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Profit Patterns Across American Agriculture

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To remain viable, agriculture in each location must offer returns that are competitive with those from alternative investments and sufficient to cover producers' financial obligations. Economic theory says that rates of return converge over time as resources flow into more-profitable industries and out of less-profitable industries, causing factor price changes. Both traditional growth and trade theories say factor markets will adjust to equalize commodity returns over time. This study examines spatial relationships in agriculture's profitability over time. Results show temporal and spatial convergence of returns consistent with trade and development theories. However, there are profit patterns unique to state/regional agriculture, raising policy implications.

Key words: convergence, return on assets, "risk of ruin"

Introduction

The future of American agriculture will ultimately depend on its profitability within geographic regions and individual states. To remain viable, agriculture in each location must offer returns (expressed as the rate of return on investments) that are both competitive with those from alternative investments and sufficient to cover producers' financial obligations. In turn, economic theory says that rates of return converge over the long term as resources flow into more-profitable industries and out of less-profitable industries, causing factor price changes (O'Rourke and Williamson, 1994). Both traditional growth and trade theories say factor markets will adjust to equalize commodity rates of return over time. For example, Kim (1997, pp. 1–2) notes:

> The neoclassical Heckscher-Ohlin trade model argues that incomes of regions vary because of their differing factor endowments and factor prices. Economic integration and trade in goods leads to income convergence through factor price equalization.... Since regions differ in their factor endowments, regions will specialize in different industries.

This implies that differences in agricultural returns across states and regions over time are most likely due to different "crop portfolios" being produced across locations (Schott, 2003).

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Convergence is important because it raises the question of whether the total rate of return to which an area's agricultural markets converge is sufficient to keep agriculture viable. That is, if financial obligations exceed current income in the short run, or if opportunity costs exceed total returns in the long run, off-farm income is needed for producers to avoid leaving agriculture. Returns from current income are a "cash flow" available in the short run to pay financial obligations. Furthermore, returns from capital gains are not liquid; they are gains in wealth fully captured only in the longer term. Therefore, the composition of total returns and its variance influence viability (Plaxico, 1979).

Melichar (1979) used the theoretical and empirical relationships among the rate of return on farm assets from current income, capital gains, and asset prices to illustrate several key points about convergence. First, according to asset-pricing theory, a farm economy characterized by rapid growth in the current return to farm assets will tend to experience large annual capital gains and a low rate of return to assets (p. 1085). Second, long-run capital market equilibrium requires that the annual rate of increase in the price of an asset equals the growth rate of the annual return, and that the rate of return from current income plus the rate of return from capital gains equals the market interest rate. Since the rate of return from capital gains equals the growth rate of returns, the rate of return from current income is equal to the discount rate (market rate of interest) minus the growth rate of returns. Thus, the market discount rate determines the total rate of return, and the growth rate determines how the total (rate of) return is divided between a capital gain and a current return. Third, the market discount rate used by investors to discount expected returns may vary across farm production regions due to differences in opportunity costs of farm investments and in the ability of investors to manage market (systematic) risk by holding well-diversified portfolios. Therefore, even in the long run, ex post (total) rates of return on farm assets may differ across farm regions.

Furthermore, Melichar (1979) examined (total) rates of return on farm assets over subperiods, divided based on differences in either the growth rate of the current return, or in the relative importance of capital gains. Consequently, (total) rates of return may be markedly different across farm production regions from those expected from the asset-pricing model. In the short run (over subperiods), when factors like farmland and other farm capital are "quasi-fixed," rates of return typically differ from their long-run equilibrium values.

This paper examines whether there are spatial relationships in agriculture's profitability over time. Theory suggests that, in the long run, factor markets adjust to (approximately) equalize agriculture's marginal rates of return over space. However, in the short run, agriculture's marginal rates of return may not equalize across states/regions due to (*a*) factor immobility (Davis and Weinstein, 2001), and (*b*) factor and output price distortions. Differences in the general level of profitability across states/regions suggest that factor markets have not fully adjusted and that factor and commodity price distortions persist. Furthermore, differences in marginal rates of return in global commodity markets indicate factor price equalization and factor endowment convergence have yet to fully integrate all markets (Gutierrez, 2000; Schott, 2003). Accordingly, the general objective of this paper is to assess the profitability of American agriculture over space and time so as to identify regions with agricultural sectors most likely to prosper or decline under the pressure of current global economic conditions. The results generally show temporal and spatial convergence of rates of return consistent with trade and development theories. However, there are constraints in convergence patterns unique to state/regional agriculture.

Propositions to Be Examined

The objective is met by evaluating three general propositions that help explain observed aggregate financial results and the farm-level decisions leading to them. Hopefully, this will lead to future research on these important issues.

- PROPOSITION 1—Convergence. *Convergence in rates of return to American agricultural producers occurs over time and space.*
- PROPOSITION 2—Minimum Return to Remain in Agriculture. *There is a minimum rate of return needed to remain in agriculture, and it will be apparent if the data converge to a stable trend over time.*
  - PROPOSITION 2a. *If there are no off-farm income sources available, the minimum rate of return to production must be at least 0% (a breakeven operation) and greater than zero if there are opportunity costs for producers to stay in agriculture.*
  - PROPOSITION 2b. *If there are off-farm income sources available, the minimum rate of return to production can be less than 0% (an unprofitable operation), depending on a farmer's willingness and ability to personally subsidize the farm.*
  - PROPOSITION 2c. *The minimum rate of return needed to remain in agriculture influences the "probability of lost farms" in a state/region.*
- PROPOSITION 3—Sources of Returns. *The sources of income/returns are important in determining the economic prospects of agriculture in a state/region over time.*
  - PROPOSITION 3a. *The farm share of a state's gross state product and that state's farmers' rate of return from current production income will be positively correlated.*
  - PROPOSITION 3b. *The farm share of a state's gross state product and that state's farmers' rate of return from capital gains will be negatively correlated.*

The rationale for Propositions 1 and 2 is apparent. Proposition 3 is based on expectations derived from the work of Melichar (1979), Plaxico (1979), and others. The relationship stated in Proposition 3a is expected due to the need for higher agricultural income in states with relatively fewer opportunities for off-farm income. Proposition 3b states a relationship created when nonfarm sectors in states vary in size, and thus have different effects on agricultural asset values.

The economic implications of Propositions 1–3 are (*a*) that structural adjustments in the agricultural sector will (continue to) occur in locations (i.e., states, regions) with below-minimum profitability, until average results are reached, if factor markets permit sufficient adjustment; and (*b*) if factor markets do not permit sufficient adjustment, agriculture will be under pressure to shrink, subject to the willingness and ability of farmers to earn sufficient off-farm income to maintain the required minimum profitability levels.

Thus, rates of return to commodities—and the states and/or regions in which they are produced—will vary across locations unless factor markets can adjust sufficiently over time. If differences are found, as expected, the profitability performance of locations will reflect the relative strength or weakness of each area's agricultural sector.

Methodology

Profitability of the agricultural sectors of each state is assessed using returns on assets data from the U.S. Department of Agriculture/Economic Research Service's web site (USDA/ERS, 2003). State-level annual data from 1960 through 2002 are used. Also, geographic regions are being used increasingly by economists to facilitate analyses of locations sharing common attributes (e.g., Dodson, 1994; Isserman, 2002; Kim, 1997; Quigley, 2002). To that end, the U.S. Department of Agriculture aggregated the contiguous 48 states into ten "farm production regions" based on the dominant agricultural enterprises within each state. This study uses those regions.

The general objective is fulfilled by evaluating the propositions presented above. First, the analysis tests for convergence by comparing states and regions to regional and national average profit performance, as measured by return on assets, and by identifying trends over the 1960–2002 period (Proposition 1).[1] Second, a "safety-first" criterion is used to evaluate the level of risk facing agricultural producers as long-run returns converge to a single, minimum level across space and time (Proposition 2). This criterion provides results consistent with, but more detailed than, the results generated using standard market risk measures as applied by Daniel and Featherstone (2001) and others. Also, how off-farm income affects the minimum return required and viability of agriculture is considered by inserting the minimum return into a safety-first measure. Finally, how the sources of returns (current income, capital gains, and off-farm income) affect profit patterns and the long-run viability of production agriculture is evaluated (Proposition 3). Examining these three general propositions facilitates identification of locations where production agriculture is most likely to prosper or decline.

