \sum_{i=1}^{3} \sum_{j=1}^{3} n_{ij} \, .$$

The probability of occurrence (d_i) is the relative frequency of each directional movement within the sampling period:

(19) $$d_i = \sum_{j=1}^{3} n_{ij} / N.$$

The forecast likelihood (f_j) is similarly the frequency with which bankers forecast each directional movement:

(20) $$f_j = \sum_{i=1}^{3} n_{ij} / N.$$

Bankers' forecast accuracy is measured using three statistics; the overall bias, probability of detection, and the proportion correct. These statistics provide information on the overall reliability of the survey forecasts.

The bias statistic represents the overall miscalculation in bankers' expectation of future land value movement. It is measured by taking the difference in the frequency of prediction and the frequency of occurrence for each directional movement:

(21) $$bias = f_j - d_i \text{, when } i = j.$$

The percentage of correct forecasts (PCF) indicates the percentage of correct forecasts out of the total number of forecasts made for each category:

(22) $$PCF_i = n_{ij}/f_j \text{,} \quad \text{when } i = j.$$

The probability of detection (POD) shows how bankers forecasting accuracy differs based on the eventual outcome. It represents the percentage of outcomes that were correctly predicted given a specific outcome:

(23) $$POD_j = n_{ij}/d_i \text{,} \quad \text{when } i = j.$$

The proportion correct (PC) is the proportion of all *N* observations that were correctly forecasted. The PC is calculated by summing the frequency of correctly forecast outcomes (cells containing correct forecasts are located on the main diagonal elements of the contingency table) and dividing by the total number of observations *N*. Alternatively, it is the sum of the probability of detection across all *i*-outcomes:

(24) $$PC = \sum_{i=1}^{3} n_{ii}/N \text{ .}$$

Using Pearson's chi-squared test, we test the null hypothesis of independence between bankers' predictions and observed outcomes. If bankers' forecasts are independent of the observed outcome, the expected value for each cell is equal to the product of the corresponding forecast likelihood and outcome frequency:

(25) $$E[n_{ij}] = d_i * f_j$$

where $E[n_{ij}]$ is the expected value of the cell n_{ij}. The corresponding chi-squared test statistic for testing the independence of bankers' forecasts is:

(26) $$\chi^2 = \sum_{j=1}^{3} \sum_{i=1}^{3} (n_{ij} - E[n_{ij}])^2 / E[n_{ij}].$$

Though we are working with 3x3 contingency tables, the rows and columns are mutually exclusive and exhaustive, so that the chi-squared critical value has 4 degrees of freedom. If the test statistic exceeds the critical value, then we reject the null that outcomes are independent of predictions and assume that a relationship exists between forecasts and outcomes.

Forecasting Discrete Qualitative Outcomes: Briers Probability Score

In a previous study of Federal Reserve qualitative land value forecasts, Covey (1999) used Brier's mean probability scores (Brier 1950) to analyze aggregated land value data from the Chicago Federal Reserve Bank's *Survey of Agricultural Credit Conditions.* For each state or region in the survey sample, the relative percentage of banks forecasting up, down, and stable movement may be observed. Covey described these relative percentages as the likelihood of occurrence for each directional movement. In each period, survey respondents predict land value movement in any one of K=3 possible directions (up, stable, down). The percentage of bankers expecting movement in each direction represents the forecasted probability of each outcome k and is denoted *fup*, *fstable, fdown* such that:

(27) $$\sum_k f_k = 1 \quad .$$

An outcome index is also created using the observed change in average land values reported by bankers in the same survey. Each quarter, the actual change in land values follows one of the K=3 directions. The discrete outcome index (d_k) is likewise denoted d_{up}, d_{stable}, and d_{down}. The values of the outcome index are assigned by:

(28) $$d_k = 1, \quad \text{If average land values move in the } k\text{th direction},$$

$$= 0, \quad \text{If average land values do not move in the } k\text{th direction}.$$

Covey used a +/- 4 percent change in land value to determine which quarters were assigned upward and downward land value movements. A minimum quarterly change of four percent is used to distinguish quarters in which land values moved either up or down from quarters in which land remained stable. It is important to note that the results of this method are sensitive to the bounds of the no change category. To overcome these challenges, bound sensitivity is examined in appendix A.

Brier's Probability Score (PS) evaluates the accuracy of the probabilistic forecasts using the sum of squared errors between bankers' probability forecasts and the realized outcome index:

(29) $$PS_t = \sum_k (f_{k_t} - d_{k_t})^2 \qquad ; 0 \leq PS \leq 2$$

where f_{k_t} is the forecasted probability for k-th directional movement in time t, and d_{k_t} is the outcome index value for k-th directional movement in time t. The probability score ranges between zero and two. A probability score of zero represents assigning a forecast of absolute certainty to an outcome that eventually occurred. A probability score of two results from assigning a probability of zero to the occurring directional outcome.

The mean probability score ($\overline{\text{PS}}$) measures the total forecast accuracy for all directional forecasts over all *T*=28 periods in the sample:

(30) $$\overline{PS} = \frac{1}{T}\sum_{t=1}^{T}\sum_{k}(f_{k_t} - d_{k_t})^2 \qquad ; 0 \leq \overline{PS} \leq 2.$$

Yate's Covariance Decomposition

Yates derived a decomposition of $\overline{PS}$ called the covariance decomposition (Yates, 1982) which can be used with either discrete or continuous forecasts. The Yates covariance decomposition may be expressed as:

(31) $$\overline{PS}(f,d) = \text{Var}(d) + \text{Var}(f) + \text{Bias}^2 - 2\text{Cov}(f,d).$$

where Var(*d*) is the variance of outcomes, Var(*f*) is the variance of forecasts $Bias^2$ is the squared forecasting bias and $\text{Cov}(f,d)$ is the covariance between the forecast and outcome indices.

Var(*d*) represents the part of the probability score that is not influenced by the forecaster:

(32) $$\text{Var}(d) = \bar{d}(1-\bar{d})$$

Where $\bar{d}$ is the outcome frequency over all *N* periods.

The bias is defined by

(33) $$Bias = \bar{f} - \bar{d}$$

where $\bar{f}$ is the mean probability forecast over all *N*-occasions. The bias statistic shows how well forecast frequencies match outcome frequencies for the event of interest.

Cov(*f*,*d*) contributes negatively to the probability score and should, therefore, be maximized. The covariance may be expressed as:

(34) $$\text{Cov}(f,d) = [slope][\text{Var}(d)]$$

where *slope* is the slope of the regression line when forecast values are regressed on outcomes. When the outcomes take discrete values of zero or one, the slope can be defined as:

(35) $$slope = \overline{f_c} - \overline{f_0} \qquad ; \; -1 \leq slope \leq 1$$

where: $\overline{f_c} = \frac{1}{T_c}\sum_m f_{c_m} \qquad m = 1, \ldots, T_c$

is the conditional probability judgment for the target event over those T_c occasions when the event actually occurs; $\overline{f_0}$ is defined similarly for the remaining T_0 instances when the event does not occur, with $T = T_1 + T_0$. In the ideal case, the forecaster always provides $f_k = 1$ when the realized outcome *k* occurs and $f_k = 0$ when it does not. The slope measures the average amount by which the average probability estimates change conditional on the occurrence of the forecasted outcome. The more expertise bankers demonstrate in effectively discriminating occasions of likely land value movements, the higher the slope score will be. The optimal slope score is one and occurs when bankers offer perfect foresight.

