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EVIDENCE OF ASSET FIXITY IN THE PORTFOLIO RESPONSES OF AGRICULTURAL BANKS

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In this paper we report on an analysis of short run portfolio responses of agricultural banks to changes in exogenous economic variables. The paper builds on previous studies in the finance and banking literature, and goes beyond earlier applied work in the area to focus on the asset portfolio adjustment process of these smaller, agriculturally-specialized banking institutions. Determinants of bank asset allocation decisions are derived from portfolio theory and dynamic econometric models are specified and tested using historical bank data from Minnesota. Our central objective is to evaluate the portfolio adjustment process to determine if asset fixity plays a significant role in the capacity of these banks to adapt to changes in a deregulated and risky economic environment.

A recent analysis of agricultural bank portfolio composition indicated that those institutions were responsive to variability of short term interest rates, increases in the expected rate of loan default, and the expected rate of return on securities (Pokharel). The study also found that significant asset complementarity and substitution relationships existed in bank asset portfolios during 1976-1987. That period was characterized by both significant interest rate variability and escalating farm loan default rates. This paper extends the earlier static analysis to consider some of the dynamic responses of agricultural banks.

The Portfolio Choice Model

The bank is assumed to be an imperfect competitor for loans and a perfect competitor for securities. While loans are considered to be risky assets, securities are assumed to be default-free and available to the bank with a perfectly elastic supply. Assuming the bank exhibits risk averse behavior and the random returns on bank assets are normally distributed, an optimal asset allocation (q) can be derived for a portfolio consisting of two lending sectors and a single security investment (Pokharel).

$$q_t = a + b\ W_t + c\ r_{t+1} + dEY_{1t} + eEY_{2t} + f\ \sigma^2_{Rt} + q\ \phi_{1t} + h\ \phi_{2t} + i\ \sigma^2_{1Yt} + j\ \sigma^2_{2Yt} + k\ \sigma_{R1Yt} + l\ \sigma_{R2Yt} + m\ \sigma_{1Y2Yt} \quad (1)$$

In equation (1) the variables are: W_t - the wealth or size of the bank in period t; r_{t+1} - the expected rate of return on securities (the bank's opportunity cost of funds); EY_{1t}, EY_{2t} - the expected returns on projects in sectors 1 and 2; σ^2_{Rt} - the variance of the market interest rate; ϕ_{1t}, ϕ_{2t} - the proportions of variable rate loan contracts in sectors 1 and 2; σ^2_{1Yt}, σ^2_{2Yt}, σ_{1Y2Yt} - the variances and covariance of returns on projects funded by the bank in sectors 1 and 2; and σ_{R1Yt}, σ_{R2Yt} - the covariances between interest rates and rates of return on projects in sectors 1 and 2. The remaining notation in (1) indicates structural parameters of the static model.

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Since several of the variables in (1) are not observable, we make a couple of variable substitutions. We define D_{it} as the expected rate of default on projects (loans) funded by the bank in sector i, and I_t as an index of sector economic performance (e.g., the expected return on sector i projects relative to the expected return on sector j projects). The expected default rate on loans substitutes for σ^2_{1Yt}, σ^2_{2Yt}, σ_{1RYt}, σ_{2RYt}, and σ_{1Y2Yt} which are the variables that capture credit risk in the asset portfolio. The index of sector performance is used to replace EY_1 and EY_2, the expected levels of sector returns. The effects of ϕ_1 and ϕ_2 on portfolio decisions are assumed to be reflected by the interest rate variance variable, and they are deleted from the model. The rewritten portfolio equation in general form is

$$q_t = a + b\ W_t + c\ r_{t+1} + d\ I_t + e\ \sigma^2_{Rt} + h\ D_t + \epsilon_t \qquad (2)$$

where ϵ_t is the error term. If banks are risk averse, parameters e and h are expected to carry negative signs. Signs of the other parameters cannot be predicted a priori.