Rates of Return and Profitability

The profitability of investments can be described with various financial measures. The USDA/ERS estimates both the rate of return from current income and the total economic rate of return, including capital gains for the farm business sector, independently of who owns these assets. The rate of return on assets (ROA) from current income is the ratio of residual income to farm assets from current income to the average value of the beginning and end of year's farm assets. The residual income to farm assets is calculated by ERS as income to farm assets less the imputed returns to labor and to management. The rate of return on farm equity (ROE) is the ratio of residual income to farm assets excluding interest paid, to the average value of the beginning and end of year's farm equity. The total economic (ex ante, expected) rate of return to assets (equity) is divided into two components: current income as a percentage of assets (equity) and unrealized capital gains/losses as a percentage of assets (equity):

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[1] Farms generating insufficient returns will exit over the long run, and farms earning returns significantly above average will face competitive pressures causing decreases in returns over time. Thus, long-run returns are expected to cluster around the average for the geographic area if convergence is occurring.

$$\text{(1)} \qquad \textit{Total ROA (ROE)} = \frac{\textit{Returns from Current Income} + \textit{Returns from Capital Gains}}{\textit{Average Value of Farm Assets (Equity)}}.$$

In periods of rapidly changing farm income and land values, measures which include capital gains may give better estimates of the farm sector's profitability than those that do not (Ahrendsen, 1993; Crisostomo and Featherstone, 1990; Dunford, 1980; Melichar, 1979). Therefore, this study uses total ROA as its primary measure of profits.

Evaluating Convergence

Convergence is assessed using both qualitative and quantitative methods. Both approaches focus on historical returns data. Patterns in the data across locations and time are first identified qualitatively using descriptive statistics. Then, cointegration analysis is used to test for long-run convergence. Finally, a trend model is used to test hypotheses regarding convergence, divergence, and stability in rates of return.

Cointegration Analysis

A typical formulation of convergence (Sala-i-Martin, 1996) can be expressed as:

$$\text{(2)} \qquad \ln\left(\frac{y_{it}}{y_{*t}}\right) = \alpha_0 + \alpha_1 \ln\left(\frac{y_{i,t-1}}{y_{*,t-1}}\right) + \alpha_2 \mathbf{z}_{it} + \varepsilon_{it},$$

where $\ln(\cdot)$ denotes the natural logarithm; y_{it} is the level of income per capita in region or state i in time t; y_{*t} is the index income per capita at time t; $\mathbf{z}_{it}$ is a vector of other economic variables (such as initial capital) in region or state i at time t; ε_{it} is an error term; and α_0, α_1, and α_2 are estimated coefficients. In this formulation, if $\alpha_0 \to 0$, $\alpha_1 < 1$, and $\alpha_2 = 0$, the income in region i converges over time toward the income of the index. Further, this convergence is unconditional, or does not depend on other variables (such as initial capital). The convergence is conditional if $\alpha_0 \to 0$, $\alpha_1 < 0$, and $\alpha_2 \neq 0$.

Implicit in most discussions of convergence is the assumption that incomes have grown monotonically over time. Empirically, growth implies

$$\text{(3)} \qquad y_{it} = \gamma_0 + \gamma_1 y_{i,t-1} + \nu_{it},$$

where γ_0 and γ_1 are estimated parameters and ν_{it} is an error term. Monotonic economic growth could imply that $\gamma_1 \to 1$, or that income per capita may be nonstationary. This potential nonstationarity introduces the possibility of spurious regression results (Granger and Newbold, 1974). This study, however, analyzes whether the rate of return on agricultural assets is converging across regions. Thus, income in equation (3) is replaced with the rate of return on assets giving

$$\text{(4)} \qquad r_{it} = \gamma_0 + \gamma_1 r_{i,t-1} + \nu_{it},$$

where r_{it} is the rate of return on agricultural assets in state i. The Phillips-Perron tests for nonstationarity of the rates of return on agricultural assets are presented in table 1. Note that in 24 of the 48 states, nonstationarity is rejected at the 95% confidence level.

Table 1. State-Level Phillips-Perron Z_α Statistics for the Rate of Return on Assets

Region/State	α	Z_α Statistic	Region/State	α	Z_α Statistic
Northeast:			**Southeast:**		
Connecticut	0.7195	-9.2909	Alabama	0.6124*	-13.3791
Delaware	0.6143**	-13.9086	Florida	0.7244*	-11.0628
Maine	0.3241***	-26.8908	Georgia	0.6374*	-12.2322
Maryland	0.5421**	-16.2135	South Carolina	0.2759***	-28.0804
Massachusetts	0.8160	-6.2148	**Delta States:**		
New Hampshire	0.2009***	-33.9048	Arkansas	0.5273**	-19.0899
New Jersey	0.7996	-9.3533	Louisiana	0.6937*	-13.0915
New York	0.6833	-10.5786	Mississippi	0.2114***	-32.7156
Pennsylvania	0.5274**	-16.7369	**Southern Plains:**		
Rhode Island	0.8936	-7.5609	Oklahoma	0.6065**	-15.7822
Vermont	0.7532	-7.8786	Texas	0.2823***	-30.4629
Lake States:			**Mountain States:**		
Michigan	0.8720	-2.9123	Arizona	0.7945	-7.5593
Minnesota	0.5571**	-17.7833	Colorado	0.8282	-8.3992
Wisconsin	0.6932	-8.6551	Idaho	0.7780	-8.5935
Corn Belt:			Montana	0.6894*	-13.1110
Illinois	0.4204***	-24.2368	Nevada	0.5026***	-20.7059
Indiana	0.3145***	-28.0607	New Mexico	0.6311**	-14.3258
Iowa	0.5163***	-21.1702	Utah	0.6685*	-13.5349
Missouri	0.5178**	-17.3323	Wyoming	0.8590	-7.6754
Ohio	0.3967***	-26.2823	**Pacific States:**		
Northern Plains:			California	0.8165	-10.3938
Kansas	0.6425**	-15.4928	Oregon	0.8409	-8.5828
Nebraska	0.6714*	-11.3804	Washington	0.7269*	-12.9085
North Dakota	0.3986***	-25.5364			
South Dakota	0.3318***	-27.5982			
Appalachia:					
Kentucky	-0.1069***	-43.9611			
North Carolina	0.9114	-2.8644			
Tennessee	0.7255	-7.2238			
Virginia	0.4531***	-21.4534			
West Virginia	0.0511***	-39.6884			

Note: Single, double, and triple asterisks (*) denote statistical significance at the 90%, 95%, and 99% confidence levels, respectively.

Further, in 32 of 48 states, nonstationarity is rejected at the 90% confidence level. Finally, the returns data are transformed for use in the convergence analysis, as noted below.

Convergence in equation (2) is reformulated into

$$\ln(y_{it}) - \ln(y_{*t}) = \alpha_0 + \alpha_1\big[\ln(y_{i,t-1}) - \ln(y_{*,t-1})\big] + \alpha_2\mathbf{z}_{it} + \varepsilon_{it}, \tag{5}$$

$$d_{it} = \alpha_0 + \alpha_1 d_{i,t-1} + \alpha_2\mathbf{z}_{it} + \varepsilon_{it},$$

where d_{it} is the logarithmic difference between returns in state i and the index state at time t. Since the rate of return data for agricultural assets in equation (5) are first-differenced, convergence can be estimated directly. Unfortunately, the formulation in equation (5) cannot be directly applied because negative rates of return are sometimes observed in the agricultural data. Thus, equation (5) is redefined so that $d_{it} = r_{*t} - r_{it}$, where, for each of ERS's 10 regions, r_{*t} is the maximum rate of return to agricultural assets from one state. Finally, α_0 and α_1 in equation (5) are estimated using maximum likelihood.

Trend Analysis

Cointegration analysis has a weakness relative to the objectives of this study that trend analysis can address. This weakness is the inability of standard cointegration methods to provide detailed information about the underlying processes in time series that do not appear to be converging. For example, time series may be diverging or they may have converged previously and are in some stable "equilibrium" during a period of interest. Trend analysis allows these special cases to be identified.

A convergence model derived by Ben-David (1993) is modified here by adding a trend variable. It begins as:

$$R_{i,t} - R_t^* = \varphi(R_{i,t-1} - R_{t-1}^*) + T_t, \tag{6}$$

where $R_{i,t}$ is the average return for producers in the states pooled to form region i in year t, R_t^* is the average return for producers in the United States in year t, and T is a time trend variable. Letting $Y_{i,t} = R_{i,t} - R_t^*$ (a first-difference), equation (6) can be rewritten as:

$$\Delta Y_{i,t} = \alpha - \beta Y_{i,t-1} + \gamma T_t + \varepsilon, \tag{7}$$

where $\Delta Y_{i,t} = Y_{i,t} - Y_{i,t-1}$ (a second-difference), α is a constant, β and γ are coefficients to be estimated, and ε is an error term. In this specification, $\beta = -(1 - \varphi)$, and γ and β jointly indicate whether the region's average returns are converging, diverging, stable, or mixed relative to national average returns.