The remaining component, Var(*f*), is the variance of the forecasts. It contributes positively to the probability score and the forecaster should minimize the forecast variance. However, when the variance of the forecasts is at an absolute minimum of zero, the forecaster is providing constant forecasts and these constant forecast forces the covariance to zero by the elimination of the *slope* value. Thus, a proper objective of the forecaster should be to minimize the variance of the forecasts conditional on the attainment of a given slope (Yates 1988). As a result, forecasts should generally have a lower variance than outcomes.

The probability forecast for bankers are measured against two models. Both of these no-skill forecasters provide constant forecast probabilities each quarter causing the slope score to be zero. The first is a uniform model where the probability of directional movement is equal across outcomes ($\boldsymbol{f_k = 1/K}$ for all $\boldsymbol{k = 1, \ldots, K}$). For this application, forecasts of probability equal to one-third are assigned to increases, decreases, and stable land value movement for each quarter.

The second model is a relative frequency model which assigns probabilities based on the relative frequency of the actual outcomes ($\boldsymbol{f_k = \overline{d}_k}$ for all $\boldsymbol{k = 1, \ldots, K}$). The relative frequency model is calculated in-sample from all observed outcomes. The model provides constant, unbiased forecasts and no constant probability forecaster can perform better than the relative frequency forecast; decomposition shows that the probability score for the relative frequency forecaster is equal to the outcome variance (Var(*d*)). Since forecasts are generated in-sample, this model takes advantage of future information and provides a test of how well bankers provide forward-looking predictions.

Predicting Bankers' Responses

To better understand how bankers' expectations anticipate future land values, it is important to determine the relationship between the percentage of bankers predicting a given directional movement and percentage of bankers that actually realize the predicted directional movement. Using Briers probability score, discrete outcomes are defined based on pre-determined bounds for observed changes in average farmland value. However, the results and interpretations of the Briers score depend on the bounds established for stable land values which are not explicitly defined in the survey. An alternative outcome index may be defined as the percentage of bankers that report movement in each *K*=3 directions ($d^*_{up}, d^*_{stable}, d^*_{down}$) such that:

(36) $$\sum_k d^*_{k_t} = 1$$

where $d^*_{k_t}$ is the percentage of banks reporting movement in the *k*-th direction in time *t*. The percentage of bankers forecasting movement in the *k*-th direction is now the forecasted percentage of banks that actually realize *k*-th directional movement.

The expected level of $d^*_{k_t}$ is $f_{k_{t-1}}$. For example, $f_{up_{t-1}}$is the expected percentage of banks reporting increasing land values in period *t* ($d^*_{up_t}$). Furthermore, the percentage of bankers forecasting decreases ($f_{down_{t-1}}$) may be a negative indicator of banks observing increasing land values. Thus, we establish the following equation to predict upward and downward land value movements:

(37) $$d^*_{k_t} = \beta_0 + \beta_1 f_{up_{t-1}} + \beta_2 f_{down\ t-1} + \varepsilon_t.$$

It follows that the percentage of bankers predicted to observe land value changes in the following quarter are determined using:

(38) $$\hat{d}^*_{k_t} = \hat{\beta}_0 + \hat{\beta}_1 f_{up_{t-1}} + \hat{\beta}_2 f_{down_{t-1}}$$

where $\hat{d}k^*_t$ is the percentage of bankers expected to report movement in the *k*-th direction in time *t*. Two forecasts are estimated for upward and downward directional movements, $d^*_{up_t}$ and $d^*_{down_t}$. Since the outcomes sum to one (equation 36), d^*_{stable} is the percentage of banks not reporting directional movements. Thus, the stable category does not contribute information not already present in upward and downward outcomes. Due to this redundancy, the stable category is not directly forecasted. Each quarter, the model is updated to include the most recently observed information. Since the sample from which the estimates are produced is changing, each period will have slightly different coefficients.

The forecasting model is evaluated against a naïve benchmark model. This model forecasts the percentage of banks expected to observe movement in the next quarter using a linear function of the percentage of banks who recently observed movement in the *k*-th direction:

(39) $$\hat{d}^*_{k_t} = d^*_{k_{t-1}}.$$

Bankers' one-step-ahead forecasts and corresponding naïve forecasts are evaluated out of sample over the final 8 quarters of the data set (2007:III-2009:II). The forecasts are evaluated against the benchmark using root mean squared error criterion. The root mean squared error (RMSE) is calculated as

(40) $$\text{RMSE}_\text{k} = \left[\frac{1}{n}\sum_{t=1}^{n}\left(d^*_{k_t} - \hat{d}^*_{k_t}\right)^2\right]^{\frac{1}{2}}.$$

Forecasting Land Values

The previous sections considered only forecasting the direction of land price movements, but the forecasts can also be used to forecast land prices themselves. To convert bankers' qualitative forecasts into a forecast of land values, the percentage changes in land values are regressed against bankers' forecasts:

(41) $$\%\Delta\, Land\ Value_t = \beta_0 + \beta_1\, fup_{t-1} + \beta_2 fdown_{t-1} + \varepsilon_t$$

where fup_{t-1} is the percentage of bankers forecasting increasing land values for period *t* and $fdown_t$ is the percentage of banks forecasting decreases in land values. The percentage of banks forecasting stable movement is removed from the equation to prevent collinearity among the independent variables. The dependent variable $\%\Delta\, Land\ Value_t$ is the average percent change reported by all banks in the Federal Reserve's 10^{th} District in time *t*. As in the previous section, the last 8 quarters are forecasted out of sample as one-step-ahead predictions.

Bankers' land value forecasts are evaluated against a naïve no-change benchmark model. This model forecasts the expected percentage change in land value as the change reported in the previous period:

(42) $$\%\Delta\, Land\ Value_t = \%\Delta\, Land\ Value_{t-1} + \varepsilon_t.$$

Testing bankers' forecasts against this benchmark will determine if bankers are providing forward looking forecasts. Forecast errors are evaluated using RMSE criterion.

In addition to evaluating bankers' forecasts against a naïve model, we determine if the forecasts satisfy conditions of optimal forecasts. Deibold and Lopez (1996) specify forecasts as being optimal forecast given that they meet the following criteria:

1. Optimal forecast errors have zero mean;
2. One-step ahead forecast errors are white noise, i.e., have a zero mean and constant variance;
3. At most, *p*-step-ahead optimal forecast errors are a moving average of order *p*-1; and
4. The p-step-ahead optimal forecast error variance is non-decreasing in *p*.

Criterion one is evaluated using t-tests to determine if the forecast errors have a mean of zero. This is accomplished by comparing the mean forecast error to the standard error of the forecasts where the standard error of the forecast is equal to the standard deviation of the forecast errors divided by the square root of the number of forecast errors. Criterion two could be tested using a Breusch–Godfrey (1981) test for serial correlation. However, with only eight forecast residuals for each land type, such tests have extremely limited statistical power.