A Dynamic Model Characterization

To motivate a dynamic analysis of the bank portfolio adjustments we hypothesize that changes in asset composition will depend on learning behavior of bank management in addition to changes in the exogenous variables in (2). In the context of the bank's loan portfolio, learning is defined as the process by which bank management develops subjective estimates of the distribution of default rates. Since lending decisions are influenced to a considerable extent by previous lending experience in a sector, we assume that the stock of lending expertise is not perfectly transferrable to other sectors which the bank may serve. As a result, banks exhibit a degree of asset fixity as portfolio composition is adjusted in response to shifts in exogenous variables. Thus, portfolio fixity is characterized by the lack of ability to freely adjust the bank's mix and level of assets to achieve the new portfolio equilibrium as new information on interest rates and sector economic performance becomes available.

The stock of bank expertise is a state variable which is not directly observable. Operationally, we assume that learning and, therefore, expertise increases proportionately with increases in loan volume (q) and depreciates at some rate, α. If the economic environment is quite uncertain, the rate of depreciation is expected to be relatively high. The corresponding change in the stock of expertise at time t is defined as

$$s_t - s_{t-1} = q_t - \alpha s_t \qquad (3)$$

Rewriting and expanding (3) we get

$$s_t = q_t/(1+\alpha) + q_{t-1}/(1+\alpha)^{t-1} + q_{t-2}/(1+\alpha)^{t-2} + \ldots \qquad (4)$$

and the stock of expertise at a point in time is the sum of the discounted values of all past learning with α serving as the implied rate of discount. The current level of expertise depends on all past levels of asset activity in the bank, though more heavily on recent levels. Clearly, as the bank's economic environment becomes more uncertain and α rises, the stock of expertise depreciates more rapidly. Since we hypothesize that the learning process either directly or indirectly influences a bank's perception of the distribution of default rates, we make a final variable substitution of s_t for D_t. Rewriting (2), we have

$$q_t = \mu + b W_t + cr_{t+1} + d I_t + e \sigma^2_{Rt} + f s_t + \epsilon_t. \quad (5)$$

In (5) a value of $f>0$ is indicative of asset fixity in the corresponding sector, since an increase in sector expertise will tend to increase the portfolio allocation to those assets independent of changes in market signals. Analogously, $f<0$ indicates an adjustment sector in the bank's portfolio.

A State-Adjustment Model

The model in (5) is similar to the state-adjustment, dynamic model developed by Houthakker and Taylor for commodity portfolios of consumers, although the stock equation is different. In a "state adjustment model" the effect of past behavior on current decisions is assumed to be represented entirely by current values of the identified state variables. These state variables are in turn changed by current decisions and the observed result is that of distributed lag behavior, or sluggish adjustment (rather than strict asset fixity). We follow procedures in Houthakker and Taylor and Winder to derive the discrete econometric counterpart to (5). First, it is assumed that the rate of change of the lending expertise stock variable is a linear function of time over a finite unit interval of time. Then equation (5) can be rewritten by substituting $(s_t + s_{t-1})/2$ for s_t

$$q_t = \mu + b W_t + c r_{t+1} + d I_t + e \sigma^2_{Rt} + f (s_t + s_{t-1})/2. \quad (6)$$

Similarly, equation (3), the stock adjustment equation, can be written in first-difference form as $\Delta s_t = q_t - \alpha (s_t + s_{t-1})/2$. Next, substituting (6) into the first difference form of the stock adjustment equation we have,

$$\Delta s_t = q_t - \alpha/f (q_t - \mu - b W_t - c r_{t+1} - d I_t - e \sigma^2_{Rt}). \quad (7)$$

The first-difference of equation (6) is,

$$\Delta q_t = b \Delta W_t + c \Delta r_{t+1} + d \Delta I_t + e \Delta \sigma^2_{Rt} + f (\Delta s_t + \Delta s_{t-1})/2. (8)$$

We substitute (7) into (8) and use the identity, $X_t = \Delta X_t + X_{t-1}$ to replace W_t, I_t, r_{t+1}, and σ^2_{Rt} in the resulting equation. The portfolio state adjustment equation becomes,

$$\begin{aligned} q_t = a\mu/p + q_{t-1} [1+(f-\alpha)/2]/p + \Delta W_t\, b\, (1+\alpha/2)/p + W_{t-1}\, b\alpha/p \\ + \Delta r_{t+1} c\, (1+\alpha/2)/p + r_t\, c\alpha/p + \Delta I_t\, d(1+\alpha/2)/p + I_{t-1}\, d\alpha/p \\ + \Delta\sigma^2_{Rt}\, e\, (1+\alpha/2)/p + \sigma^2_{Rt-1}\, e\alpha/p \quad (9) \end{aligned}$$