If the estimated γ is not significantly different from zero over some time period, then location i's returns may be "stable" relative to U.S. average returns, thereby indicating a period of "equilibrium" caused by that location's markets having previously converged to the national average (or some stable amount above or below national average returns). During such a "stable" time period, differences in a location's returns relative to the U.S. average for individual years are expected to occur and are captured by the error term. Thus, the R^2 for an estimate of equation (7) is an indicator of how strongly the location has converged to the national market. In the extremely unlikely case of "perfect" convergence, there is no difference between $R_{i,t}$ and R_t^*, so $Y_{i,t} = 0$ at all times. In the equally unlikely case of "parallel" convergence (defined as two series with a fixed difference between them not equaling zero), $Y_{i,t}$ equals some fixed amount at all times. In both cases, $\gamma = 0$, $\beta = 1$, $\alpha = Y_{i,t}$, $\Delta Y_{i,t} = 0$, and the R^2 is 100%.

If γ is significantly different than zero over some time period, then location i's rates of return are in the process of either converging to, or diverging from, U.S. average returns.

The slope of the trend is indicated by γ, and its sign indicates the direction: a positive sign slopes upward to the right, a negative sign slopes down to the right. Convergence occurs when there is a downward trend in positive $Y_{i,t}$ values or when there is an upward trend in negative $Y_{i,t}$ values (i.e., $|Y_{i,t}|$ decreases). The reverse is true for divergence. Therefore, convergence is indicated by a significant β with an absolute value of one or more (i.e., $|\beta| \geq 1$), and divergence is indicated when a significant β has an absolute value between zero and one (i.e., $1 > |\beta| > 0$).

It is possible for a single trend (a period with a significant γ) to include periods of both convergence and divergence (in that order), thus requiring visual inspection of the data to avoid mislabeling the results. In such a case, the sign of $Y_{i,t}$ changes during the trend period. This means that the values of $|\beta|$ may signal either convergence or divergence, depending upon the relative number of positive and negative $Y_{i,t}$ values, although the result ought to be labeled as a "transition" period with mixed trends.

Safety-First Decision Criteria and the Minimum Return Required

Safety-first criteria are alternative performance measures (Hagigi and Kluger, 1987) and widely used tools for decision making under risk (Berck and Hihn, 1982; Encarnacíon, 1991; van Kooten, Young, and Krautkraemer, 1997) that are compatible with standard utility theory (Bigman, 1996; Pyle and Turnovsky, 1970). In agriculture, producers have adopted safety-first decision rules when the scale of possible losses from an investment is significant (Moscardi and de Janvry, 1977).

Safety-first models create a rank ordering of decision alternatives by placing constraints upon the probability of failing to achieve certain goals of the firm. These orderings also serve as measures of performance relative to the specified goal. Several forms of safety-first models have been proposed as alternatives to expected utility maximization (Telser, 1955; Hatch, Atwood, and Segar, 1989; Bigman, 1996). For example, Roy (1952) was the first to suggest that in some situations, such as when the survival of the firm is at stake, decision makers select activities that minimize the probability of failing to achieve a certain goal for income, i.e., minimize $\Pr\{\Pi < \Pi_*\}$, where $\Pr\{\cdot\}$ is the probability of event $\{\cdot\}$, Π is an income random variable, and Π_* is an income goal often referred to as the "safety threshold." All safety-first models have some safety threshold or minimum income goal that serves as the basis for performance measurements.

Therefore, in an era when decreasing profits threaten the economic viability of many farms, it is reasonable to propose that farmers' decisions are influenced by safety-first criteria. In such a case, a farmer's objective is to earn a profit expected to at least equal some designated minimum level of return, Π_*, with at least the desired level of probability (Mahul, 2000). The designated safety threshold, Π_*, is a personal preference based on financial obligations, lifestyle goals, and opportunity costs. Thus it varies across individuals. The desired probability level is also a personal choice, reflecting the individual's degree of risk aversion.

Empirical applications of safety-first models often use a measure called the "probability of loss" (PL), or "risk of ruin," that incorporates Π_*. This measure indicates the chance (in percentage terms) a producer will generate a return below some critical level. At an aggregate level, this measure can indicate the percentage of farms at risk of failure (hence, it could be called the "probability of lost farms"). The PL is found by calculating a "z" score and finding the relevant probability for that z value in a statistical table. The z for state or region i is calculated here as:

$$z_i = \frac{E(R_i) - k}{\sigma_i}, \tag{8}$$

where $E(R_i)$ is the expected (average) return (on assets, equity, or some other factor) for state or region i; k is some critical value (such as Π_*); and σ_i is the standard deviation of returns for state or region i. The average return and its standard deviation are calculated for 1960–2002.

The PL is the chance of earning a return below k; thus, $PL = \Pr\{R_i < \Pi_* = k\}$. The value of k is usually made zero, but it can be made any critical level of return. By making $k = 0$, the PL is the chance of suffering a loss. If some other value is used for k, such as the return needed to cover all financial obligations, the estimated PL represents the probability of earning insufficient returns to cover k (i.e., the chance of defaulting on some obligations).

In this study, PL estimates are calculated with varying values for k to show the sensitivity of production regions to the risks in their agricultural sector. Those estimates also serve as performance measures to rank the regions in terms of their likely decline due to economic pressures from globalizing commodity markets.

Off-Farm Income Availability

Off-farm income is increasingly important to the survival of many farms and ranches (Ahituv and Kimhi, 2002; Betubiza and Leatham, 1994; El-Osta and Ahearn, 1996; Kimhi, 2000; Mishra and Sandretto, 2002; USDA/ERS, 2001). In locations where agricultural returns fall below requirements, as expressed in safety-first models, off-farm income can serve as an alternative source (i.e., a good form of diversification) for enabling farms and ranches to remain in business. If off-farm income is readily available, farm profitability can fall with little impact on agricultural output, as implied in Proposition 2b. When off-farm income is less easily found, farmers must try harder to increase farming profits[2] so as to meet financial obligations or face exiting the industry, as noted in Proposition 2a. Thus, the decline of an agricultural sector can be slowed or reversed by producers' willingness and ability to subsidize their farms and ranches with off-farm income (Blank, 2002). However, the availability of off-farm employment varies across locations.

To proxy this important factor affecting the profitability of agricultural sectors, this study uses data on gross state product (GSP) from the Commerce Department's Bureau of Economic Analysis. It is expected that the farm share of GSP in a state is inversely

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[2] Profits per acre from farming can be increased through two general routes: (*a*) shift to a more profitable (and more risky) portfolio of crops/enterprises, and (*b*) lower costs per unit of output. The second route, lower costs, may be achieved either through using fewer inputs per unit of output (i.e., a technological and/or managerial advance) or having the cost of inputs fall (i.e., a factor market adjustment). However, there are constraints on both routes. Agronomic constraints may limit which crops can be produced in a location, and factor markets may not adjust to falling demand from agricultural uses when there are nonagricultural sources of demand for particular inputs. In the face of these constraints, many farmers seek to increase total farm profits by expanding the total size of the farm (i.e., producing on more acreage).

related to the availability of off-farm employment and investment opportunities—as the nonagricultural sector of a state's economy grows, more off-farm opportunities develop. Two versions of the data are used, the farm share of GSP and the "location quotient" (LQ), calculated as follows:

$$\text{(9)} \qquad Farm\ Share\ of\ GSP = \frac{Farm\ GSP_i}{Total\ GSP_i},$$

$$\text{(10)} \qquad LQ = \frac{(Farm\ GSP_i / Total\ GSP_i)}{(Farm\ GNP_{US} / Total\ GNP_{US})},$$

where *Farm* GSP_i is the dollar amount of state *i*'s farm net value added, *Total* GSP_i is the dollar amount of state *i*'s total net value added, and *Farm* GNP_{US} and *Total* GNP_{US} are the same values for the United States. The *LQ* is an index with a value of 1.0 for a state with exactly the same percentage of total net value added contributed by agriculture as is the case for the nation.

