**AJAE appendix for "The Financial Health of Agricultural Lenders"**

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Note: The material contained herein is supplementary to the article named in the title and published in the *American Journal of Agricultural Economics* (AJAE).

This appendix provides supporting information for the corresponding AJAE article. In particular, the debt repayment capacity utilization measure is discussed as well as the vector auto-regression model and results.

*Debt Repayment Capacity Utilization Assumptions*

The following assumptions and calculations are taken from the Economic Research Service of the USDA and can be found at http://www.ers.usda.gov/Briefing/farmincome/glossary/def_drcu.htm. A maximum loan payment is calculated by taking the farm sector's income for debt coverage (net cash income plus interest payments) divided by an assumed minimum debt coverage ratio (1.25:1).

$$(1)\ Maximum\ Loan\ Payment = \frac{(Farm\ Sector\ Net\ Cash\ Income + Farm\ Sector\ Interest\ Payments)}{Minimum\ Debt\ Coverage\ Ratio}$$

This maximum loan payment is then multiplied by the present value of an annuity of $1 at the average non-real estate interest rate (*r*), taken from the Agricultural Finance Databook, for a hypothetical repayment term (*n*) of 7 years.

$$(2)\ Debt\ Repayment\ Capacity = Maximum\ Loan\ Payment\ * \frac{1-(1+r)^{-n}}{r}$$

Finally, debt repayment capacity utilization is calculated by taking the total farm sector debt divided by the calculated debt repayment capacity from equation 2.

$$(3)\ Debt\ Repayment\ Capacity\ Utilization = \frac{Total\ Farm\ Sector\ Debt}{Debt\ Repayment\ Capacity}$$

*VAR Model and Results*

Real agricultural land values and net loan charge offs at agricultural banks are related because agricultural banks will secure loans with agricultural land as collateral. Past studies have found that agricultural land values have a propensity for bubbles (Featherstone and Baker) and land value declines are influenced by a stressed agricultural environment (Burt). Thus, the objective here is to test if there is a significant relationship between real agricultural land values and net loan charge offs. And if so, stress agricultural land values to test how net loan charge offs would react.

In order to meet this objective, an empirical model is necessary that captures the dynamic relationship between real agricultural land values and net loan charge offs. A VAR model is selected because it allows the dynamics of real agricultural land values to be affected by the stochastic process of net loan charge offs. This is accomplished by modeling each variable as being endogenous and including lags of each variable. In addition, VAR strengthens system identification and minimizes spurious dynamic relationships between the endogenous variables (Sims). Before implementing the model, an analysis of the data shows that real agricultural land values has a unit root. Thus, this data is first differenced (Δ). The two equation system to be modeled is,

(1) $$\Delta RealAgLand_t = \alpha_1 + \gamma_1 t + \tau_1 t^2 + \sum_{i=1}^{n} \beta_{1i} \Delta RealAgLand_{t-i} + \sum_{i=1}^{n} \mu_{1i} ChargeOff_{t-i} + \varepsilon_{1t} ,$$

(2) $$ChargeOff_t = \alpha_2 + \gamma_2 t + \tau_2 t^2 + \sum_{i=1}^{n} \beta_{2i} \Delta RealAgLand_{t-i} + \sum_{i=1}^{n} \mu_{2i} ChargeOff_{t-i} + \varepsilon_{2t},$$

where $t$ is time; $\alpha$, $\gamma$, $\tau$, $\beta$, and $\mu$ are parameters to be estimated; $n$ is the optimal number of lags; and $\varepsilon$ is the error term of each equation that is estimated as a white noise process. VAR and subsequent orthogonal impulse response functions are estimated in SAS 9.1.

In order to estimate the VAR model, the number of lags must be determined. A total of one to ten lags were tested. To determine the optimal lag length, the following criteria were examined; the minimum Akaike Information Criterion and Schwarz Bayesian Criterion information tests, a stationary system (autoregressive characteristics polynomial roots are less than one in absolute value), and errors are white noise (Jarque-Bera normality test). After ensuring these criteria were met, the optimal lag length was five. To ensure the VAR system captures the quadratic nature of the data, a time squared variable is added. The results of the VAR estimation are presented in appendix table 1.

