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Where Is American Agriculture in Its "Life Cycle"?

Steven C. Blank

The increasing globalization of agricultural markets in recent decades appears to be changing the economics of the American production agriculture sector, reducing its economic importance and raising questions about its life cycle. This study contributes to the product life cycle literature by creating tests of hypotheses about the economic life of American production agriculture. A methodology to test the hypotheses is proposed and then applied in an empirical analysis. In general, it appears that a new stage in American agriculture's life began during the 1973–1983 period. Finally, the results and their implications for the American production agriculture sector are discussed.

Key words: absolute advantage, comparative advantage, global markets, life cycle model

Introduction

Agriculture was the dominant industry in the nation for much of America's history (Cochrane). It caused mass migrations and large-scale investments that created and supported the economies of entire regions. It may now be at its productive prime. But it is slowly shrinking in size and importance due to numerous economic developments over the past century (Anderson; Antle; Blank 2001a; Johnson). Farms and ranches in this country currently number less than one-third of the 1935 peak of 6.8 million. About one-quarter of the land in agriculture in 1954 has now left the industry [U.S. Department of Agriculture (USDA) 1999]. Ghost towns are beginning to appear in parts of the Midwest where agriculture was the economic mainstay (Goetz and Debertin). These dramatic structural shifts are typical of those expected as an agricultural sector develops over time (Mundlak). There are recognized patterns in life, whether the subject is people, products, or industries. Life cycle models identify and describe those patterns, not explain them; yet knowing which stage of the life cycle is being observed provides insight into expected behavior and events as the patterns unfold. Therefore, identifying where production agriculture is in its economic life could help both business and policy decision makers anticipate important structural changes in the industry.

Much literature indicates changes over a life span seem to follow a similar pattern. That general pattern includes a series of time periods over which the total sales and profits of an economic unit first increase, peak, and then decline. Klepper found there are explainable regularities in the evolutionary pattern of industry development. He expanded the extensive life cycle literature by showing how technical innovation, productivity, cost, profitability, and other factors affect an industry's life cycle.

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Industries can change dramatically. Obviously, the pace of changes for an industry is much slower than the pace of changes observed at the firm or individual product levels, but the pattern of changes appears to be similar (Agarwal; Klepper; Jovanovic and MacDonald). Also, some industries have changed faster than others. As the scale of aggregation increases, from product line to firm to industry, the average life span also increases. However, entire industries have reached the end of their life spans and disappeared (Chi and Liu; Dunne, Roberts, and Samuelson; Jovanovic). Although American agriculture can be viewed as a collection of regional industries, the fact that virtually all of those industries are suffering economic hardships (USDA 2001) makes it appropriate to discuss the problem in aggregate, national terms.

Therefore, this analysis contributes to the literature by presenting a modification of the standard "product life cycle" model (Lilien and Kotler, pp. 608–13) designed to create a test of general hypotheses identifying where American production agriculture is in its life cycle. The contributions include both a first empirical application of the life cycle model (LCM) to an industry whose output is undifferentiated commodities, and a theoretical justification for using the LCM with a national commodity-based industry.

The Life Cycle Model and Industry Analysis

The life cycle model offers a description of the relationship between an economic unit and its market as reflected in sales and profit patterns over time. Although the model was developed originally to look at specific products or product lines, it has been extended to firms and to industries because those larger economic units also follow a growth and decline process based in the results of sequential decisions (Agarwal; Bolle).

The success of those decisions in satisfying market demand, relative to the decisions of competitors, influences the competitive position of the product, firm, or industry at each point in time (Anderson and Zeithaml; Rink, Roden, and Fox; Shankar, Carpenter, and Krishnamurthi). However, each group of decision makers has some constraints upon their ability to completely satisfy demand. Some constraints include the attributes of the product or service being sold, the selling price, the cost of production, the volume of output per time period, the storage and distribution system available, and many others (Agarwal; Dunne, Roberts, and Samuelson). The net effects of those constrained decisions create a unique life cycle for a firm or industry.

In essence, the LCM shows the effects of the economic unit's comparative and absolute advantages and how they change over time. A theoretical explanation of how these advantages change when an industry faces international competition is presented after the LCM is introduced.

Sales, Profits, and the Life Cycle Model

The standard LCM is shown in figure 1. The model is based on the idea that there are four distinct stages of the life cycle, and these successive stages are each characterized by different patterns in sales and profit performance. The sales and profit patterns are considered to be economic signals indicating the degree of success the unit is having in both satisfying market demand and coping with market competitors (Anderson and Zeithaml), which, for American agriculture, are foreign agricultural industries.