Results

The empirical results show evidence of patterns in profitability across spatial locations and across time. These patterns and their implications for the propositions and the general objective are discussed in the following sections.

Patterns Across and Within Locations

Table 2 shows the average returns on assets and equity earned by agriculture in individual states, the regions, and the entire United States for the 1960–2002 period. Four general results are discussed.

First, it is noted that there is a wide range of returns across states. The top five states in terms of profit performance and their ROA (ROE) for the entire period are North Carolina 9.3% (10.0%), Florida 8.6% (9.5%), Georgia 8.0% (8.6%), California 7.7% (8.5%), and Vermont 7.6% (8.4%). The five states with the lowest ROA (ROE) results are West Virginia -7.6% (-8.9%), New Hampshire -2.9% (-3.5%), New Mexico -0.4% (-1.1%), Oregon 0.3% (-0.6%), and Pennsylvania 0.3% (-0.3%). These states are the focus of further analysis below.

Second, there are some patterns in the relative contributions in returns for the top and bottom states. These patterns support Proposition 3—sources of returns. For the high-performing states, a majority of total ROA usually comes from current income (i.e., agricultural production profits). Vermont is the only one of those five states to obtain a bigger contribution to total ROA from capital gains (ROA_k, i.e., real estate appreciation)[3] than from current income. For Vermont, growth in residential demand for land over the period fueled capital gains to farmland owners (the nation's highest). For the least profitable states, the relative source of return weakness varies from East to West. The more densely populated eastern states of New Hampshire, West Virginia, and Pennsylvania all had negative returns from current income and better results from capital gains

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[3] Real estate appreciation represents about three-quarters of capital gains to agriculture historically (USDA/ERS, 2000).

Table 2. Average Rates of Return by State and Region, 1960–2002

State/Region	ROA from Current Income	ROA from Capital Gains	Total ROA	Std. Dev. of Total ROA	Total ROE	Std. Dev. of Total ROE
	<-------------------------		(Percent)		------------------------->	
Connecticut	2.00	2.67	4.67	4.40	4.75	4.83
Delaware	5.07	2.21	7.28	6.52	7.95	7.95
Maine	-0.21	1.47	1.26	5.89	0.73	7.28
Maryland	1.58	1.50	3.07	5.29	2.89	6.16
Massachusetts	0.71	3.44	4.15	4.72	4.21	5.30
New Hampshire	-4.07	1.21	-2.86	9.16	-3.53	10.33
New Jersey	0.96	2.50	3.46	5.30	3.50	5.90
New York	-0.18	3.69	3.51	4.32	3.16	5.35
Pennsylvania	-1.50	1.75	0.25	4.43	-0.34	5.22
Rhode Island	2.38	3.69	6.07	8.25	6.34	9.11
Vermont	0.98	6.63	7.61	5.97	8.35	7.26
NORTHEAST:	**-0.03**	**2.56**	**2.54**	**3.65**	**2.24**	**4.38**
Michigan	0.58	2.16	2.74	5.41	2.18	6.91
Minnesota	2.65	1.76	4.41	8.06	4.01	10.51
Wisconsin	1.54	2.59	4.13	5.39	3.79	7.05
LAKE STATES:	**1.82**	**2.13**	**3.95**	**6.22**	**3.53**	**8.15**
Illinois	3.61	0.89	4.51	8.19	4.25	9.56
Indiana	2.87	0.88	3.75	8.27	3.30	10.22
Iowa	4.72	0.82	5.54	9.21	5.39	11.83
Missouri	1.30	0.80	2.09	7.01	1.45	8.65
Ohio	1.24	2.32	3.56	6.95	3.26	8.16
CORN BELT:	**3.13**	**1.06**	**4.18**	**7.83**	**3.86**	**9.57**
Kansas	3.51	0.34	3.86	6.90	3.51	8.80
Nebraska	4.56	0.61	5.17	6.89	5.03	8.95
North Dakota	3.23	0.65	3.89	7.64	3.33	9.03
South Dakota	4.43	2.27	6.70	6.61	6.80	8.48
N. PLAINS:	**3.97**	**0.83**	**4.80**	**6.57**	**4.57**	**8.37**
Kentucky	2.44	2.05	4.49	4.91	4.35	6.06
North Carolina	8.04	1.24	9.28	6.67	9.96	7.90
Tennessee	0.05	2.11	2.15	5.04	1.74	6.07
Virginia	0.64	1.02	1.66	5.30	1.26	6.09
West Virginia	-5.74	-1.86	-7.60	9.10	-8.89	10.11
APPALACHIAN:	**2.58**	**1.45**	**4.04**	**4.59**	**3.86**	**5.52**
Alabama	4.28	2.34	6.62	5.20	6.90	6.37
Florida	6.73	1.92	8.64	5.23	9.45	6.25
Georgia	5.72	2.32	8.04	5.80	8.56	7.31
South Carolina	3.07	0.25	3.32	5.43	2.85	6.86
SOUTHEAST:	**5.50**	**1.92**	**7.42**	**4.48**	**7.90**	**5.50**
Arkansas	5.58	-0.73	4.84	6.99	4.74	8.76
Louisiana	3.95	0.51	4.45	7.30	4.13	9.18
Mississippi	3.99	0.44	4.42	6.96	4.02	9.08
DELTA:	**4.62**	**-0.02**	**4.60**	**6.58**	**4.34**	**8.42**

(continued . . .)

Table 2. Continued

State/Region	ROA from Current Income	ROA from Capital Gains	Total ROA	Std. Dev. of Total ROA	Total ROE	Std. Dev. of Total ROE
	<---------- (Percent) ---------->					
Oklahoma	1.16	0.05	1.21	5.83	0.38	7.56
Texas	2.07	0.88	2.95	5.18	2.75	6.05
S. PLAINS:	**1.87**	**0.71**	**2.58**	**4.92**	**2.27**	**5.88**
Arizona	3.88	2.65	6.54	5.91	6.87	6.96
Colorado	2.85	1.15	4.00	5.96	3.91	7.84
Idaho	3.74	1.67	5.42	6.09	5.48	7.97
Montana	2.28	2.07	4.34	7.07	4.17	8.72
Nevada	1.16	1.99	3.14	6.46	2.99	7.51
New Mexico	2.87	-3.28	-0.41	7.34	-1.08	8.56
Utah	0.81	0.49	1.30	6.59	0.80	7.74
Wyoming	1.16	1.83	2.99	6.25	2.78	7.47
MOUNTAIN:	**2.67**	**1.24**	**3.90**	**5.51**	**3.78**	**6.88**
California	6.41	1.27	7.68	5.57	8.51	7.40
Oregon	1.17	-0.85	0.32	5.61	-0.59	7.24
Washington	4.77	1.28	6.05	5.94	6.30	7.47
PACIFIC:	**5.41**	**0.97**	**6.39**	**4.95**	**6.84**	**6.57**
Alaska	-0.06	2.67	2.61	12.49	2.50	13.82
Hawaii	3.22	1.85	5.07	5.41	5.17	5.97
AK&HI:	**2.93**	**1.92**	**4.85**	**5.26**	**4.92**	**5.80**
U.S. TOTAL	**3.04**	**1.26**	**4.30**	**5.26**	**4.12**	**6.60**

Notes: "ROA" is the return on assets, "ROE" is the return on equity, and "Std. Dev." is the standard deviation of the time series.

(although West Virginia had negative returns from capital gains). New Mexico and Oregon both had negative ROA from capital gains, but positive returns from current income. These results appear to illustrate the "urban influence" on farmland values described by the USDA/ERS (2000, p. 30):

> Although average agricultural land values nationally are determined primarily by the income earning potential of the land, nonagricultural factors appear to be playing an important role in many local areas. To some extent, the buoying effect of these nonagricultural factors on agricultural land values could be partially offsetting the effect of lower returns from agricultural production.

The third general observation from table 2 reveals there are some patterns across regions. Six regions' returns have converged around the national average, while two regions have significantly higher returns and two regions have significantly lower returns.[4] This result supports Proposition 1—convergence. The average total ROA (ROE) for agriculture in the United States is 4.3% (4.1%). Six of the 10 regions had average

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[4] A paired comparison *t*-test was conducted for each region for the hypothesis that the region's average total ROA equaled the U.S. average total ROA over the 1960–2002 period. The hypothesis could not be rejected for the following six regions (with the calculated *t*-statistics in parentheses): Appalachia (-0.68), Corn Belt (-0.24), Delta (0.70), Lake States (-0.90), Mountain (-1.39), and the Northern Plains (1.39). The hypothesis was rejected for the Southeast (*t*-statistic = 7.99), Pacific (3.72), Northeast (-2.93), and Southern Plains (-2.92).