where $p = [1-(f-\alpha)/2]$. The reduced form estimating equation of (9) is,

$$\begin{aligned} q_t = k_0 + \mu_0 q_{t-1} + \mu_1 W_{t-1} + \mu_2 \Delta W_t + \mu_3 r_t + \mu_4 \Delta r_{t+1} + \mu_5 I_{t-1} \\ + \mu_6 \Delta I_t + \mu_7 \sigma^2_{Rt-1} + \mu_8 \Delta\sigma^2_{Rt} + \epsilon_t. \quad (10) \end{aligned}$$

Estimates of the coefficients in (9) and (10) represent short term relationships between the exogenous variables and the bank's portfolio allocation at time t.

Parametric restrictions can be imposed on the basis of the structure of (9). The restrictions are; $\mu_2/\mu_1 = \mu_4/\mu_3 = \mu_6/\mu_5 = \mu_8/\mu_5 = \mu_8/\mu_7$. Since there are seven parameters to be estimated and seven independent relations in the system an econometric solution exists.

A Partial Adjustment Model

A partial adjustment, dynamic model approach provides an appropriate comparison model when banks are assumed to adjust their portfolios to achieve their long term, desired portfolio composition in response to information that is currently available. The model is,

$$q_t^* = \mu + b\ W_t + cr_{t+1} + d\ I_t + e\ \sigma_{Rt}^2 \qquad (11)$$

$$q_t - q_{t-1} = h\ (q_t^* - q_{t-1}) + v_t \qquad (0<h<1) \qquad (12)$$

where q^* is the desired asset allocation and h is the speed of adjustment coefficient. Substituting (12) into (11) and collecting terms we get

$$q_t = \mu h + (1-h)\ q_{t-1} + bh\ W_t + ch\ r_{t+1} + dh\ I_t + eh\ \sigma_{Rt}^2 + v_t \qquad (13)$$

In this model b, c, d and e are the long run parameters and bh, ch, dh and eh are the short run parameters of the portfolio adjustment.

Bank Data

Small agricultural banks (those with total assets less than $100 million and ratios of outstanding agricultural loans/total loans greater than or equal to .25) located in Minnesota were selected for the analysis. A total of 318 banks were identified and bank portfolio and earning data were assembled from semi-annual Reports of Condition and Reports of Income for 1976-1987 (Federal Reserve System).

Bank portfolios were disaggregated into three general asset categories: agricultural loans (the sum of farm production loans and loans secured by farm real estate), nonagricultural loans, and securities (computed as the residual of total bank assets minus total loan volume). Total bank funds (W) is measured by the price-level deflated series of reported average total assets. The expected rate of return on securities (r) is measured by the forward rate on one-year U.S. Treasury bills. Variability of market interest rates (σ_R^2) was approximated by the estimated variance of the weekly nominal Fed funds rate.

Alternative indicators of relative sector economic performance were identified. We selected the index of agricultural land values (Govindan and Raup). Asset pricing theory defines asset value as the sum of the discounted future stream of net returns. Although numerous factors influence land values, the implied relationship between land values and the expected returns to land is sufficiently strong to make the land value index a good proxy for the performance of the agricultural sector. The one-period, lagged land value index is specified as the expected sector economic performance variable.

A seasonal dummy variable (Dm) was added to each of the estimating equations (10 and 13) to account for intra-year loan volume fluctuations where Dm = 0 (if June) and Dm = 1 (if December).

Results of Estimation

Several of the independent variables are common to both the state adjustment and partial adjustment models. Therefore, the estimated coefficients in Tables 1 and 2 can be directly compared for W_t, r_{t+1}, I_{t-1}, σ^2_{Rt-1}, and Dm_t. Those coefficients are the basis for our evaluation of the short run, single-period portfolio responses of banks under the two model specifications. The additional information on the stock depreciation rate (α), the stock adjustment (asset fixity) parameter (f), and the partial adjustment parameter (λ) is not directly comparable across the two models.