Results

Contingency Tables

This section presents the contingency tables that use disaggregate data. Bankers' forecasting accuracy is measured by their own ability to predict their later subjective assessment of land values. The contingency tables for each type of farmland are found in tables II.1-II.3. These tables show the total number of banks forecasting changes and reporting outcomes for each direction across each land type. Summary statistics from the contingency tables are in table II.4. Notice that the forecast frequency is relatively similar across land types. Across all sample periods, approximately 75 percent of bankers expected no change in land values, 20 percent expected land values to rise, and 5 percent forecasted declining land values.

Bankers forecast frequency was biased toward the no-change category (table II.4). Bankers tended to under predict the occurrence of increasing and decreasing land values by 9 percent and 7 percent respectively. Across all land types, forecast frequencies for stable land values were around 16 percent higher than observed no-change outcomes. This result is typical of qualitative business surveys. Keeton and Verba (2004) argue that, when given a choice of categories such as up, down and no-change, an implausibly respondents tend to choose the no-change category, but this is actually necessary if the forecast is to be useful. For forecasts of land movement to be beneficial, the variance of forecasts must be less than the variance of outcomes.

The percentage of forecasts that were correct is also found in table II.4. Again, the results were consistent across the type of farmland considered. About 40 percent of the time that bankers forecasted upward movement, land values did increase. No change forecasts were correct 63 percent of the time. Additionally, 17-20 percent of downward forecasts were correct.

Overall, bankers' proportion of correct forecasts was .562, .544, and .564 for non-irrigated cropland, irrigated cropland, and ranchland respectively (figures II.4 and II.5). The tendency for bankers to forecast no-change causes the probability of bankers detecting stable land values to be extremely high (around 80 percent). Bankers had difficulty in predicting the relatively infrequent decreases in land values. In fact, when land values declined, bankers had forecasted increasing land values twice as often as they had forecasted decreases. Depending on the type of land considered, bankers correctly predicted between 25 and 28 percent of increases in farmland values.

Forecasting Discrete Qualitative Outcomes: Briers Probability Score

Briers probability score is the first of the three analyses to use data aggregated at the Federal Reserve's 10th District level. Briers score is a useful method because it assigns probabilities for discrete outcomes based on the relative percentage of bankers predicting increases and decreases in land values. Thus, for each period, qualitative forecasts data provide probability estimates for one-step-ahead out of sample directional movements. Bankers' forecasts are evaluated against a naïve model and a relative frequency model that uses in sample information to create unbiased estimates. The relative frequency model represents the best unbiased, no-skill forecaster.

Table II.5 presents the calculated probability scores for each of the models considered. The probability scores produced by bankers were lower than the naïve uniform and relative frequency forecasting models for each land type considered. For increasing and stable farmland value, bankers' forecasts were superior to the relative frequency forecasts. This result suggests that bankers are able to distinguish quarters in which land value is likely to increase. Bankers' probability scores were higher than relative frequency forecasts for downward movement because there were no quarters in which farmland values declined by more than four percent.

Yate's Covariance Decomposition

The covariance decomposition (table II.6) provides further insight into the reason why bankers produced better forecasts than do no-skill forecasting models. Forecasters skill, observed in the slope score, increases Cov(f, d) enough to overcome bankers' forecasting bias.

Bias scores were lowest for predictions of downtrend (table II.7). Bankers were overconfident about upward movements for cropland and showed a bias to stable movement for ranchland. However, it is important to note that directional bias is directly related to the definition of the range of "stable" land values.   Recall that the range of stable land values is +/- 4%. It is not necessary that this range be the same for all land types. Caution should be taken in comparing and interpreting the different bias statistics across land types. Refer to appendix A for sensitivity analysis on the bound of stable land values.

Bankers' forecasting skill is measured by the calculated slope scores (table II.8). For all upward and stable movement, slope scores were positive, suggesting that bankers have forecasting ability with respect to increasing and stable land value movement. For downward movement, slope scores were around -5 percent for all land types, which is due to having no occasions of decreasing land value. For pasture, the percentage of bankers forecasting upward movement was 9.1 percent higher in quarters in which land values increased. Contrasting these values to cropland, the difference in the banks predicting increases was 19 percent higher in quarters when cropland values actually increased. These results show that bankers have some ability to distinguish quarters in which land value movements are likely to increase.

Predicting Bankers' Responses

This section changes the discrete outcome index used in the probability score analysis to a more continuous outcome index. Predicted outcomes are the percentage of bankers that will report a given land value movement in the following quarter. Data are aggregated at the District level. The final eight quarters are used to determine out of sample forecasting accuracy. Bankers forecasts are compared to a naïve no change model and are compared based on root mean squared error.

The forecasts for 2009:III are presented in table II.9. The in-sample estimation produces r-squared values that average 0.40. The forecast coefficients take the expected signs. Increases in the percentage of banks that forecast increases suggests that more banks are expected to observe increases in the next quarter. The percentage of banks expected to observe increasing land values decreases when the percentage of banks forecasting declining land values increases. Thus, negative indicators take expected signs, but do not show statistical significance. Forecasts for the third quarter of 2009 indicate that about 20 percent of banks are expected to report increasing farmland value, while 13.7%-15.0% are expected to report decreases depending on land type.

Bankers' forecasts are shown to improve on naïve forecasts (table II.10). The RMSE was lower for each forecasted directional movement across all land types. These out of sample tests show that bankers have some forecasting ability.

Forecasting Land Values

The final evaluation procedure directly estimates the change in aggregate land values as a function of the percentage of bankers forecasting this movement. Forecasts for the third quarter of 2009 are found in table II.11. The coefficients for forecasted increases take expected signs, but coefficients for forecasted decreases do not take appropriate signs for irrigated or non-irrigated cropland. Each model explains substantial in-sample variation with r-squared values ranging from 0.392 to 0.495. Out of sample, bankers forecasted better than the naïve model for each land type as shown by lower RMSE values (table II.12).

In the out of sample periods, land values were generally declining and forecasts tended to be higher than outcomes (figures II.6-II.8). Table II.13 shows the results of testing the forecasts errors as having a zero mean. We find that the t-statistics are not statistically significant and we cannot reject the null that the means of forecast errors are zero.

Conclusion

Contingency tables based on disaggregated forecasts showed that bankers forecasted no-change at an extremely high rate, allowing them to forecast stable land value movement well. Around 40% of bankers forecasts for upward movement were correct, but only 20% of downward forecasts were correct. Bankers correctly forecasted 60% of all reported outcomes.

Using Brier's probability score and Yate's covariance decomposition, we assumed a range of stable land values at +/- 4% average change from the previous quarter's value. Additionally, the percentage of bankers forecasting land value movement is assumed to be a probability estimate for the outcome in question. Under this model, bankers' forecasts were superior to an unbiased relative frequency forecaster for all land types considered.

Aggregating data at the District level, the percentage of bankers forecasting increasing and decreasing is indicative of the percentage of banks that actually report movement. Using this method, bankers outperformed naïve models for directional forecasts.