ROAs (ROEs) in the range of 3.9%–4.8% (3.5%–4.6%). These results support Proposition 2—minimum return, suggesting the minimum return required by agricultural producers is in this range. The Southeast and Pacific regions had much higher average total returns (ROA of 7.4% and 6.4%, respectively) with a large majority of it coming from current income, implying their agricultural sectors are strong. The Northeast and Southern Plains regions had low returns, each with a total ROA of just under 2.6%. For the Southern Plains, current income represented a majority of returns, while virtually all of the Northeast's ROA came from capital gains. Clearly, different factors are affecting the convergence process in each region, as discussed below.

Finally, there are some consistent patterns within regions. Rates of return and sources vary across states within regions in nearly all cases, which supports Proposition 3. The only region to have consistent total rates of return across all states is the three-state Delta. The difference between highest and lowest total ROA across the states was just 0.42 percentage points.[5] The Delta also had a fairly consistent pattern across states for one source of returns, with a highest-to-lowest difference of 1.24 percentage points for capital gains.[6] Three other regions had some consistency in capital gains across states. The Southern Plains region of just two states had an insignificant difference in rates of return from capital gains of 0.83 percentage point ($t = 1.10$). An insignificant difference in ROA_k is found in the Lake States and Corn Belt regions, although Ohio is an outliner in the Corn Belt. The difference across the other four states in that region is only 0.09 percentage point, indicating an amazing degree of convergence in farmland markets.

Patterns by Source Over Time

Figure 1 shows the national average results disaggregated by source over time. Two conclusions can be drawn from the figure. First, as expected, returns from capital gains (which reflect changes in valuations based on expected future income) were much more volatile than returns from current income (which is an historic measure) over the 1960–2002 period: $\sigma_k > \sigma_\pi$. Second, the variability of returns, especially from capital gains, was smaller during the 1960s and 1990s, compared to the volatile 1970s and 1980s. Jointly, these results support Proposition 3—that sources of returns are important in determining the economic prospects of agriculture over time; nationally, current income has been a less-risky source of returns making states/regions with adequate income more viable than areas with agricultural sectors relying on capital gains.

To facilitate evaluation of patterns in returns across time by source, table 3 presents data for average ROA aggregated by region and for the country. Several important observations can be made about those results.

First, there is a consistent pattern in total ROA over time, supporting Proposition 1—convergence. At the national level and for every region except the Northeast, total

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[5] Paired comparison t-tests for the hypothesis of equal mean total ROA generated the following results: Arkansas versus Louisiana $t = 0.36$, Arkansas versus Mississippi $t = 0.39$, and Louisiana versus Mississippi $t = 0.03$. Thus, the hypothesis could not be rejected in any of the three cases in this region.

[6] Comparing the three capital gain rates generated t-statistics of 1.29 for Arkansas versus Louisiana, 1.21 for Arkansas versus Mississippi, and 0.07 for Louisiana versus Mississippi, none of which are statistically significant. On the other hand, the rate of return from income for Arkansas was significantly different than that for the two other states (Arkansas versus Louisiana $t = 5.08$, Arkansas versus Mississippi $t = 4.95$). There was no difference in ROA_π between Louisiana and Mississippi ($t = 0.14$).

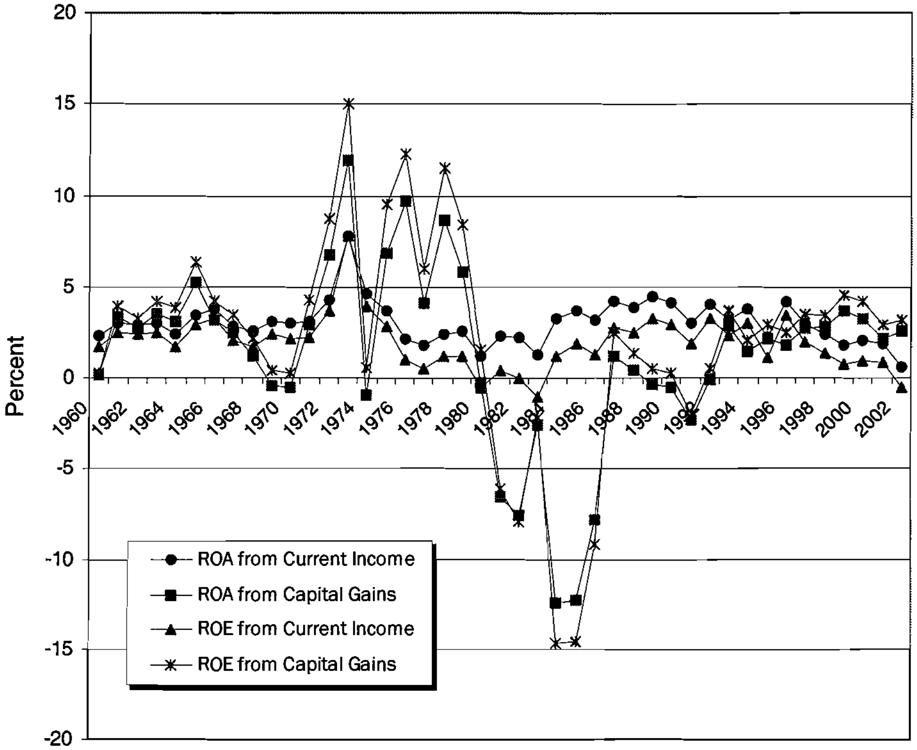

Figure 1. U.S. returns on assets and equity, 1960–2002

ROA was highest during the 1970s and lowest during the 1980s. Also, only the two most profitable regions, the Southeast and Pacific, had positive total returns during the 1980s.

Second, evaluating the source of returns over time provides mixed results. There is a clear pattern over time in returns from capital gains. For every region, ROA_k was highest during the 1970s and lowest during the 1980s (being negative in each case). No clear pattern holds for ROA_π. This implies capital markets are more integrated than are commodity markets.

When comparing the average level of returns for the 1960s and the 1990–2002 period (the decades before and after the boom-recession 1970–89 period), an interesting pattern emerges for the two sources. Between the 1960s and 1990–2002, ROA_π decreased in three of the regions, with a fourth (Mountain) virtually unchanged, and it increased in six regions.[7] The reverse is seen for ROA_k, which increased in four regions and decreased in six regions. At the national level, ROA_π was surprisingly stable, while ROA_k decreased between the two periods. One interpretation of these patterns is that they are consistent with Melichar's (1979) point—i.e., in equilibrium, the total rate of return on farm assets would equal the market interest rate, thus linking the returns from current income and capital gains in an inverse relationship.

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[7] These results are based on t-tests comparing mean returns for the two time periods. This is also true for the other results reported in this section.

Table 3. Regional Average Rates of Return on Assets Over Time, by Source

Description	1960–1969	1970–1979	1980–1989	1990–2002
	<---------------- (Percent) ---------------->			
Northeast:				
ROA from current income (ROA_π)	0.44	-0.06	0.78	-0.98
ROA from real capital gains (ROA_k)	5.02	5.18	-0.90	1.33
Lake States:				
ROA from current income (ROA_π)	3.03	3.42	2.35	-0.74
ROA from real capital gains (ROA_k)	2.77	6.67	-4.60	3.30
Corn Belt:				
ROA from current income (ROA_π)	3.92	3.92	2.86	2.11
ROA from real capital gains (ROA_k)	2.05	6.84	-7.49	2.41
Northern Plains:				
ROA from current income (ROA_π)	3.21	4.68	3.76	4.18
ROA from real capital gains (ROA_k)	2.52	5.57	-5.35	0.64
Appalachian:				
ROA from current income (ROA_π)	2.39	2.30	2.03	3.38
ROA from real capital gains (ROA_k)	3.25	4.79	-3.60	1.39
Southeast:				
ROA from current income (ROA_π)	4.64	4.84	5.53	6.65
ROA from real capital gains (ROA_k)	3.34	5.55	-2.46	1.40
Delta:				
ROA from current income (ROA_π)	3.99	5.29	3.72	5.27
ROA from real capital gains (ROA_k)	2.50	4.16	-6.81	0.06
Southern Plains:				
ROA from current income (ROA_π)	1.63	2.17	1.64	2.00
ROA from real capital gains (ROA_k)	2.70	3.72	-3.57	0.15
Mountain:				
ROA from current income (ROA_π)	2.68	3.05	2.37	2.66
ROA from real capital gains (ROA_k)	1.73	5.82	-5.01	2.14
Pacific:				
ROA from current income (ROA_π)	3.84	6.23	6.27	5.33
ROA from real capital gains (ROA_k)	0.93	4.21	-2.98	1.56
UNITED STATES:				
ROA from current income (ROA_π)	2.94	3.54	2.95	2.79
ROA from real capital gains (ROA_k)	2.46	5.53	-4.81	1.72