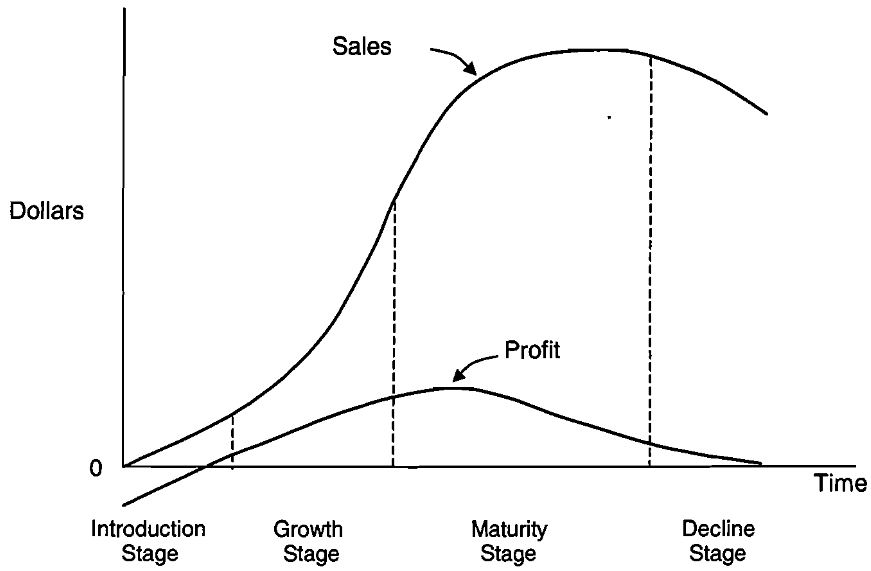


Figure 1. The LCM product life cycle

As shown in figure 1, the life cycle begins when the first sale is made. For an industry, this occurs when the first firm to sell a new type of product introduces it into the market—hence the name "*introduction*" for the first stage of the life cycle. For the American production agriculture industry, the life cycle began shortly after people arrived on the continent. The *introduction stage* is characterized by a slow increase in sales over time, and profit levels that are negative initially, but less so over time. The *introduction stage* ends sometime soon after profits become positive.

The *growth stage* is characterized by sales increasing at an increasing rate over time, and profit levels that increase in absolute amounts over time. While total profits increase during this stage, profit margins may increase at first, but are expected to decrease later in the stage. For an industry, sales growth comes from both new firms entering the industry and existing firms expanding their output (Shankar, Carpenter, and Krishnamurthi). The *growth stage* ends when both sales and profits slow in their rate of increase over time. For American agriculture, there was a long growth period as settlers moved west from the Atlantic and expanded the number of farms and amount of land in production.

The *maturity stage* is characterized by turning points in both profits and sales volumes, with profits leading sales revenues. Sometime early in this stage, profit totals per unit of time peak and begin declining because of competition between firms and from other industries. Late in the stage, total sales volume per time period peaks and slowly begins to decrease due to competition from other industries and market saturation, which occurs when changes in the industry's demand and supply curves cause marginal revenues to be zero. Between the two peaks, profit margins are clearly decreasing rapidly. American agriculture probably entered its *maturity stage* sometime during the 1900s as the country completed its westward expansion.

The *decline stage* is the final segment of the life cycle. It begins sometime soon after total sales per time period begin decreasing. The sales decrease is usually a result of a decrease in demand brought on by the introduction of an alternative product which is considered "better," or by competitors' ability to provide a similar product at a lower price. Total sales and profits both decrease during the *decline stage* although, on average, profits remain positive. The life cycle ends when sales end, usually when remaining firms become suppliers for a different market. Exit decisions are triggered by the availability of better profit margins offered by alternative investments; consequently, firms usually leave before profits fall to zero. For an industry, total sales are the sum from all firms within the industry. Therefore, many individual exit decisions must be made before the industry disappears. Thus, industries can decline over a lengthy period of time. For American agriculture, the question is whether or not it has reached its *decline stage*.

An Economic Explanation of Industry Changes

American production agriculture's size, importance, and profitability are declining because it is feeling the effects of two types of ongoing changes: changes in its comparative advantage over the long run, and changes in its absolute advantage over recent decades. The general effects of these changes are illustrated in figure 2.

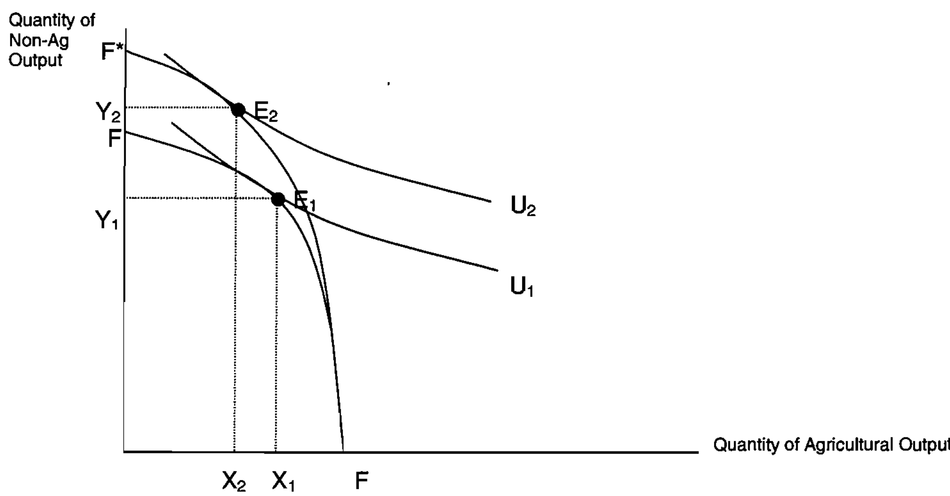
Changes in comparative advantage occur as technological advances create new industries or substantially change existing industries within a region or country (Acs and Audretsch; Dasgupta and Stiglitz; Shaked and Sutton). When those advances result in changes in the relative profitability between industries, they can reduce the attractiveness of investments in existing industries, such as agriculture, causing resources to be shifted out.