Average land value changes are also directly forecasted from aggregate directional predictions. Coefficients for upward and downward movement take the expected signs, but were relatively small in magnitude. Intercept terms are positive and statistically significant due to bankers forecasting no-change in quarters in which land values increased. Additional testing shows that the residuals exhibit characteristics of optimal forecasts. Bankers' forecasts were superior to forecasts produced by a naïve no-change model.

For each forecasting method used, bankers outperformed the selected naïve or no-skill benchmark models. These results show that bankers are able to forecast the direction of land value movement.

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TABLES

Table II.1. Forecast Contingency Table: 10th District Non-irrigated Cropland

		Forecasted Directional (f_j)			
		Up	No Change	Down	Total
Actual Change	Up	509	1230	72	1811
(r_i)	No Change	569	2923	160	3652
	Down	179	514	66	759
	Total	1257	4667	298	6222

Table II.2. Forecast Contingency Table: 10th District Irrigated Cropland

		Forecasted Directional (f_j)			
		Up	No Change	Down	Total
Actual Change	Up	325	868	57	1250
(r_i)	No Change	397	2137	136	2670
	Down	117	366	53	536
	Total	839	3371	246	4456

Table II.3. Forecast Contingency Table: 10th District Ranchland

		Forecasted Directional (f_j)			
		Up	No Change	Down	Total
Actual Change	Up	422	1212	59	1639
(r_i)	No Change	540	2924	164	3628
	Down	164	487	47	698
	Total	1126	4623	270	6019

Table II.4. Total Banker Bias and Probability of Detection for Directional Forecasts

Land Type	Direction	Forecast Frequency	Frequency of Occurrence	Bias	Forecasts Correct	Probability of Detection
Dryland	Up	0.202	0.291	-0.089	0.405	0.281
	No-Change	0.750	0.587	0.163	0.626	0.800
	Down	0.048	0.122	-0.074	0.221	0.087
Irrigated	Up	0.188	0.281	-0.092	0.387	0.260
	No-Change	0.757	0.599	0.157	0.634	0.800
	Down	0.055	0.120	-0.065	0.215	0.099
Ranch	Up	0.187	0.281	-0.094	0.375	0.257
	No-Change	0.759	0.603	0.165	0.632	0.806
	Down	0.045	0.116	-0.071	0.174	0.067

Note: Bias is defined as the forecast frequency minus the frequency of occurrence. Forecasts correct are the percentage of all forecasts that were correct for the specified direction. Probability of detection is the percentage of all outcomes that were correctly forecasted.

Table II.5. Briers Probability Score across Various Forecasters and Land Types

		Forecast		
Land Type	Mean PS	Bankers	Uniform	Rel. Freq. (Sample)
Non-irrigated	Up	0.0897	0.2302	0.1224
	Stable	0.1042	0.3254	0.1224
	Down	0.0065	0.1111	0.0000
	Total	0.2004	0.6667	0.2448
Irrigated	Up	0.0762	0.1468	0.0957
	Stable	0.0935	0.4087	0.0957
	Down	0.0064	0.1111	0.0000
	Total	0.1761	0.6667	0.1913
Ranch	Up	0.1828	0.2063	0.2041
	Stable	0.1893	0.3492	0.2041
	Down	0.0057	0.1111	0.0000
	Total	0.3778	0.6667	0.4082

Note: This table shows the calculated probability scores for three different forecasts. Each directional forecasts has its own probability score and the Total probability score is equal to the sum of Up, Stable, and Down probability scores.

Table II.6. Yates Covariance Decomposition across Various Land Types and Directional Forecasts

		Direction			
Land Type	Mean PS	Total	Down	Stable	Up
Non-Irrigated	Var (*d*)	0.2449	0.1224	0.1224	0.0000
	Var(*f*)	0.0220	0.0112	0.0066	0.0041
	$Bias^2$	0.0174	0.0034	0.0115	0.0024
	Cov(*f*,*d*)	0.0419	0.0237	0.0182	0.0000
	PS	0.2004	0.0065	0.1042	0.0897
Irrigated	Var (*d*)	0.1914	0.0000	0.0957	0.0957
	Var(*f*)	0.0217	0.0033	0.0068	0.0116
	Bias2	0.0282	0.0031	0.0186	0.0065
	Cov(*f*,*d*)	0.0326	0.0000	0.0138	0.0188
	PS	0.1761	0.0064	0.0935	0.0762
Ranch	Var (*d*)	0.4082	0.0000	0.2041	0.2041
	Var(*f*)	0.0125	0.0037	0.0028	0.0060
	Bias2	0.0147	0.0021	0.0028	0.0098
	Cov(*f*,*d*)	0.0287	0.0000	0.0102	0.0185
	PS	0.3778	0.0057	0.1893	0.1828

Note: PS = Var(d) +Var(f)+ $Bias^2$ -2Cov(f,d) . The values in the Total column are equal to the sum of values in the Up, Stable, and Down columns.

Table II.7. Bankers' Bias Scores

		Direction		
Land Type		Down	Stable	Up
Non-irrigated	$\bar{f}_k$	0.049	0.760	0.202
	$\bar{d}_k$	0.000	0.857	0.143
	Bias	0.049	-0.097	0.059
Irrigated	$\bar{f}_k$	0.056	0.756	0.188
	$\bar{d}_k$	0.000	0.893	0.107
	Bias	0.056	-0.137	0.081
Ranchland	$\bar{f}_k$	0.046	0.767	0.187
	$\bar{d}_k$	0.000	0.714	0.286
	Bias	0.046	0.053	-0.099

Note: Stable land values are within +/- 4% of previous quarter. The variable $\bar{f}_k$ is the average probability forecast. The variable $\bar{d}_k$ is the average outcome frequency. The bias is calculated as $\bar{f}_k$-$\bar{d}_k$.

Table II.8. Bankers' Slope Scores

Land Type		Direction: Down	Stable	Up
Non-irrigated	$\bar{f}_c$	0.000 (0)	0.771 (24)	0.367 (4)
	$\bar{f}_0$	0.049 (28)	0.622 (4)	0.174 (24)
	Slope	-0.049	0.149	0.193
Irrigated	$\bar{f}_c$	0.000 (0)	0.772 (25)	0.363 (3)
	$\bar{f}_0$	0.056 (28)	0.628 (3)	0.167 (25)
	Slope	-0.056	0.144	0.196
Ranchland	$\bar{f}_c$	0.000 (0)	0.782 (20)	0.252 (8)
	$\bar{f}_0$	0.046 (28)	0.732 (8)	0.161 (20)
	Slope	-0.046	0.050	0.091

Note: Stable land values are within +/- 4% of previous quarter. The variable $\bar{f}_c$ is the average forecast on occasions when land values move in the forecasted direction. The variable $\bar{f}_0$ is the average forecast on occasions when land values did not move in the forecasted direction. Values in parentheses indicates the number of observations assigned to each outcome. The slope is calculated as$\bar{f}$-$\bar{f}_0$.