Finally, the profitability performance patterns by region show a distinct shift in American agriculture from the northeast to the west, a shift that is probably a result of the convergence process. The Northeast region's returns were lower from both sources (ROA_π and ROA_k) in the 1990–2002 period compared to the 1960–69 period—the only region to have such results—despite efforts to raise profit margins, such as expanding direct marketing and the production of alternative crops. Also, two of the three negative results for ROA_π in table 3 are for the Northeast (i.e., 1970–79 and 1990–2002). The other negative result for ROA_π is for the Lake States region during 1990–2002. That region and the Corn Belt both had lower returns from current income during the recent decade compared to the 1960s. Thus, the only three regions with lower returns from agricultural income during the most recent decade were the three in the north-by-northeast section of the United States.

The next five regions to the south and west (Northern Plains, Appalachian, Southeast, Delta, and Southern Plains) all had higher average returns from current income and lower returns from capital gains during the 1990–2002 period, compared to the 1960s, and current income provided the majority of total returns during the recent period. Also, the three lowest results for ROA_k outside of the 1980s occurred in the Northern Plains, Delta, and Southern Plains regions during the most recent decade.

The two western regions (Mountain and Pacific) had the most positive patterns. Both regions had higher levels of returns from capital gains during the 1990–2002 period, compared to the 1960s, and while the Mountain region's returns from current income were about the same between the two periods, the Pacific region had higher ROA_π in the recent period. Thus, the Pacific was the only region to have higher returns from both sources over the two periods.

The profit-induced shift in agriculture described above is apparent in data showing changes in aggregate cropland acreage over the 1945–1997 period, as reported by Vesterby and Krupa (2001). Over that period, cropland reductions in the Northeast, Southeast, Appalachia, Lake States, and the Delta totaled about 35 million acres. Over the same period, however, there were cropland acreage increases in the other regions (Pacific, Southern Plains, Corn Belt, Northern Plains, and Mountain) totaling about 38 million acres. Hence, the cropland increases (predominantly in the western half of the United States) replaced the decreases (mostly in the eastern half of the country). In total, there was a net gain of about 3 million acres of cropland over the 1945–1997 period despite a steady decrease in total land in U.S. agriculture after the peak in 1954. The slight expansion of cropland in combination with a drop in total land in agriculture from 1.2 billion acres in 1954 to 931 million acres in 1997 clearly indicates that the composition of American agriculture's portfolio of enterprises is slowly shifting away from livestock grazing and toward higher-value crops and intensive livestock that generate higher returns. This trend is an integral part of the process causing convergence of rates of return.

Overall, total returns increased for only two regions between the 1960s and the 1990–2002 period: the Pacific and Mountain regions. Total returns were virtually unchanged over the two periods for the Southeast region and were lower in all other regions. Thus, while most of the country is following the U.S. trend of lower total returns over time, the agricultural sectors in many western states appear to have converged to a higher rate of returns.

Convergence: Cointegration and Trend Results

The empirical results for the cointegration convergence model in equation (5) are presented in table 4. Based on the data, the rate of return on agricultural assets in Delaware is generally higher than for the remaining states in the Northeast. Thus, Delaware was chosen as the Northeast's index state in equation (5). Following this criterion, Minnesota is used as the index state for the Lake States, Iowa as the index for the Corn Belt, Nebraska as the index for the Northern Plains, North Carolina as the index for Appalachia, Florida is used for the Southeast, Arkansas as the index for the Delta, Texas as the index in the Southern Plains, Idaho is used for the Mountain region, and California as the index state for the Pacific region.

Table 4. Estimated Autoregression Coefficients for Difference in Rate of Return on Assets

Region/State	α_1	Standard Deviation	α_0	Standard Deviation
Northeast:				
Connecticut	0.42727	0.14016	0.03915	0.00781
Maine	0.16453	0.15391	0.05370	0.00745
Maryland	0.54789	0.13075	0.03825	0.00680
Massachusetts	0.66263	0.11415	0.05027	0.01331
New Hampshire	0.29933	0.15009	0.10615	0.02317
New Jersey	0.55701	0.12832	0.04900	0.00912
New York	0.72217	0.10466	0.05099	0.01441
Pennsylvania	0.68446	0.11083	0.07170	0.01268
Rhode Island	0.62615	0.11949	0.03835	0.01378
Vermont	0.67631	0.11208	0.04426	0.01393
Lake States:				
Michigan	0.19130	0.15320	0.02966	0.00369
Wisconsin	0.44944	0.13839	0.01419	0.00477
Corn Belt:				
Illinois	0.36472	0.14484	0.01380	0.00294
Indiana	0.29675	0.14939	0.02256	0.00356
Missouri	0.64570	0.11802	0.04156	0.00593
Ohio	0.35765	0.14676	0.04471	0.00415
Northern Plains:				
Kansas	0.57572	0.12687	0.01151	0.00416
North Dakota	0.51570	0.13259	0.01077	0.00705
South Dakota	0.75043	0.10322	0.00337	0.00675
Appalachian:				
Kentucky	0.90350	0.06173	0.06648	0.02926
Tennessee	0.94620	0.04424	0.09253	0.04018
Virginia	0.93138	0.05004	0.08740	0.03171
West Virginia	0.41308	0.14127	0.15907	0.02731
Southeast:				
Alabama	0.33804	0.14661	0.01761	0.00277
Georgia	0.48546	0.13725	0.00171	0.00435
South Carolina	0.62855	0.13076	0.02993	0.00791
Delta:				
Louisiana	0.21042	0.15337	0.01466	0.00264
Mississippi	0.32691	0.14744	0.01544	0.00334
Southern Plains:				
Oklahoma	0.46637	0.13884	0.00596	0.00248

(continued . . .)

Table 4. Continued

Region/State	α_1	Standard Deviation	α_0	Standard Deviation
Mountain:				
Arizona	0.88021	0.07524	0.00937	0.01653
Colorado	0.88023	0.08500	0.01446	0.01478
Montana	0.82381	0.09603	0.02205	0.01359
Nevada	0.75457	0.10247	0.03855	0.00886
New Mexico	0.74262	0.10087	0.01766	0.00862
Utah	0.85301	0.08231	0.04053	0.01199
Wyoming	0.87713	0.07765	0.03504	0.01786
Pacific:				
Oregon	0.70482	0.10823	0.04769	0.00505
Washington	0.55746	0.12789	0.01053	0.00429

Note: The index states for each region are: Northeast = Delaware, Lake States = Minnesota, Corn Belt = Iowa, Northern Plains = Nebraska, Appalachian = North Carolina, Southeast = Florida, Delta = Arkansas, Southern Plains = Texas, Mountain = Idaho, and Pacific = California.

In general, convergence occurs if α_1 is less than one, implying that the difference between the rates of return for the index and a particular state is declining over time. As indicated by the results reported in table 4, all the rates of return to agricultural assets converge over time within all regions except Appalachia. Within the Appalachian region, the data fail to reject $\alpha_1 = 1$ at the 95% confidence level for Kentucky, Tennessee, and Virginia. Overall, the results support at least conditional convergence for the rates of return on agricultural assets within all regions except Appalachia.

To test for unconditional convergence, the convergence between each of the 10 index states is examined. The data suggest using North Carolina to normalize the index states for each region. Again, the estimated autoregression coefficient for each region (shown in table 5) is less than one at any conventional level of statistical significance. It is therefore concluded that the rates of return on agricultural assets across regions are converging.

Table 6 shows results of estimates of trends using equation (7) for each region's total ROA and return from agricultural income pooled across the states in that region. In general, the regression results are consistent with the qualitative assessments of profit patterns presented in previous sections: convergence has occurred across the country. All 10 equations estimated for total ROA had βs that were significant at the 99% confidence level, meaning there is a relationship between the regional and U.S. average returns. In addition, nine of the ten equations have a "stable" relationship ($\gamma = 0$); only the Lake States' equation had a significant time trend. These findings provide strong, consistent support for the argument that convergence of total returns has occurred in U.S. agriculture since 1960. The 10 income rates of return equations provide mixed evidence of convergence, thereby supporting the hypothesis that the *source* of returns is important in determining the economic prospects for agriculture in a region, as noted below.