For example, panel A of figure 2 shows how changes in comparative advantage due to technological advances in the non-agricultural sector of the American economy make declines in the agricultural sector possible. As observed in panel A, the production possibility frontier, *FF*, shifts upward to *FF** when technical advances lower the marginal costs of production in the non-agricultural sector. In this two-sector model, the result is that the equilibrium output shifts from point E_1 to E_2, which is on a higher indifference curve, and thus America is better off. At that new equilibrium point, non-agricultural output increases from Y_1 to Y_2. Agricultural output is expected to decline from X_1 to X_2 because (as Johnson, Anderson, and others have shown) even if a country retains a strong comparative advantage in agriculture, the industry's terms of trade relative to manufacturing and other non-agricultural industries will decline with economic growth. This is true even if factor productivity growth is biased to agriculture because income-inelastic demand for agricultural output ensures that agriculture's terms of trade will still decline over time (Anderson).

Changes in absolute advantage affect the degree of competition an industry faces. International competition and absolute advantage are now relevant to some industries in which comparative advantage exists, like American agriculture, because a regional comparative advantage in the production of some commodity is insufficient to overcome the industry's absolute disadvantage in a global market.

A global market now exists for a growing number of agricultural commodities due to technological advances in production, storage, and transportation. Technology expanded production output, making it possible to saturate local markets (discussed later in this section). As a result, producers were forced to look to more geographically distant consumers to purchase the surplus output. Technological improvements to storage methods

Panel A. Technology changes comparative advantage



Panel B. Technology changes absolute advantage

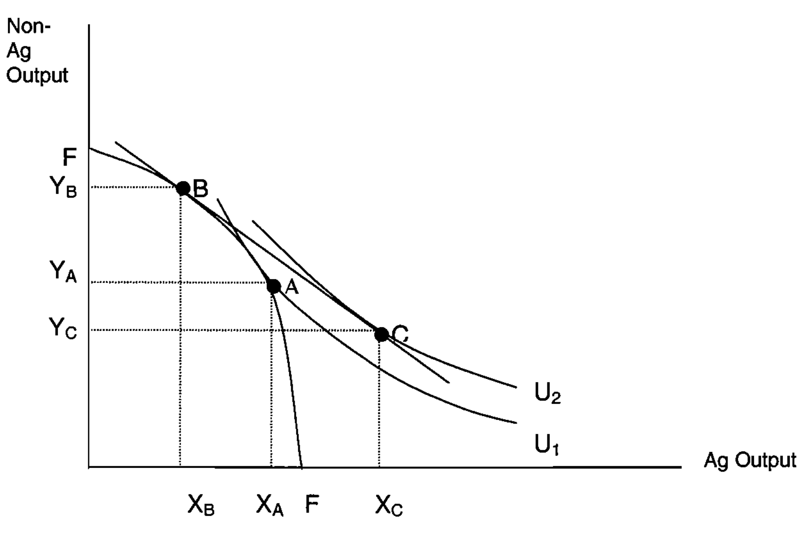


Figure 2. Effects of changes in comparative and absolute advantages

enabled commodities—even the most perishable—to be kept in marketable condition longer which, when combined with technological improvements to transportation systems, enabled suppliers to cover more distance and reach new markets. It is now routine for perishable agricultural commodities to be traded from one continent to another. This means every producer of a commodity is in direct or indirect competition with all other producers of that commodity who sell during the same season, wherever those producers might be located. This competitive market structure is a symptom of the undifferentiated nature of agricultural commodities.

Panel B of figure 2 illustrates how being a part of a global market affects the terms of trade between America's agricultural and non-agricultural sectors. To begin, assume no international trade of agricultural commodities occurs because it is not technically possible to deliver marketable products to foreign locations. Each country has available to it only the agricultural commodities it can produce. In that situation, the American economy operates at point A on the production possibility frontier, FF. At that point, the domestic price ratio is $-P_x/P_y$, agricultural output is X_A, and non-agricultural output is Y_A. Then, assume a technological advance in product shipping makes it possible to deliver commodities to foreign markets. No trade will occur if agricultural prices in America (P_x) and the rest of the world (P_{xw}) differ by no more than per unit shipping costs, s. However, if another technical advance in production, storage, or transportation occurs outside of America such that $P_x - s > P_{xw}$, international trade will occur (if trade barriers do not prevent it) and the terms of trade between the American agricultural and non-agricultural sectors will change.

In panel B, the lower foreign price would shift the inverse price ratio in America to $-P_{x*}/P_{y*}$, which is the slope of the line BC. America would move to a new equilibrium in which it produced combination B and consumed combination C. Combination B involves America reducing its agricultural output from X_A to X_B and increasing its non-agricultural output from Y_A to Y_B. America would export $Y_B - Y_C$ to pay for its imports of $X_C - X_B$.

In summary, panel B shows that technological advances in production which reduce commodity prices in other agricultural industries, such as those of less-developed countries, reduce America's absolute advantage in global commodity markets and reduce the terms of trade between our agricultural and non-agricultural sectors. The same result is also caused by technical advances which reduce shipping costs, s. Both of these results cause resources to be shifted out of American agriculture.