Table II. 9. Forecasting the Relative Percentage of Bankers Responses for Up and Down Directional Movement. 2009:III

Land Type	RHS Variable	Estimated Coefficients: Intercept	fup_{t-1}	$fdown_{t-1}$	R^2	2009:III Forecast
Non-Irrigated	$\hat{d}up^*{}_t$	0.200***	0.465***	-0.067	0.391	0.216
	$\hat{d}down^*{}_t$	0.114***	-0.036	0.324***	0.438	0.145
Irrigated	$\hat{d}up^*{}_t$	0.183***	0.520***	0.014	0.424	0.201
	$\hat{d}down^*{}_t$	0.106***	-0.028	0.355**	0.380	0.137
Ranchland	$\hat{d}up^*{}_t$	0.226***	0.373*	-0.315	0.405	0.202
	$\hat{d}down^*{}_t$	0.115***	-0.065	0.301**	0.368	0.150

Note: Asterisk (*), double asterisk (**), and triple asterisk (***) denote variables significant at 10% and 5% and 1% respectively.

Table II.10. Bankers' Forecasts of the Percentage of Future Respondents Reporting Increasing and Decreasing Land Value Movement

Land Type	Model	Directional Forecast	RMSE
Non-irrigated	Banker Forecast	Up	0.105
		Down	0.042
	Naïve no-change	Up	0.111
		Down	0.045
Irrigated	Banker Forecast	Up	0.105
		Down	0.051
	Naïve no-change	Up	0.125
		Down	0.054
Ranchland	Banker Forecast	Up	0.087
		Down	0.045
	Naïve no-change	Up	0.102
		Down	0.057

Table II. 11. Forecasted Percentage Change in Land Values 2009:III

		Estimated Coefficients				
Land Type	RHS Variable	Intercept	fup_{t-1}	$fdown_{t-1}$	R^2	2009:III Forecast
Non-Irrigated	$\%\Delta\ Land\ Value_t$	-0.000	0.123***	0.021	0.392	0.008
		(0.010)	(0.037)	(0.061)		
Irrigated	$\%\Delta\ Land\ Value_t$	-0.005	0.141***	0.030	0.495	0.002
		(0.010)	(0.035)	(0.066)		
Ranchland	$\%\Delta\ Land\ Value_t$	0.008	0.125*	-0.031	0.416	0.021
		(0.012)	(0.050)	(0.064)		

Note: Asterisk (*), double asterisk (**), and triple asterisk (***) denote variables significant at 10% and 5% and 1% respectively. Values in parentheses are standard errors.

Table II.12. Accuracy of Bankers Forecast and Naïve No-Change Forecasts for Changing Land Values 2007:III-2009:II

Land Type	Model	RMSE
Non-irrigated	Banker Forecast	0.023
	Naïve no-change	0.031
Irrigated	Banker Forecast	0.027
	Naïve no-change	0.038
Ranchland	Banker Forecast	0.026
	Naïve no-change	0.036

Table II.13. Testing One-Step-Ahead Forecasts Errors as Having Zero Mean

	Land Type		
Independent Variable	Non-irrigated	Irrigated	Ranch
Mean Forecast Error	-0.0106	-0.0095	-0.0065
SD of Forecast Error	0.0254	0.02682	0.02347
Standard Error of Forecast	0.0095	0.0095	0.0083
T-stat	-1.18	-1.00	-0.79

FIGURES

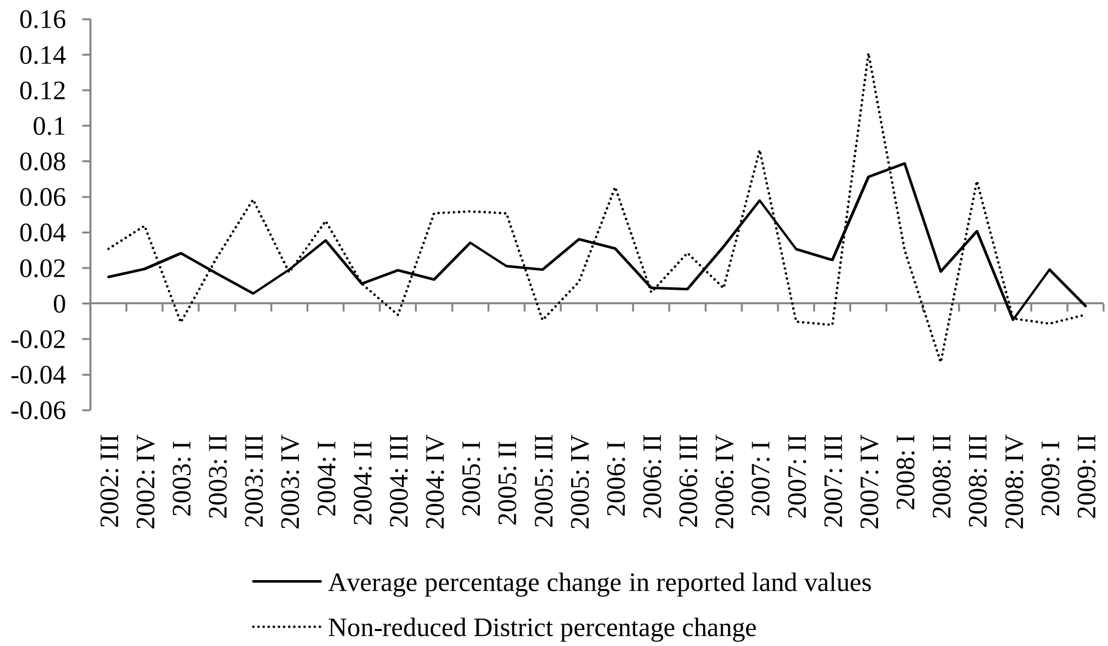

Figure II.1. Smoothing land price changes using the average percent change: Non-irrigated Cropland, 2002:III – 2009:II

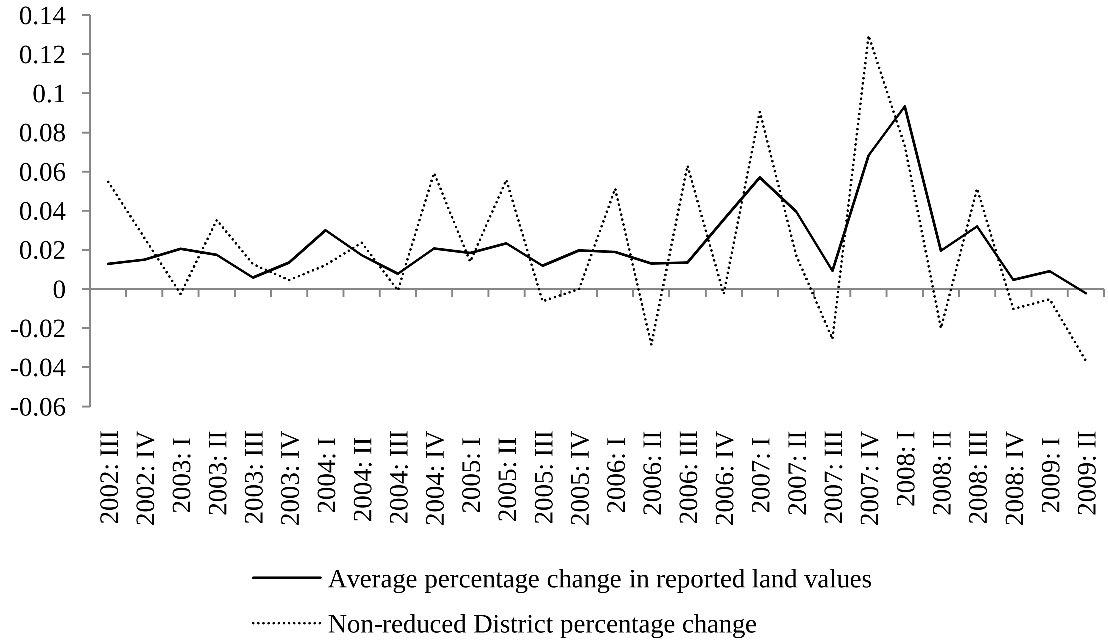

Figure II.2. Smoothing land price changes using the average percent change: Irrigated Cropland, 2002:III – 2009:II