Sixteen of the 20 estimates in table 6 indicate a stable relationship between regional and national returns, as reported in the last column. The four estimates that do *not*

Table 5. Estimated Autoregression Coefficients Between Regions

Index State	α_1	Standard Deviation	α_0	Standard Deviation
Delaware	0.14355	0.15523	0.00137	0.00686
Minnesota	-0.02785	0.15611	-0.00004	0.00609
Iowa	0.12998	0.15541	-0.00164	0.00657
Nebraska	-0.33293	0.14674	0.00084	0.00402
Florida	-0.14876	0.15695	-0.00047	0.00499
Arkansas	0.19544	0.15309	0.00039	0.00778
Texas	0.26661	0.15199	-0.00427	0.00933
Idaho	0.12068	0.15599	-0.00370	0.00779
California	0.23690	0.15307	0.00169	0.00770

Note: North Carolina is used to normalize the index states for each region.

Table 6. Regional Rates of Return Convergence/Divergence Trend Results, 1960–2002

Region	Source[a]	$\beta_{i,t}$ Coefficient	t-Statistic	Trend Coefficient	t-Statistic	R^2	Trend Type[b]
Northeast	ROA total	-0.33***	-2.80	-0.02	-0.71	0.167	S
	Income	-0.31**	-2.67	-0.01	-0.59	0.155	S
Lake States	ROA total	-0.71***	-4.63	-0.05*	-1.70	0.355	M
	Income	-0.50***	-3.68	-0.06***	-3.01	0.258	D
Corn Belt	ROA total	-0.52***	-3.75	-0.03	-0.80	0.267	S
	Income	-0.82***	-5.25	-0.04***	-3.91	0.415	M
N. Plains	ROA total	-0.64***	-4.25	-0.01	-0.40	0.317	S
	Income	-0.60***	-3.93	0.01	0.86	0.287	S
Appalachian	ROA total	-0.88***	-5.58	0.02	0.77	0.444	S
	Income	-0.50***	-3.65	0.02	1.68	0.255	S
Southeast	ROA total	-0.65***	-4.33	0.05	1.44	0.325	S
	Income	-0.57***	-3.92	0.04***	2.91	0.283	D
Delta	ROA total	-0.62***	-4.22	-0.01	-0.42	0.315	S
	Income	-0.47***	-3.33	0.01	0.97	0.228	S
S. Plains	ROA total	-0.67***	-4.42	-0.01	-0.20	0.335	S
	Income	-0.66***	-4.37	0.01	1.40	0.336	S
Mountain	ROA total	-0.95***	-5.92	0.03	1.18	0.479	S
	Income	-0.80***	-4.82	0.002	0.21	0.378	S
Pacific	ROA total	-0.49***	-3.59	0.05	1.26	0.248	S
	Income	-0.39***	-3.04	0.02	1.17	0.193	S

Note: Single, double, and triple asterisks (*) denote statistical significance at the 90%, 95%, and 99% confidence levels, respectively.

[a] Source data are regional average total return on assets and return on assets from farm income.

[b] Trend types are defined as follows: S = stable ($\gamma = 0$), D = divergence, and M = mixed transition (converge then diverge).

indicate a stable relationship between regional and national average returns support the hypothesis that economic prospects for a region depend greatly on the profitability of the primary commodities produced there. Total ROA and returns from production income in the Lake States region, plus income returns for the Corn Belt region, all have a significant negative trend. Both of these regions depend heavily on grain production and have suffered as world grain markets have become more competitive (i.e., less profitable) over recent decades. In contrast, production income in the Southeast region has a positive trend over the 1960–2002 period—causing regional returns to diverge from the national average (i.e., rising further above the U.S. level), especially since 1973. This finding implies that the intensive livestock and specialty crops produced in the Southeast make it a much stronger agricultural sector, and consequently the Southeast region is more likely to remain in agriculture after the Lake and Corn Belt regions decline, ceteris paribus.

Probability of Loss Across Regions

The sensitivity of each region's agricultural sector to variance in returns is reported in table 7, showing the probability of loss for each region and the United States for different levels of total returns. Each column of the table shows the probability that average producers in the region would not meet some specified minimum total return, expressed as k in equation (8). For example, the first column (for $k = 0$) shows that average American agricultural producers have a 20.6% probability of earning returns that fall below the breakeven point (i.e., zero total returns). Each successive column reports the probability of average producers falling short of a higher return: 1% through 4%. As shown in the final column, although average American agricultural producers have a 47.6% probability of failing to earn a 4% total return, the probability ranges as high as 65.5% for the Northeast and as low as 22.4% for the Southeast.

The results in table 7 reveal that as opportunity costs increase, a significantly higher percentage of agricultural producers must consider diversifying outside of agriculture and, possibly, leaving the sector entirely, as implied in Proposition 2c. A risk-averse producer using a safety-first decision criterion is very unlikely to be satisfied with a 47.6% chance of failing to reach a 4% total return when nonagricultural investments are available.

Off-Farm Income Effects on Returns

The most common nonagricultural investment made by farmers and ranchers is to allocate some family labor to off-farm employment (USDA/ERS, 2001). The opportunity to make such a labor investment increases as the nonagricultural sector of the economy grows. The relative availability of off-farm income in each state is proxied in table 8 using two data series. The second column shows the percentage of gross state product contributed by the farm sector of the state listed in the first column. The third column converts that percentage into the location quotient (LQ), with 1.0 equaling the average farm share for the entire country (i.e., 0.79%). In South Dakota, for example, the LQ indicates the agricultural sector represents 8.5 times as much of the state output as represented by the national agricultural sector. This, in turn, suggests that opportunities for off-farm income are much less common in South Dakota than they are across the country, on average.

Table 7. Regional Average Probability of Loss, 1960–2002

Region	Probability of Loss with k = 0%	1%	2%	3%	4%
	<-------------------		(Percent)		------------------->
Northeast	24.2	33.7	44.0	55.2	65.5
Lake States	26.4	31.9	37.8	44.0	50.4
Corn Belt	29.8	34.1	39.0	44.0	49.2
Northern Plains	23.3	28.1	33.4	39.4	45.2
Appalachian	18.9	25.5	33.0	40.9	49.6
Southeast	4.8	7.6	11.3	16.1	22.4
Delta	24.2	29.1	34.5	40.5	46.4
Southern Plains	30.1	37.4	45.2	53.6	61.4
Mountain	23.9	29.8	36.3	43.3	50.8
Pacific	9.8	13.8	18.7	24.8	31.6
UNITED STATES	**20.6**	**26.4**	**33.0**	**40.1**	**47.6**

Note: These Probability of Loss values were calculated using average Total Return on Assets.

Table 8. Farm Share of Gross State Product, 2000

State	Farm % of Gross Product	Location Quotient	State	Farm % of Gross Product	Location Quotient
UNITED STATES	**0.79**	**1.00**	Missouri	0.91	1.15
			Montana	2.91	3.66
Alabama	1.23	1.55	Nebraska	3.77	4.74
Alaska	0.09	0.11	Nevada	0.26	0.32
Arizona	0.69	0.87	New Hampshire	0.17	0.22
Arkansas	2.57	3.23	New Jersey	0.13	0.17
California	0.99	1.24	New Mexico	1.40	1.76
Colorado	0.73	0.92	New York	0.18	0.23
Connecticut	0.20	0.25	North Carolina	1.20	1.51
Delaware	0.52	0.65	North Dakota	4.48	5.64
Florida	0.88	1.11	Ohio	0.50	0.62
Georgia	0.81	1.02	Oklahoma	1.85	2.32
Hawaii	0.70	0.88	Oregon	1.40	1.76
Idaho	3.88	4.88	Pennsylvania	0.50	0.62
Illinois	0.45	0.57	Rhode Island	0.09	0.11
Indiana	0.73	0.92	South Carolina	0.64	0.81
Iowa	3.45	4.35	South Dakota	6.76	8.50
Kansas	1.96	2.47	Tennessee	0.55	0.69
Kentucky	1.68	2.11	Texas	0.77	0.97
Louisiana	0.46	0.58	Utah	0.66	0.83
Maine	0.65	0.81	Vermont	1.41	1.78
Maryland	0.32	0.41	Virginia	0.41	0.52
Massachusetts	0.08	0.11	Washington	1.11	1.40
Michigan	0.43	0.54	West Virginia	0.35	0.45
Minnesota	1.33	1.67	Wisconsin	1.10	1.38
Mississippi	1.65	2.08	Wyoming	1.76	2.22

Source: U.S. Department of Commerce, Bureau of Economic Analysis.