Technological advances in American agriculture counteract the effects of technical advances overseas by reducing costs per unit, thus improving American agriculture's terms of trade and absolute advantage. Unfortunately, improvements in production have come with a downside for producers over the last several decades. "Agriculture in the twentieth century was characterized ... by technological innovation that ... made it possible for agricultural production to grow faster than the demand for food despite a rapidly growing world population. The result was a decline in real agricultural commodity prices throughout this era..." (Antle, p. 993). The "technological treadmill" of continual productivity improvement expands global supplies, pushing commodity prices lower when productivity outpaces demand for food (Johnson and Quance). American agriculture has suffered from this treadmill for a century (Schultz).

The combined effects of globalization of agricultural markets and the competitive structure of local markets facing individual producers have turned the "treadmill" to a critical point for American agriculture. The problem begins with the different demand curves facing producers versus the industry. For a producer in a perfectly competitive market for an undifferentiated commodity, the demand curve is flat. This creates a marginal revenue curve that is also flat. Marginal revenue (*MR*) is defined as:

$$MR = \frac{dR}{dQ} = \frac{d(PQ)}{dQ} = P + Q\left(\frac{dP}{dQ}\right). \tag{1}$$

As can be seen in equation (1), a flat demand curve has marginal revenues at all price levels of $MR = P$. For a producer, if *MR* exceeds marginal costs, the producer will expand output. Also, there is an incentive for each producer to adapt any technological advance that reduces marginal costs because it enables profits to be increased by expanding output. Thus, a flat demand curve encourages each producer to push his or her supply curve as far to the right as possible.

Unfortunately, the demand curve facing the entire American production agriculture industry is downward sloping to the right—meaning both real prices and marginal revenues will decrease with increased market supplies, which has happened for a century. Nominal prices have also fallen in recent decades, as indicated by the USDA's index of prices received by all U.S. farmers. These trends suggest the industry may have saturated its market. The saturation point is where $MR = 0$. When $MR < 0$, sales revenues decrease with expanded output. Therefore, the addition of new foreign supplies to the global market, plus productivity improvements around the globe, may have created a new equilibrium where the demand curve facing American producers offers negative marginal revenues for many commodities.

Clearly, based on the discussion above, a key issue in a global competitive market is the *relative* rates of productivity increases between competitors. Duffy (pp. 344–45) points out that "while the U.S. has out-paced the average of the other industrialized countries in increasing its production, the greatest gains have occurred in the developing nations." She reports Laspeyres indices of productivity for the 1961–2000 period of 2.0 for America, 1.6 for other developed countries, and 3.5 for less-developed countries. Thus, unit costs have dropped faster in newly competitive nations, enabling them to remain profitable despite falling world prices. America is losing the absolute advantage battle created by the advent of global commodity markets.

According to the Heckscher-Ohlin theory of international trade, when a country does not have an absolute advantage in the global market for a product in which it has a comparative advantage, it is forced to compete on the basis of lower factor prices or by adjusting its currency exchange rates (Harrigan; Peterson and Valluru). In America, however, falling agricultural factor prices create incentives to shift resources out of agriculture and into alternative investments. When land, capital, and other factor prices are pushed down by declining agricultural profitability, as they have been in the northern and southern plains over the past two decades (USDA 2000a, b), non-agricultural uses of those factors become more attractive. Thus, agricultural output will decline most quickly in regions where there are the most alternative uses of input factors. In regions with few alternatives, like the grain-producing regions of the Midwest (Weimar and Hallam), agricultural production will continue as long as it offers any profits, but global markets affect the life span.

A Formal Model of Agriculture's Life Cycle

A simple model of the agricultural industry and of individual firms within it is presented in this section to provide economic insights into the circumstances which create the patterns in sales and profits described in the LCM. Some of those insights are presented here as definitions and propositions, the two different types of conditions making up the LCM of production agriculture. Definitions are derived directly from the literature as the conditions that demarcate specified parts of the cycle. Thus, the definitions presented here are not refutable hypotheses, but necessary conditions against which relevant data are compared when attempting to identify the life cycle stage. Propositions are refutable hypotheses, presented and tested to provide deeper insights into the structural changes expected as agriculture progresses through its life cycle.

For this analysis of American production agriculture, total sales revenues (R) and profits (Π) are defined below. Only revenues from farmers' and ranchers' sales of production output are considered; government transfers and other income sources are excluded. Therefore, the industry's revenue from all agricultural commodities ($i = 1, 2, ..., n$) at time t is given as:

$$(2) \qquad R_t = \sum_{i=1}^{n} P_{it} Q_{it},$$

and the industry's profit from all agricultural commodities at time t is

$$(3) \qquad \Pi_t = R_t - C_t - K_t,$$

where

$$Q_{it} = Y_{it} A_{it},$$
$$C_t = \Sigma_i \Sigma_j c_{jt} x_{ijt},$$
$$K_t = \Sigma_i \Sigma_h k_{ht} z_{iht},$$

and $P_i, c_j, k_h > 0$; $Y_i, A_i, x_j, z_h \geq 0$. The number of commodities produced by the industry is denoted by n; P_{it} is the average unit price of commodity i at time t; Q_{it} is the quantity of commodity i produced at time t; Y_{it} is the average yield per acre of commodity i; A_i is the total acreage devoted to commodity i; C_t is the total production costs of all commodities at time t; c_j is unit costs of j variable inputs; x_{ij} is quantities of j variable inputs to be applied in the production of commodity i; K_t is the total ownership costs of all commodities at time t; k_h is unit costs of h capital inputs (land, improvements, equipment, etc.); and z_{ih} is quantities of h capital inputs used in the production of commodity i.