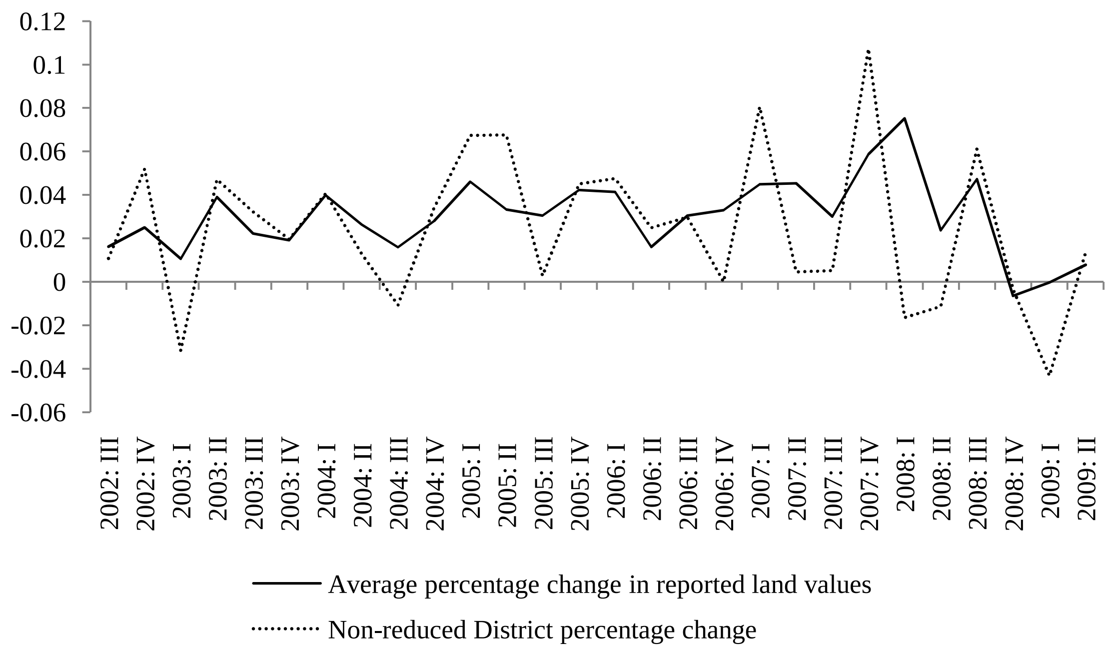

Figure II.3. . Smoothing land price changes using the average percent change, 2002:III – 2009:II

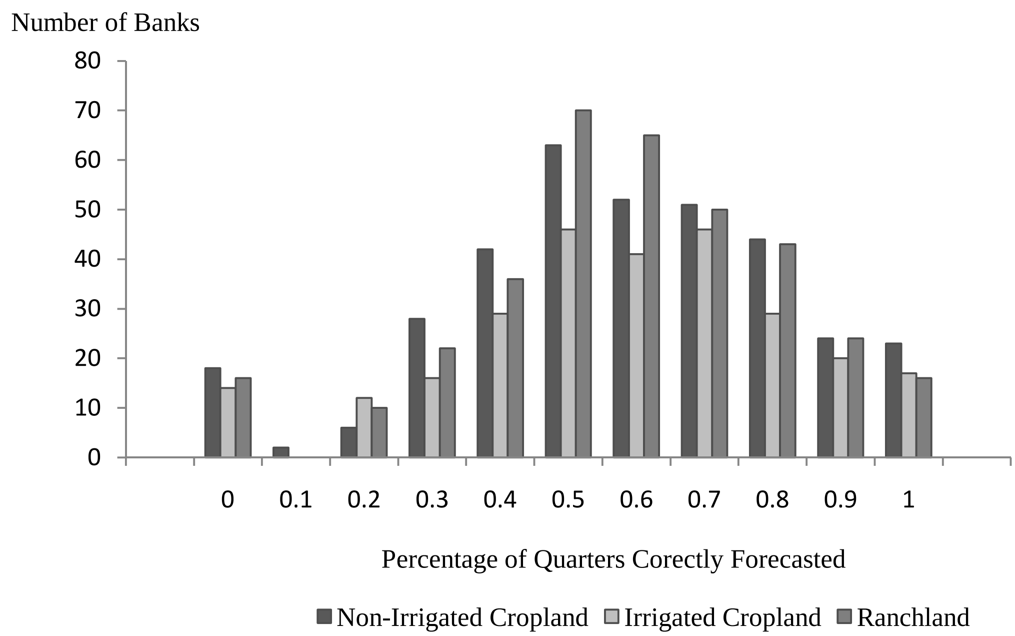

Figure II.4. Banker Forecast Accuracy Distribution across Land Types

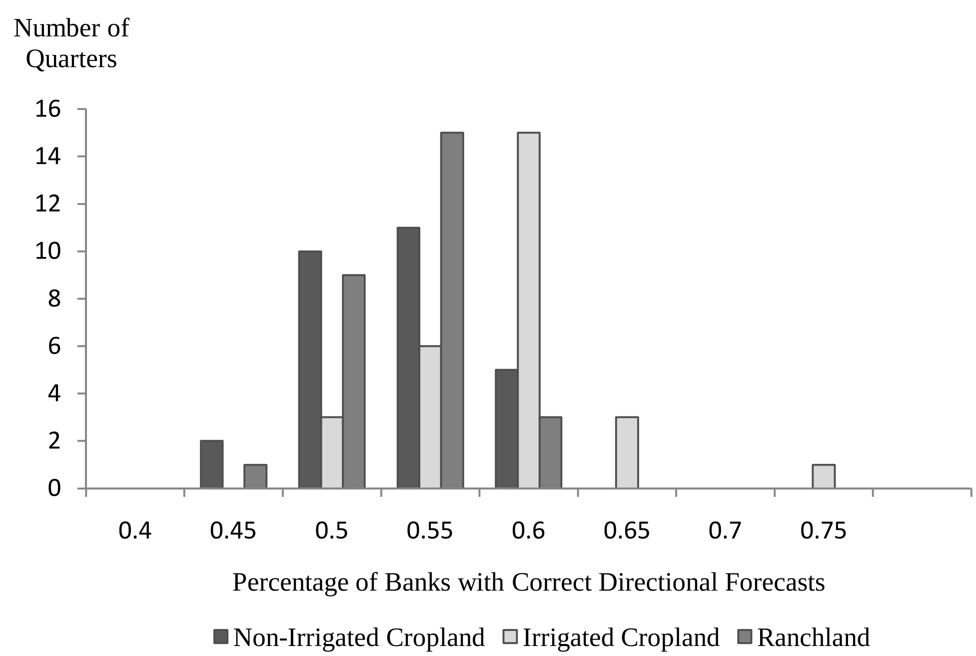

Figure II.5. Banker forecasting accuracy distribution over quarters 2002:III- 2009:II