At least two implications of the *LQ* results above can be tested. First, *LQ* scores and returns from current income are expected to be positively correlated (Proposition 3a). This is due to the need for agricultural income to be higher in a state with relatively fewer opportunities for off-farm income (i.e., a higher *LQ*) compared to a state with more plentiful off-farm opportunities. Second, it is expected that *LQ* scores and returns from capital gains will be negatively correlated, as stated in Proposition 3b. This is due to the effects of a state's nonfarm sector on agricultural asset values. In a state where the nonfarm sector is relatively large (i.e., a lower *LQ*), there is more demand for agricultural land and other assets to be converted to nonfarm uses; thus asset prices are expected to increase faster than in states with relatively larger agricultural sectors.

Both of these propositions are supported by the data. Simple correlations between the 50 states' *LQ* values in table 8 and the ROA_π and ROA_k values in table 2 are 0.36 and -0.14, respectively. It also follows that the correlation between *LQ* values and total *ROA* is 0.24, indicating higher total returns are required as off-farm income decreases, as stated in Propositions 2a and 2b.[8]

These results are consistent with the type of substitution between sources of returns that is necessary if producers are using a safety-first criterion with a minimum return level for decision making. Such a minimum return can be composed of returns from three sources: current income from agriculture, capital gains on agricultural assets, and off-farm income. When returns from one source are insufficient to meet the minimum return level required for a person to stay in agriculture, returns from another source must be sought to make total returns reach the minimum. As noted often in the literature (e.g., USDA/ERS, 2001), off-farm income is sought by most agricultural producers because it is a relatively low-risk source of liquid returns. When off-farm income sources are not available to an individual, increased ROA_π must be sought because individuals have little control over the ROA_k available to them and ROA_k is not a liquid cash flow. Thus, in areas with relatively few off-farm opportunities, agricultural producers must pursue higher ROA_π by producing a portfolio of enterprises that are more profitable and risky (this is an expansion of Propositions 2a and 2b). A person unwilling to take on the higher production risk exposure necessary to achieve the minimum return level over the long run is forced to either leave agriculture or voluntarily accept operating losses like a "hobby farmer."

The results supporting Propositions 2a, 2b, 3a, and 3b have ironic implications for American agriculture's development across the country: farms and ranches are more likely to disappear from areas in which agriculture is a relatively more important part of the economy. In areas where agriculture is a relatively small part of the economy, returns from off-farm income and capital gains on agricultural assets are more available, on average, thereby making it more likely that they can adequately substitute for ROA_π in meeting a producer's financial needs. This is the most likely explanation for the Northeast region's agricultural sector's convergence to a level below the national average for total returns over the 1960–2002 period. On the other hand, in areas where agriculture is a relatively large part of the economy, such as the Northern Plains (with

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[8] The correlations between *LQ* and ROA_π and total *ROA* are statistically significant at the 99% and 90% confidence levels, respectively. The correlation between *LQ* and ROA_k was not significant using only the data for 2000 reported in table 8. Thus, further research with expanded data may be needed to resolve questions about whether the size of an area's agricultural sector influences farmers' returns from capital gains. It may be that the very small portion of a state's economy represented by agriculture causes capital markets to ignore that sector.

state location quotients of 2.47 to 8.50), total returns converged on the national average because returns from current income rose sufficiently to substitute for the weak capital gains and relatively scarce off-farm income. The average ROA_{π} levels reported in table 2 for the Northern Plains were likely achieved, in great part, through attrition. Specifically, less profitable farms and ranches left agriculture over time, as expected in areas with relatively few opportunities for off-farm income.

Concluding Comments

All the propositions presented in this paper are consistent with empirical data observed in American agriculture, as summarized in exhibit 1. In general, the results show temporal and spatial trends toward convergence of returns that are consistent with trade and development theories, but there are constraints unique to state/regional agriculture. Results are summarized here for each of the three general propositions.

Convergence

Most regions converged to the national average for total returns over the 1960–2002 period. Nonfarm sector influences probably kept the Northeast from converging and likely will continue to do so. Conversely, in sparsely populated states with fewer off-farm income opportunities, such as the Northern Plains, convergence of returns did occur, most likely because agricultural factor markets adjusted to declining farm numbers.

Agricultural income is generally higher in regions and states that are able to produce significant amounts of fruit and vegetable crops plus intensive livestock enterprises. Returns are generally lower in areas dominated by livestock grazing, rather than intensive crop and livestock production. This finding supports Schott's (2003) contention that geographic areas with different factor endowments must expect that "price-wage arbitrage may be reduced, or broken, depending on the substitutability of goods" (p. 705) when regions do not produce an identical set of goods. This suggests convergence of returns is more likely within regions producing similar commodities than across regions specializing in different commodities. Thus, in American agriculture, what Gutierrez (2000) calls "absolute convergence" is a regional, not a national, phenomenon for total returns.

Minimum Return to Remain in Agriculture

Although a "minimum total return" level necessary for continued participation in agriculture appears to be revealed in the data presented here (i.e., an ROA of 3.9%–4.8%), no such minimum profit-per-farm amount can be detected. Only two states (Arizona and Delaware) had average net farm incomes per operation that were higher than the 2001 U.S. average household income of $58,208. State average farm incomes per operation for 2001 had totals ranging down to West Virginia's $2,327, with a national average of $21,198. Because this amount is below the poverty line for a family of four, it is not likely to be considered adequate as a financial goal by most farmers. This affirms the importance of off-farm income to producers and suggests that the necessary "minimum farm income" level is some function of off-farm income. In other words, the minimum level of returns can generate the minimum amount of *profit* required to support a family only if the farm is sufficiently large.

Exhibit 1. Summary of Empirical Results

Propositions	Samples of Supporting Data
Proposition 1. Convergence in returns to American agricultural producers occurs over time and space.	▪ Six of 10 regions have total ROA near the national average, and 16 of 20 regressions for 1960–2002 indicate a stable relationship between U.S. and regional returns. ▪ ROA_π within many regions have patterns over time. ▪ An inverse relationship between ROA_π and ROA_k is observed at the regional level across decades.
Proposition 2. There is a minimum return and/or profit-per-farm level needed to remain in agriculture, and it will be apparent if the data converge to a stable trend over time.	▪ Six of 10 regions have total ROA of 3.9% to 4.8%.
Proposition 2a. If no off-farm income sources are available, the minimum return to production must be at least 0% and greater than zero if producers face opportunity costs to stay in agriculture.	▪ On-farm and off-farm income are substitutes, as indicated by $r = 0.24$ for location quotient (LQ) scores and total ROA.
Proposition 2b. If off-farm income sources are available, the minimum return to production can be less than 0%, depending on a farmer's willingness and ability to personally subsidize the farm.	▪ The Northeast region has the highest availability of off-farm income and the lowest average ROA_π (negative for 4 states).
Proposition 2c. The minimum return needed to remain in agriculture influences the "probability of lost farms" in a state/region.	▪ The U.S. probability of loss (PL) goes from 21% to 48% as the minimum ROA goes from 0% to 4%.
Proposition 3. The sources of income/returns are important in determining the economic prospects of agriculture in a state/region over time.	▪ $ROA_\pi > ROA_k$ for strong states, western weak states. ▪ There are some ROA patterns across sources in regions. ▪ $\sigma_k > \sigma_\pi$
Proposition 3a. The farm share of a state's gross state product and that state's farmers' returns from current production income will be positively correlated.	▪ $r = 0.36$
Proposition 3b. The farm share of a state's gross state product and that state's farmers' returns from capital gains will be negatively correlated.	▪ $r = -0.14$

Importance of Sources of Returns

The share of a state's output generated by the agricultural sector is positively correlated with returns from current agricultural income, and negatively correlated with returns from capital gains, on average. These results have an ironic implication for American agriculture's development across the country: farms and ranches are more likely to disappear in areas in which agriculture is a relatively more important part of the economy. In areas where agriculture is a relatively small part of the economy, returns from off-farm income and capital gains on agricultural assets are more available, on average—making it more likely they can adequately substitute for ROA_π in meeting a producer's financial needs.

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