Industry sales and profit totals are simply the sum of results from decisions made by the individual firms constituting the industry. In American agriculture, individuals make production decisions based on the goal of maximizing expected profits. This study follows Klepper in recognizing that results are influenced by both the innovation expertise and capital available within an industry. Thus, expected profit for firm f at time t is specified as:

$$(4) \qquad E(\pi_{ft}) = E\left[R_{ft} - C_{ft} - K_{ft} + (m_f)g(cr_{ft})G - \Delta(cr_{ft})\right],$$

where R, C, and K are as defined above, but are for firm f only. $E(\cdot)$ is the expected value of $(\cdot)$; m_f denotes the innovation expertise of firm f and $m_{\max}$ is the maximum possible innovation expertise (i.e., $m_f = m_{\max}$ for the most innovative firm). The distribution of m_f is denoted $W(m)$, and is assumed to be continuous for all $m < m_{\max}$ and $W(m_{\max}) = 1$ by definition; m_f influences the firm's success at improving productivity. The probability of firm f improving its productivity in period t is $(m_f)g(cr_{ft})$, where cr_{ft} is defined as the firm's cumulative investment in human capital and productive resources through time t, and the function $g(cr_{ft})$ reflects the opportunities for improving productivity. The term cr_{ft} is some function of profits earned in all prior periods. G is the potential increase in profits earned by an innovation that improves productivity. This can result from either reduced input costs per unit (C/Q and/or K/Q) or increased revenue from a higher yield (Y). G is defined to equal $(R_{ft} - C_{ft} - K_{ft}) - (R^*_{ft} - C^*_{ft} - K^*_{ft})$, where the asterisk indicates a value which would have existed for firm f in period t without the innovation. The change in cumulative investment during period t is represented by $\Delta(cr_{ft})$; thus it equals $cr_{ft} - cr_{ft-1}$, and is constrained to be ≥ 0.

A firm's expected sales revenues are expressed as:

$$(5) \qquad E(R_{ft}) = R_{ft-1} + E\Big[(m_f)g(cr_{ft})G + \Delta(cr_{ft})\Big].$$

Current revenues are expected to equal the previous year's revenues plus expected improvements from a productivity component $[(m_f)g(cr_{ft})G]$ and an investment component $[\Delta(cr_{ft})]$.

In production agriculture, all firms producing undifferentiated commodities are price takers; thus all firms are assumed to receive the same average price for a commodity during a period. It is also assumed that the industry clears Q_t at the market price each period. This study goes beyond previous LCM applications (such as Klepper's) by using an open-economy approach. Therefore, the market-clearing price and quantity are influenced by global market conditions.

Several implications can be drawn from the model in equations (2)–(5). First, total agricultural industry sales are the sum of sales from all firms in the industry, and thus they depend on uncontrollable factors at the farm level. A firm's sales revenue depends on the commodities being produced, market prices, productivity, and firm scale, plus the uncontrollable level of opportunities to improve productivity through innovation, $g(cr_{ft})$. Opportunities will vary across agricultural products, and the ability to capitalize on opportunities will vary with m_f across firms within each product market. Therefore, innovation will cause profits to vary across firms, ceteris paribus. This means there are varying levels of incentive for firms to invest in human capital and productive resources, cr_{ft}. These factors are expected to influence the industry's life cycle because of the circular problem that profit risks influence which commodities are produced (Blank 2001b).

At the beginning of the *introduction stage* of the LCM, there is great uncertainty. Before production begins and the first sale is made, demand is latent, meaning in graphical terms that the supply curve must be above the demand curve at all quantities, so they do not intersect. The first firm must rely on technical and managerial innovation to reduce costs, thereby lowering the supply curve. It can also attempt to raise the demand curve by promoting its future product to potential consumers. In either case, only when the two curves intersect will a sale occur and long-run production be established. However, in the short run, the first producer will suffer negative profits because (marginal) operating costs, C, are being covered, but not (average) total costs, $C + K$. During the *introduction stage* of the LCM, the first firm (and all subsequent entrants) is willing to risk short-run losses because profits are expected in the long run. Thus, firms in the industry expect demand to increase and per unit costs to decrease over time. These insights lead to the following definition and proposition.

- DEFINITION 1. *At the beginning of the "introduction stage" of the LCM, industry sales are zero and profits are negative.*

- PROPOSITION 1. *During the "introduction stage" of the LCM, firms enter the industry based on expected profits.*

At the beginning of the *growth stage* of the LCM, there is great potential. Profits are being earned and expectations are for improvement. This spurs growth in many factors, as noted in the next four points.

- DEFINITION 2. *During the "growth stage" of the LCM, total industry sales and total industry profits increase.*

- PROPOSITION 2. *During the "growth stage" of the LCM, agricultural commodity prices increase in most cases.*

In a competitive market, commodity prices will rise if demand increases faster than supply. Graphically, this means the demand curve is moving to the right faster than is the supply curve. This condition is expected early in the life cycle of a successful industry because of the constraints slowing output expansion. To begin, in an infant industry, there are relatively few firms contributing to industry supply. To increase output, those firms need to acquire more resources, but they have not yet accumulated much profit, and access to agricultural loans is a function of profitability (Thompson and Blank). Demand, however, can grow as quickly as additional consumers become aware of the product.