The bank funds variable carries the expected positive sign in all three estimated equations in both the state adjustment and partial adjustment models. The positive coefficients reflect the short run increases in the three asset categories which occurred as bank sizes increased over time in real terms. An additional interpretation of these coefficients can be made for the average bank portfolio response over the study period by converting the short run coefficients to the associated long run parameters. In the state adjustment model this conversion requires that we multiply the estimated short run coefficient by $\alpha/(\alpha\text{-}f)$. The resulting long run state adjustment parameters are .19 (agricultural loans), .30 (nonagricultural loans), and .51 (securities). These parameters indicate that the increase in average bank size during 1976-1987, resulted in a 19 percent average allocation to agricultural loans, a 30 percent allocation to nonagricultural loans, and a 51 percent allocation to securities. In the partial adjustment model the estimated short run coefficients are multiplied by $1/\lambda$. The long run parameters are .31 (agricultural loans), .33 (nonagricultural loans) and .50 (securities). The long run allocation implied by the partial adjustment model estimates are higher for both agricultural and nonagricultural loans, and when one sums the coefficients the overall allocation slightly exceeds 100 percent.

The coefficients on the security rate of return variable provide mixed results. In both models the signs in the agricultural loan equations are positive and the signs in the security equations are negative. Negative signs on the security rate of return variable in the security investment equations are of some interest. It can be shown in the static model (equation 1) that the partial derivative of the optimal quantity of securities with respect to the expected rate of return on securities (r_{t+1}) is positive, if one ignores the associated wealth effect ($\partial W/\partial r_{t+1}$). The implication of the estimated negative coefficients is that the wealth effect is significant and dominates the substitution effect. Consequently, if one assumes decreasing absolute risk aversion an increase in the riskless rate of return will lead to a shift in demand into the risky asset (Ingersoll; Robison and Barry). Similar magnitudes of the estimated coefficients in the state adjustment model imply that agricultural banks exhibit nearly equivalent degrees of responsiveness in their agricultural loan and security portfolios when security yields change. The agricultural loan response in the partial adjustment model is relatively greater as reflected by the large coefficient. The partial adjustment coefficient indicates the partial derivative relationship between the current level of the asset and the current level of the independent variable ($\partial q_t/\partial x_t$). In contrast the state adjustment model coefficient captures the effect of two derivative relationships between the current level of the asset and 1) the lagged value of the independent variable ($\partial q_t/\partial x_{t-1}$) and 2) the change in the independent variable from the previous period value ($\partial q_t/\partial \Delta x_t$). Thus, the state adjustment framework may result in a larger or smaller short run adjustment coefficient depending on the magnitudes of λ, α, and f. We will return to an interpretation of the sizes of these estimated parameters.

The two models imply that short run portfolio switching occurred between agricultural loans and securities in response to changes in market rate of return signals. For example, when security yields rose the tendency was for agricultural banks to reduce their security holdings and augment their volume of agricultural loans. This pattern of portfolio adjustment is repeated with the agricultural land value index variable (I). One possible explanation for this result is that the cycle of interest rates (as reflected by the security rate of return) and the agricultural sector business cycle (as reflected by the agricultural land value index) coincided during 1976-1987, and the estimated equations are indicating bank short run responses to those cyclical changes. In each instance the estimated coefficients reflect bank responses to changing interest rates and agricultural sector conditions over the entire cycle, and do not indicate how stable those responses were through different phases of the corresponding cycles. The nonagricultural loan portfolio does not respond in a consistent fashion to changes in the security rate of return. The state adjustment model indicates no adjustment and the partial adjustment model suggests a significant positive short run adjustment. The positive coefficients on the land value index in the agricultural and nonagricultural loan equations suggest that there is a significant degree of complementarity between agricultural sector and nonagricultural sector loans.

The state adjustment and partial adjustment models strongly indicate that agricultural banks responded to expected increases in the interest rate variance by reducing loan assets and increasing securities. This short run response is consistent with adjustments predicted by portfolio theory. Risk-averse banks are expected to shift out of loans with risky returns and into securities with safe returns, thereby eliminating the credit risk associated with volatile interest rates and reducing the expected variability of bank returns. We note that the estimated coefficients are similar across the two models, although the partial adjustment coefficient in the agricultural loan equation is again somewhat larger than the corresponding state adjustment model estimate.