Interpreting the results in appendix table 1 is difficult because signs on the lag variables change and there are cross equation feedbacks. In order to interpret the results of a VAR model, many studies in the time series literature do so through orthogonal impulse response functions. As discussed in Hamilton, an orthogonal impulse response is based on decomposing the estimated VAR model error terms or innovations into a set of uncorrelated components. After these uncorrelated components are obtained, the consequences of a one unit impulse or a one standard deviation shock of an endogenous variable is estimated in the VAR system. In effect, this shock is a multiplier that alters the forecast of the endogenous variables in the system.

**Appendix Appendix table 1. Estimated VAR Coefficients and Test Statistics for Real Agricultural Land Values and Net Loan Charge Offs**

| Statistic | Land Value Equation | Net Loan Charge Off Equation |
|---|---|---|
| R-square | 0.85 | 0.95 |
| Jarque-Bera normality test[a] | 0.89 | 0.73 |
| Granger causality for land value[b] | - | 11.83* |
| Granger causality for net loan charge off[c] | 10.73** | - |
| | | |
| Independent variable | Regression Coefficients | |
| Intercept | 211.67 | 0.57 |
| Time trend | -21.06 | -0.07 |
| Time trend square | 1.13* | 0.002 |
| $\Delta$Land value $_{t-1}$ | -0.53 | 0.001 |
| $\Delta$Land value $_{t-2}$ | -0.45 | -0.00003 |
| $\Delta$Land value $_{t-3}$ | -0.38 | -0.002 |
| $\Delta$Land value $_{t-4}$ | -0.73 | -0.0004 |
| $\Delta$Land value $_{t-5}$ | -0.59 | 0.003 |
| Net loan charge off $_{t-1}$ | -215.97** | 1.27*** |
| Net loan charge off $_{t-2}$ | 65.58 | -0.96** |
| Net loan charge off $_{t-3}$ | -71.26 | 0.63 |
| Net loan charge off $_{t-4}$ | -10.32 | -0.70* |
| Net loan charge off $_{t-5}$ | -54.12 | 0.52** |

Note: All significant tests and coefficients at the 5 percent level are signified by an *.
a) Chi-squared test of the null hypothesis that the residuals represent a white noise process.

b) Wald test of future values of land values are influenced by past land values and past net loan charge offs.

c) Wald test of future values of net loan charge offs are influenced by past net loan charge offs and past land values.

*Orthogonal Impulse Response*

Testing the effect of real agricultural land values on net loan charge offs is done through an orthogonal impulse response function. The variance/covariance matrix of innovations between real agricultural land values and net loan charge offs is $\begin{matrix} 1655.23 & -4.18 \\ -4.18 & 0.03 \end{matrix}$. Given the negative relationship between land values and charge offs and the objective of the VAR in this paper, a negative innovation (shock) in real agricultural land values is necessary to assess the rise in net loan charge offs. In addition, the estimator and the standardized shock process asymptotic properties are normal. Thus, estimating the Δ*Real Ag Land Value* as being negative to create a decline in the standardized shock of the orthogonal impulse response is appropriate.

The response of the dynamic system to a negative orthogonal shock in real agricultural land values is listed in appendix table 2.

**Appendix Table 2. Orthogonalized Impulse Response of Net Loan Charge Offs to a Negative Innovation Shock of Real Agricultural Land Values**

| | (-)ΔLand value | | Net loan charge off | |
|---|---|---|---|---|
| Lag | Response | Standard Error | Response | Standard Error |
| 0 | 40.68 | 5.64 | 0 | 0 |
| 1 | 0.74 | 11.17 | 0.10 | 0.05 |
| 2 | -3.84 | 12.65 | 0.03 | 0.07 |
| 3 | -6.97 | 12.07 | 0.09 | 0.06 |
| 4 | 2.01 | 13.57 | 0.10 | 0.06 |
| 5 | 3.63 | 14.37 | -0.09 | 0.07 |
| 6 | -12.33 | 13.04 | -0.15 | 0.06 |
| 7 | -4.25 | 11.89 | -0.06 | 0.07 |
| 8 | 5.32 | 11.53 | 0.02 | 0.07 |
| 9 | 1.45 | 11.07 | 0.07 | 0.07 |
| 10 | 8.35 | 11.13 | 0.06 | 0.07 |

Note: To obtain a negative shock in Δland value, the system is estimated with Δland value having a negative value.

As discussed in the text, the land value shock amounts to one-fourth of the shock land values experienced in 1985. The differenced decline in real agricultural land values in 1985 was 161.19. The shock shown in appendix table 2 is 40.68. Thus, the orthogonal response of net loan charge offs to a decline in agricultural land values is about one-fourth of the magnitude experienced at the peak of the 1980s farm debt crisis.