While unlikely, it is possible for commodity prices to decrease during the *growth stage*. For this to occur, technological advances would be required to decrease costs per unit faster than prices are declining. Without the expectation of such an expanding profit margin, commodity producers would not be willing or able to expand output at this stage of the LCM.

Two effects of rising prices on existing firms are (*a*) the profit margin on each unit sold increases, thus causing total sales revenues and total profits to increase for current sales quantities, and (*b*) the number of units that can be produced and sold at a profit increases, thus increasing total sales and profits further. This means existing firms move to a new equilibrium point farther to the right on their supply curves.

- PROPOSITION 3. *During the "growth stage" of the LCM, the number of firms in the industry increases.*

Rising prices make it profitable for new firms to enter the industry. As long as demand is expanding faster than supply, prices will increase. An upward price trend raises expectations for the future, thus encouraging firms for which $P > MC$ (marginal cost) to consider entering the market based on a forecast that $P > AC$ (average cost) in the long run.

■ PROPOSITION 4. *During the "growth stage" of the LCM, firms in the industry increase their levels of investment.*

Rising profits and opportunities for innovation encourage increased investment by firms in the industry. A firm with increasing profits is financially able to increase its investment, cr_{ft}, and if opportunities for innovation are growing $[g(cr_{ft+1}) > g(cr_{ft})]$, expected profits rise with higher cr_{ft}.

The *maturity stage* of the LCM is characterized by changes brought on by the reversal of several trends. Insights into these changes are offered in the following definition and five propositions.

■ DEFINITION 3. *During the "maturity stage" of the LCM, total industry profits peak and then begin decreasing before total industry sales do.*

■ PROPOSITION 5. *During the "maturity stage" of the LCM, average commodity prices peak before total industry profits and total industry sales do, and then decrease.*

In a competitive market, commodity prices will fall if supply increases faster than demand. Graphically, this means the supply curve is moving to the right faster than is the demand curve. This condition is expected during the *maturity stage* because the constraints slowing output expansion previously are eliminated. At this point, many firms are contributing to industry supply, and profits earned earlier enable them to acquire additional resources as needed.

The combined pressure of falling prices and rising costs continues to reduce profit margins until total profits peak and then fall, despite increasing numbers of units being sold. Therefore, falling prices cause proportionately larger decreases in profit margins in this stage.

During this stage, the supply curve is expected to eventually move far enough right that its intersection with the demand curve shifts from the elastic portion to the inelastic portion of demand. Consequently, the increasing unit sales made possible by supply innovations will cause total sales revenues to increase at first, peak, and then decrease as marginal revenues shift from being positive to negative.

■ PROPOSITION 6. *During the "maturity stage" of the LCM, firms entering (exiting) the industry are those more (less) able to innovate, ceteris paribus.*

As profit margins on unit sales decrease, it affects which firms (and industries) can compete profitably. As shown in equation (4), firms (and industries) with higher values for m_f will have higher profit margins than other firms, ceteris paribus. Thus, firms with highly skilled managers will be able to capture more of the potential profits from innovations which are causing total supplies to increase, and therefore be able to enter the industry first and exit last because of their higher productivity.

If trade is allowed, foreign firms can enter the industry by selling products in domestic markets. Entering foreign firms may have lower costs, C and K, because they are buying resources from different input markets. Foreign firms may also have more opportunities for innovation, $g(cr_{ft})$, because they may lag behind the American industry in adopting new technologies (Mundlak), thus having unused opportunities still available to them at a time when American producers have no new opportunities. These factors, plus the fact that all firms receive the same global price, make foreign firms potentially more profitable than domestic firms.

- PROPOSITION 7. *During the "maturity stage" of the LCM, the average size of firms in the industry increases.*

As shown by equation (4), profits are expected to be higher for firms with larger cumulative investments in human capital and productive resources, cr_{ft}, giving an incentive for firms to grow larger in scale. The higher profits from economies of scale will, over time, enable larger firms to purchase their smaller, less-profitable competitors. As this consolidation continues, average firm size must eventually increase.

- PROPOSITION 8. *During the "maturity stage" of the LCM, the number of firms in the industry may initially rise or fall, but by the end of the stage, total firm numbers decrease.*

The combined effects of falling profit margins and the consolidation of firms in the industry both contribute to declining firm numbers during this stage. If trade is allowed, substitution of foreign firms for domestic producers also reduces the number of domestic firms.

- PROPOSITION 9. *During the "maturity stage" of the LCM, firms in the industry may initially increase or decrease their levels of investment, but by the end of the stage, firms decrease their levels of new investment.*

Firms in an industry facing falling prices, profits, and sales revenues have decreasing incentives to invest, especially if the industry faces inelastic demand. Firms do have incentives to invest in cost-saving innovations, but firms with falling profits will have fewer funds to invest over time.

During the *decline stage* of the LCM, there is no uncertainty about the direction of all economic trends. The only question concerns the amount of time remaining before the life cycle ends. The following two points outline the major trends.

- DEFINITION 4. *During the "decline stage" of the LCM, average commodity prices, total industry profits, total industry sales revenues, and total units sold all decrease.*

Only two general scenarios can result in all of the trends listed in Definition 4. First, the usual scenario is for demand to decline as consumers substitute some other product in place of the output of the industry being evaluated. This means the demand curve is moving to the left, causing the market equilibrium point to be farther down the supply curve. That movement down the supply curve continually lowers the market price and profit margin, and firms are forced to exit the industry.