The large and significant negative coefficients on the seasonal dummy variable in the agricultural loan equations confirm the strong intra-year seasonal variations of those assets. The corresponding large positive coefficients in the security investment equation complete the characterization. At the end of the year agricultural banks reinvest the excess funds due to seasonal loan repayment in securities. Mixed signs on the seasonal dummy in the nonagricultural loan equations suggest that commercial, consumer, and other loan categories in aggregate do not exhibit strong seasonality.

Estimated stock adjustment coefficients (f) are positive and significant in the loan portfolio equations and negative in the security equation (Table 1). The positive loan parameters indicate that there is a stock effect in the short run portfolio adjustments of agricultural banks. Moreover, the sharply larger coefficient in the agricultural loan equation suggests a relatively high degree of asset fixity in that part of the portfolio. One explanation for the relatively smaller stock parameter in the nonagricultural loan equation is that the portfolio is comprised of several subcategories of loans (consumer, commercial, residential, etc.), which have potentially quite different returns characteristics. The bank can reallocate loans within the nonagricultural portfolio to achieve the desired optimal mix of nonagricultural loans and hedge returns without making large short run adjustments in the total volume of nonagricultural loans. In contrast, the security equation indicates that no fixity is present in that portfolio. Banks have typically used their security investment to provide liquidity. This requires that the security portfolio be quickly adjusted when market conditions change. In addition bank security portfolios are dominated by short maturity investments which provide banks with greater ability to make short run adjustments. Finally, agricultural banks have historically been net suppliers of Fed funds. Agricultural banks have used the Fed funds market to respond to short run changes in the interest rate environment as well as changes in the demand for loans.

An examination of the stock depreciation coefficients (α) indicates that the agricultural sector loan portfolio is also characterized by relatively rapid reduction in the stock of expertise when compared to the nonagricultural loan and security portfolios. Conditions in the agricultural sector changed quickly during the latter 1970s and 1980s. The implication is that the accumulation of previous lending expertise in the agricultural sector was discounted heavily during those years due to the problems banks had in predicting how their farm loan portfolios would perform based on their existing loan underwriting standards and criteria and previous sector conditions. In contrast the nonagricultural loan portfolio default rate remained quite stable during 1976-1987. An interesting case of stock adjustment model occurs when the stock adjustment parameter is close to the stock depreciation parameter. In this situation a long run equilibrium interpretation of the state adjustment model does not hold, although asset fixity is still plausible. Since the estimated parameters are relatively close to each other in the agricultural loan equation, the implication is that the agricultural loan portfolio exhibits fixity but no long term equilibrium adjustment. Although the associated coefficients in the nonagricultural loan and security equations are both small in absolute value, the differences between those coefficients are considered relatively large when compared to the sizes of the estimates. Finally, it is not clear why the depreciation rate in the security equation is relatively low even though the security rate of return was volatile during the latter 1970s and early 1980s.

Table 1. State Adjustment Model Results for Agricultural Loans, Nonagricultural Loans, and Securities of Agricultural Banks

	Dependent Variables		
Explanatory Variables	Agricultural Loan Volume	Nonagricultural Loan Volume	Security Investment
Constant	-126.4 (7.0)[a/]	-304.06 (4.5)	-174.7 (19.8)
Expertise Stock Depreciation (α)	1.38 (7.8)	.106 (8.4)	.037 (14.1)
Expertise Stock (f)	1.32 (7.5)	.066 (6.5)	-.022 (9.6)
Bank Funds (W)	0.008 (6.7)	.113 (19.9)	0.813 (98.9)
Security Rate of Return (r)	11.94 (10.1)	-.092 (0.1)	-9.476 (4.9)
Agricultural Land Value Index (I)	2.15 (10.1)	4.242 (8.4)	-11.69 (13.4)
Interest Rate Variance (σ_R^2)	-13.95 (9.3)	-17.282 (9.7)	33.212 (12.8)
Seasonal Dummy (Dm)	-92.86 (24.5)	-51.369 (13.8)	163.21 (30.4)
$\bar{R}^2$	0.97	.99	.98
DW	2.29	1.99	2.03

a/ Figures in parentheses are t-statistics. Critical t-values are 2.58, 1.96 and 1.65 for confidence levels of 99, 95 and 90 percent, respectively.