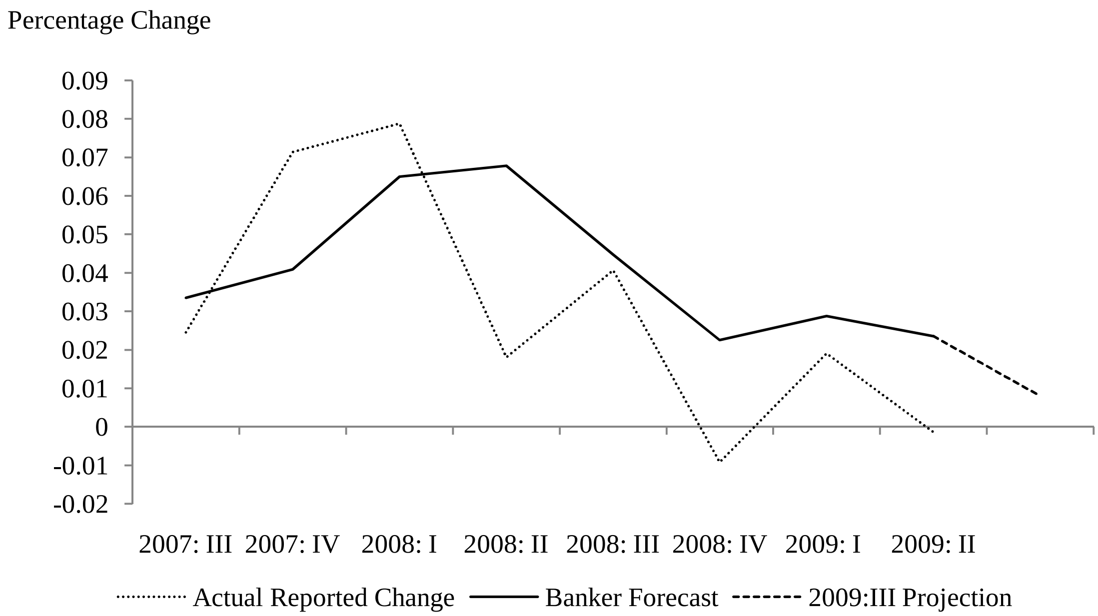

Figure II.6. Banker Prediction and actual land value changes: Non-irrigated cropland, 2002:III- 2009:II

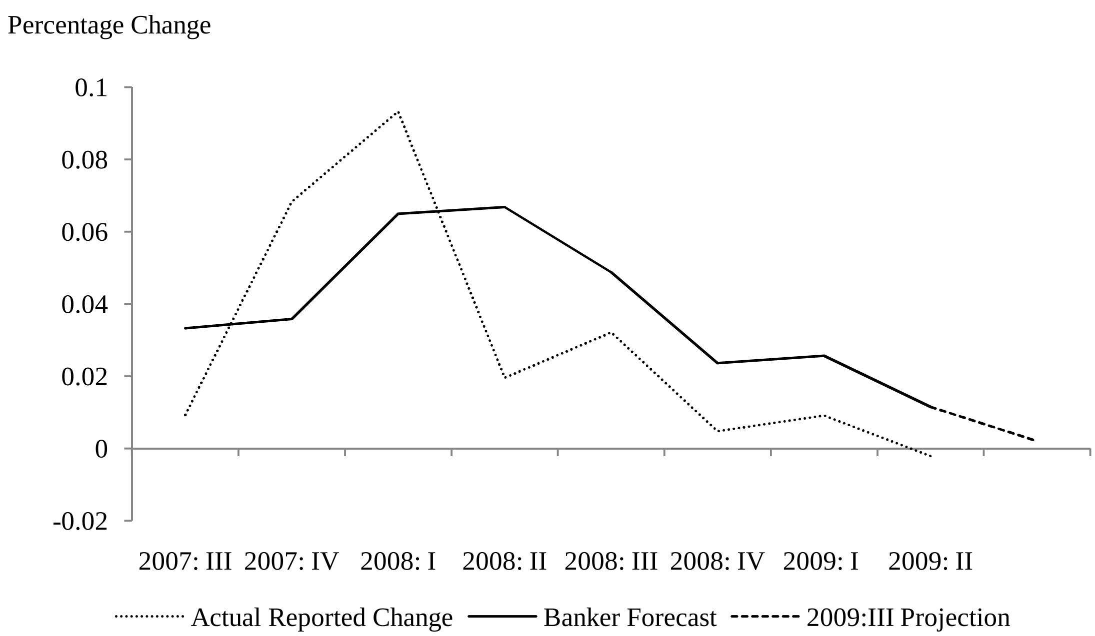

Figure II.7. Banker prediction and actual land value changes: Irrigated cropland, 2002:III- 2009:II

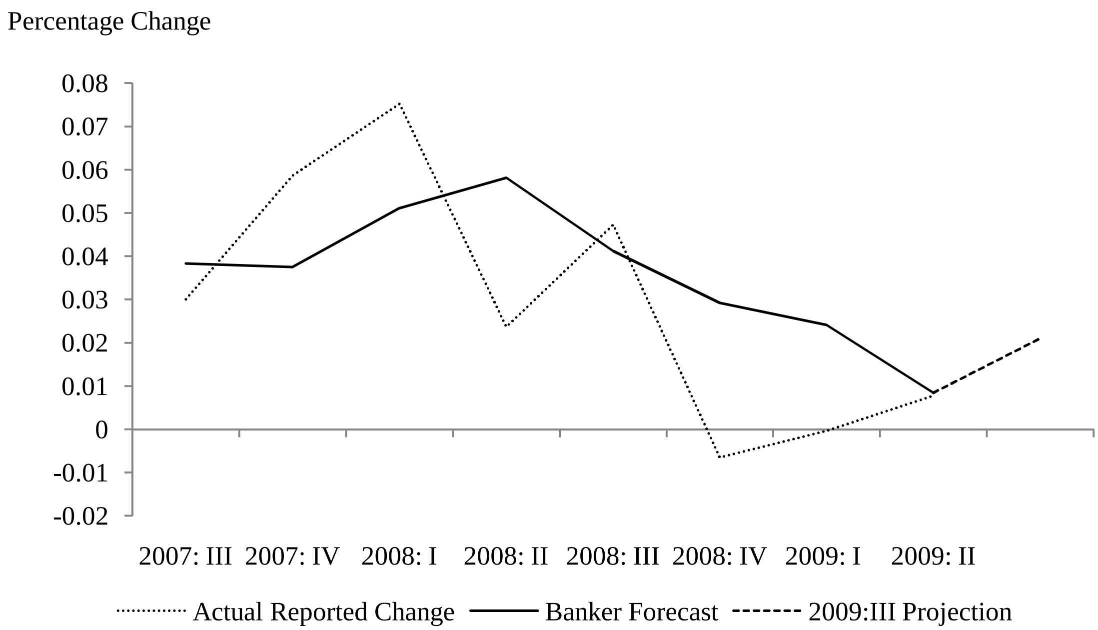

Figure II.8.Banker prediction, and actual land value changes: Ranchland, 2002:III- 2009:II