The second scenario involves substitution of foreign firms for domestic firms. However, this is possible only if trade is allowed. If trade is not allowed in an industry with stable or increasing demand, like that for food, any leftward shift in the domestic supply curve would reduce the total units sold, but would increase prices and, for a market with inelastic demand, would also increase sales revenues and total profits. Such an industry is not declining. On the other hand, trade allows foreign firms to enter a market, expanding market supplies and lowering the market price to the global price level. As that price drops and/or domestic costs increase, domestic firms are forced to exit the industry. Therefore, innovations which increase global supplies cause higher-cost domestic industries to reduce their output, which is replaced in domestic markets by increased imports at the global price. This result pushes higher-cost industries into decline.

- PROPOSITION 10. *During the "decline stage" of the LCM, the number of firms in the industry decreases, but may not reach zero.*

As noted in the discussion of Proposition 6 above, the most innovative firms ($m_f = m_{\max}$) are expected to be the most profitable over time, ceteris paribus, and may be able to survive beyond the end of the industry's life cycle. As the national domestic industry declines, it may break into regional and then local fragments. Highly innovative firms may be able to diversify out of the commodity-based industry by differentiating their output through adding value, branding, or some other strategy. By doing so, those firms become part of other industries that may have a much longer life expectancy, thereby enabling small pieces of the original industry to survive as a supplier to a different market. Such survival can occur only for innovative firms able to identify opportunities [$g(cr_{ft})$] on which only they can capitalize. This leads to Definition 5.

- DEFINITION 5. *The life cycle of an industry ends when sales are no longer made in the original market (i.e., to the original type of buyers), even if the remaining firms are making sales in a different market.*

Methodology

A methodology designed to indicate which stage of the life cycle an industry is in at any point in time is proposed here. It is based on the idea that each stage of the LCM presents testable hypotheses derived from changes in the comparative and absolute advantages of an industry and its competition, as expressed in the definitions and propositions above. The hypotheses for each stage of the life cycle are tested by comparing the expected patterns with data from the time period of interest. The industry is in the stage that offers hypotheses consistent with the data.

There are two groups of hypotheses. The primary hypotheses are derived from the definitions and are the central focus of the empirical analysis here. The secondary hypotheses are derived from the propositions and are mentioned only in the summary of empirical results.

The primary hypotheses tested here focus on the absolute size of the industry's economic outputs: total sales revenues and total profits. Sales revenues measure how the market values aggregate output, and profits measure how well the industry is performing in increasing owners' wealth. Productivity factors affect costs per unit of output and total output volume; therefore they affect profits and sales revenues, as shown in equations (4) and (5).

As summarized in exhibit 1, the approach is to jointly test groups of primary hypotheses to determine which group best fits the data for the time period of interest.

Exhibit 1. Methodology to Identify Life Cycle Stage

***Introduction Stage* Hypotheses:**

H_{I1}: Total sales revenues are increasing ($R_{t+1} > R_t$).

H_{I2}: Total profits are negative but improving ($0 > \Pi_{t+1} > \Pi_t$).

***Growth Stage* Hypotheses:**

H_{G1}: Total sales revenues are increasing ($R_{t+1} > R_t$).

H_{G2}: Total profits are positive and increasing ($\Pi_{t+1} > \Pi_t > 0$).

A convex sales function is not a necessary, but is a sufficient condition; thus:

H_{G1*}: Total sales revenues are increasing at an increasing rate, $[dR_{t+1}/d(t+1)] > (dR_t/dt) > 0$.

***Maturity Stage* Hypotheses:**

H_{M1}: Early in the stage, total sales are increasing and profits peak, ($R_{t+1} > R_t$) and $[(d\Pi_t/dt) = 0]$.

H_{M2}: Late in the stage, total profits are decreasing and sales peak, ($\Pi_t > \Pi_{t+1} > 0$) and $[(dR_t/dt) = 0]$.

***Decline State* Hypotheses:**

H_{D1}: Total sales revenues are decreasing ($R_t > R_{t+1}$).

H_{D2}: Total profits are decreasing ($\Pi_t > \Pi_{t+1}$).

Note: These are the primary hypotheses only. They are derived from the definitions. Secondary hypotheses derived from the propositions and involving factors other than sales and profits are not listed due to space constraints.

Because each primary hypothesis expresses a relationship between time and sales and/or profits, the data are time series. For each stage there are two hypotheses. For the *introduction stage*, accepting hypotheses H_{I1} and H_{I2} are each necessary, and together they are sufficient conditions to determine the industry is in the first stage of its life cycle. The same is true of hypotheses H_{D1} and H_{D2} for the *decline stage.*

As noted in exhibit 1, an industry can be identified as being in its *growth stage* in either of two ways. First, accepting both H_{G1} and H_{G2} is a sufficient condition. Second, accepting only substitute hypothesis H_{G1*} is a sufficient condition. A convex sales function is not a necessary condition, but is a sufficient condition to determine an industry is in its *growth stage*—because it is a rare situation that could occur only for a relatively new industry experiencing rapid sales growth.