In the partial adjustment model the coefficients on the lagged dependent variables are high in both loan portfolio equations (Table 2). This implies sluggish adjustment in the nonagricultural loan portfolio as well. Does this point out an inconsistency between the two models? We suggest that there is no actual inconsistency. Large agricultural loan volume adjustments were required by agricultural banks due to deteriorating financial conditions in the farm sector, while nonagricultural sector loan performance was reasonably stable. Therefore, large short run adjustments were not required in the nonagricultural loan portfolio. Conditions in the security markets did change significantly, however, and agricultural banks responded to those changing market signals as reflected by the lower coefficient on the lagged security volume variable and the corresponding larger adjustment parameter.

How justifiable are these two models of the dynamic portfolio adjustments of agricultural banks? Since there is no basic disagreement between the econometric results, and a large lag effect would also imply portfolio fixity, would not the partial adjustment model be preferred to the more complex state adjustment model? As we have seen, the stock adjustment model provides a more complete description of the degree of asset fixity as revealed by the large difference between the agricultural and nonagricultural portfolio stock adjustment coefficients. The partial adjustment would lead to the contrary conclusion that the portfolios exhibit the same degree of fixity (since the lagged loan volume coefficients are nearly identical). Moreover, there is no evidence that the lag effect is large in all asset portfolios of the bank (e.g., the security portfolio). The stock adjustment equation correctly identifies securities as the adjustment sector in the bank's allocation decision. That interpretation of the security portfolio is not clear from simply comparing the size of the coefficients in the partial adjustment model. Our empirical results from the state adjustment model provide evidence that large coefficients on the lagged dependent variable do not necessarily mean the same thing as asset portfolio fixity. Therefore, fixity in the portfolios of agricultural banks is not the result of an auto-correlation model.

Implications

This study provides empirical evidence that agricultural bank loan portfolios exhibit differential degrees of asset fixity. Asset fixity reflects a lack of ability to easily adjust the loan portfolio in response to changes in sector economic and financial market conditions. Fixity is found to be greater in the agricultural loan portfolios of these banks. One implication is that agricultural banks should not be expected to adjust their asset portfolios rapidly when conditions in the agricultural sector change. Therefore, a case can be made for public sector assistance to stabilize the farm sector during periods in which financial sector adjustments are required.

The responses of agricultural bank portfolios to changes in the rate of return on securities and the volatility of market interest rates indicate that macroeconomic policies can have significant direct and indirect effects on the availability of loan funds in agriculture via financial market conditions. This would appear to be an increasingly important dimension of the agricultural bank portfolio management problem in a deregulated environment. The relationship we found between the security rate of return and agricultural loan volume at agricultural banks indicates that performance of the bank's security portfolio plays an important role in agricultural lending decisions.

Previous studies have indicated the need to account for the joint effects of risk and market imperfections in empirical banking analyses (Dixon and Barry). Our results also suggest that asset fixity should be incorporated in dynamic models of small bank portfolio adjustment.

Table 2. Partial Adjustment Model Results for Agricultural Loans, Nonagricultural Loans, Securities of Agricultural Banks

Explanatory Variables	Dependent Variables: Agricultural Loan Volume	Nonagricultural Loan Volume	Security Investment
Constant	-142.4 (17.5)[a]	-120.9 (7.1)	122.5 (3.4)
Adjustment Parameter (λ)	0.054 (15.4)	0.051 (296.5)	0.158 (138.9)
Lagged Dependent Variable (q_{t-1})	0.946 (270.8)	0.949 (296.5)	0.842 (26.0)
Bank Funds (W_t)	0.017 (11.2)	0.017 (13.5)	0.079 (27.3)
Security Rate of Return (r)	18.89 (13.8)	8.000 (6.1)	-9.28 (3.4)
Agricultural Land Value Index (I)	3.20 (18.2)	1.68 (10.0)	-5.37 (15.0)
Interest Rate Variance (σ_R^2)	-21.31 (13.3)	-18.98 (6.8)	32.19 (10.2)
Seasonal Dummy (Dm)	-177.1 (24.4)	46.65 (6.7)	578.62 (20.2)
$\bar{R}^2$	0.97	.98	.96
DW	2.29	1.91	2.28

a/ Figures in parentheses are t-statistics. Critical t-values are 2.58, 1.96 and 1.65 for confidence levels of 99, 95 and 90 percent, respectively.

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