APPENDICES

Appendix A:

Probability Score Sensitivity Analysis

As stated in the body of the article, the results and interpretations of the Brier's Probability Score are sensitive to the bounds placed on the discrete outcomes. Since the Federal Reserve survey does not define the ranges of the stable or no-change category, it is the responsibility of the researcher to choose appropriate bounds for the analysis. Covey used a plus or minus four percent range to describe stable land values. For consistency in comparing this work to Covey's, this paper adopts the same range for stable land values. However, our analysis shows that using this range produces biased probability estimates. The downward bound of -4% is so low that no occasions are observed to have declining land prices. For cropland values, the upward bound of +4% is so high that it captures very few occasions of increasing land price movement (table II.8). In contrast, the 4% upward bound for ranchland values results in negative bias values (table II.7). Thus, the range of stable land prices is not consistent across land types.

Changing the bounds of the stable or no-change category changes the discrete outcome index. To see how sensitive probability score results are to the definition of the stable category, the bounds are changed so that the frequency of outcomes closely matches the frequency of forecasts. These new bounds minimize the bias of probability estimates. The minimally biased bounds of the no-change category are 0.0% -3.5% for irrigated and non-irrigated cropland and 0.0-4.5% for ranchland. Bias estimates from the newly defined outcome indices are found in table II.14.

Table II.14. Sensitivity Analysis: Bankers' Bias Scores

Land Type		Direction		
		Down	Stable	Up
Non-irrigated	Bias [0.0%, 3.5%]	-0.023	0.035	-0.013
	Bias [-4.0%, 4.0%]	0.049	-0.097	0.059
Irrigated	Bias [0.0%, 3.5%]	0.020	-0.029	0.009
	Bias [-4.0%, 4.0%]	0.056	-0.137	0.081
Ranchland	Bias [0.0%, 4.5%]	-0.026	0.017	0.008
	Bias [-4.0%, 4.0%]	0.046	0.053	-0.099

Note: [ ] denotes the definition of the range of stable land values

The reduction in bias reduces the probability score. However, since the outcome index has changed, the variance of outcomes, Var(*d*), also changes. Since the bounds were tightened for cropland, there are more occasions for which land increased and decreased causing the variance of outcomes to increase. This increased the probability scores for upward and downward movement. However, this is not necessarily bad since the variance of outcomes is beyond the forecaster's control. Bankers' forecasts are still lower than the benchmark models. Alternatively, the upward bound for ranchland was expanded, which decreased the variance of outcomes and decreased the total probability score for upward movement. Again, bankers' forecasts were more accurate than the forecasts of either benchmark model.

Table II.15. Sensitivity Analysis: Briers Probability Score across Various Forecasters and Land Types

		Forecast		
Land Type	Mean PS	Bankers	Uniform	Rel. Freq. (Sample)
Non-irrigated	Up	0.138	0.183	0.168
	Stable	0.182	0.349	0.204
	Down	0.058	0.135	0.066
	Total	0.378	0.667	0.439
Irrigated	Up	0.113	0.171	0.147
	Stable	0.146	0.373	0.168
	Down	0.028	0.123	0.034
	Total	0.287	0.667	0.349
Ranch	Up	0.124	0.171	0.147
	Stable	0.172	0.361	0.188
	Down	0.058	0.135	0.066
	Total	0.355	0.667	0.401

Note: Stable land values are [0, 3.5%] change for non-irrigated and irrigated cropland and [0, 4.5%] change for ranchland

Observing table II.15, we find that bankers still outperform both benchmark models. There is still evidence that bankers have some ability to forecast land price changes. Recall that the slope score is the primary measure of bankers' forecasting skill. The sensitivity of the slope scores are found in table II.16.

Table II.16. Sensitivity Analysis: Bankers' Slope Scores

		Direction		
Land Type		Down	Stable	Up
Non-irrigated	$\bar{f}_c$	0.143 (2)	0.771 (20)	0.298 (6)
	$\bar{f}_0$	0.041 (26)	0.697 (8)	0.175 (22)
	Slope	0.101	0.074	0.123
Irrigated	$\bar{f}_c$	0.199 (1)	0.775 (22)	0.315 (5)
	$\bar{f}_0$	0.051 (27)	0.687 (6)	0.160 (23)
	Slope	0.148	0.088	0.155
Ranchland	$\bar{f}_c$	0.132 (2)	0.780 (21)	0.267 (5)
	$\bar{f}_0$	0.039 (26)	0.731 (7)	0.169 (23)
	Slope	0.093	0.049	0.098

Note: Stable land values are bounded on [0, 3.5%] change for non-irrigated and irrigated cropland
Stable land values are bounded on [0, 4.5%] change for ranchland
( ) indicates the number of observations

Comparing table II.16 with table II.7, changing the bounds greatly affects the slope scores. For each land type, downward land prices are now observed. Bankers' probability estimates for declining land values are much higher when land values actually decline. The bound for increasing land values was reduced for both irrigated and non-irrigated cropland. As a result more occasions of increasing land values were observed. However, these occasions did not have as high probability estimates. This drove the slope score from 0.193 to 0.123 and 0.196 to 0.155 for non-irrigated and irrigated cropland respectively. The bound for increasing ranchland was increased. This reduced the number of quarters in which upward trends were defined, but slightly increased the slope score from 0.091 to 0.098.

Narrowing the defined range of stable land values, one risks not capturing occasions of land value price movement. As the range of stable land values is expanded probability estimates for occurrence and non-occurrence converge. This result suggests that bankers are more likely to correctly predict large changes in land values. The sensitivity analysis also shows that bankers are able to outperform naïve no-change forecasting models.

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Scope and Method of Study: This thesis is comprised of two articles that examine farmland values and farmland value forecasts for non-irrigated cropland, irrigated cropland, and pasture. The first article considers the collection and reporting procedures each of three data sources: the United States Department of Agriculture's (USDA) annual report, the Federal Reserve's quarterly 10th District Survey of Agricultural Credit Conditions, and sales data. The objective of this essay is to determine if the land value estimates from opinion based surveys are consistent with values observed from land sales. Additionally, Granger causality tests are used to determine if land values published by the Federal Reserve prior to the release of the USDA report are indicators of USDA land values. The second essay examines forecasts from the Federal Reserve's survey to determine if bankers can accurately forecast land values. Various forecasting techniques are used to compare bankers' quarterly forecasts to their own reported changes in land value.

Findings and Conclusions: In the first essay, land values from each source are found to be highly correlated, but land value averages from sales data is often higher than averages derived from survey data. With respect to the survey data, first quarter Federal Reserve Bank estimates are indicators of USDA land value estimates. The second essay finds that agricultural lenders have some ability to forecast land values for the next quarter. For each of the forecasting methods used, bankers' one-step-ahead forecasts produced had lower root mean squared errors than forecasts produced by naïve forecasting models.

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