The *maturity stage* is characterized by two turning points, one for each of the data sets, and so it is evaluated as if it were two different stages. H_{M1} identifies the "early" portion of the stage by testing sales and profit patterns jointly. Each of the two pieces of the hypothesis could be written as separate hypotheses, but for convenience they are written here as one sufficient condition. H_{M2} is treated in the same manner for the "late" portion of the stage. This means H_{M1} and H_{M2} are mutually exclusive; i.e., an industry can be in only one portion of the stage or the other, so only one of these hypotheses can be accepted.

The primary hypotheses are tested by estimating regression models of annual total industry profits and sales, and then evaluating the relevant coefficients. As explained by Perron, a Dickey-Fuller type model can be augmented with slope and intercept dummy variables and estimated with ordinary least squares. The dummy variables enable measurement of the slope or, if needed, a change in the level of a trend function between time periods. The general model to measure the slope of a given series, y_t, during some period is specified as:

(6) $$y_t = \mu + \gamma y_{t-1} + \beta T_t + e_t,$$

where μ is the intercept, T_t is a time trend dummy, γ and β are regression coefficients to be estimated, and e_t is an error term at time t specified as an ARMA(p, q) process of unknown order. The dummy $T_t = t$ during a period of interest and 0 otherwise. When both slopes and intercepts are to be measured, the model is given as:

(7) $$y_t = \mu + \gamma y_{t-1} + \beta T_t + \alpha D_t + e_t,$$

where the dummy variable $D_t = 1$ during a period of interest and 0 otherwise, and α is its coefficient. Multiple slope and intercept dummy variables may be used in a single regression.

The general industry profit and sales equations estimated, respectively, are derived from equations (4) through (7) as:

(8) $$\Pi_t = \mu + \gamma_1 \Pi_{t-1} + \gamma_2 (R_t/A_t) - \gamma_3 [\Delta(cr_t)] + \beta T_t + \alpha D_t + e_t;$$

(9) $$R_t = \mu + \gamma_4 R_{t-1} + \gamma_5 (\Pi_t/R_t) + \gamma_6 [\Delta(cr_t)] + \beta T_t + \alpha D_t + e_t.$$

In equation (8), the lagged profit variable represents the first component of equation (4) ($E[R_t - C_t - K_t]$); the revenue per acre variable represents the productivity component $[(m)g(cr_t)G]$; $\Delta(cr_t)$ represents the total capital invested in agriculture during year t [as reported by USDA (2003)]; and γ denotes the relevant regression coefficients.

Equation (9) is constructed to represent equation (5), with the average profit margin (i.e., profit as a percentage of sales) variable as the productivity component. The proxy variables representing the productivity component in equations (8) and (9) reflect the aggregate results of the industry's innovative efforts. Revenue per acre captures the results of innovations that increase output by raising yield, plus those actions that signal market approval through higher prices. The profit margin reflects market success through higher prices received and/or lower costs per unit (which could enable the industry to expand output and sales while facing falling market prices). The investment component in equations (8) and (9) is measured directly using total capital expenditures in agriculture. Multiple trend and intercept variables are used as needed for hypothesis testing. The order of the ARMA(p, q) processes was found using the testing method in Pindyck and Rubinfeld (pp. 490–94) involving R^2 and χ^2 statistics. All combinations of processes were estimated with p and q each ranging from 0 to 3, with only the best-performing combination being reported in the results.

The time-series data should be expressed in real dollars if the problem being investigated spans a long time period. When studying industries, the period will often cover decades. For American agriculture, the partial life cycle has already lasted centuries, so some data aggregation and/or truncation is appropriate. Therefore, the financial data used here are annual real sales and production income for American agriculture from 1949–2002. All the data were taken from the Economic Research Service's web site (i.e., USDA 2003).

Empirical Results for American Agriculture

The empirical analysis begins by identifying current trends in profits and sales. Then, the definitions and propositions are assessed and the current life cycle stage is identified.

Tests of Profit Hypotheses

Annual (pre-tax) net income for American agriculture over the last half-century is presented in nominal terms in table 1. The net farm income totals reported by the USDA represent one of the most commonly used measures of profitability. However, they are overstated. Among other things, those totals include direct government payments to agriculture. Thus, in table 1, direct government payments are subtracted from the net farm income totals to obtain "adjusted production income" (API), which better reflects profits earned only from agricultural production activities. Those data were converted into real dollars for the 1949–2002 period using the consumer price index (USDA 2003), with 2000 being the base year, as shown in figure 3 (to provide visual context, real data for 1910–1948 are also included).

Table 2 presents the results of estimating equation (8) using the real profit (i.e., API) data. To begin, a specification based on equation (6) was used to measure the slope in the profit trend and to test whether that slope changed in 1973, as suggested by inspection of figure 3. As shown by the results in the two columns labeled "Model 1," the trend is negatively sloped and statistically significant for both the 1950–1972 and 1973–2002 time periods. Also, a *t*-test indicates there is no significant difference in the slopes between the periods. It is noted that all variables in model 1 (and both of the other profit models) are significant and have the expected sign—positive for lagged income and revenue per acre, negative for capital expenditures.

Next, another equation (6) specification was used to test whether the 1973–1983 period was unique in its profit pattern. Model 2's results show that using three slope dummies, instead of two, provides some improvement in the estimation, but using an equation (7) specification to estimate model 3 gives the best results. By including an intercept dummy for the 1973–1983 period, the coefficient for the slope dummy $T_{73\text{–}83}$ becomes much more negative: from -1.16 to -4.60. So, 1973–1983 does appear to be an unusual period in American agriculture's profit performance, but it does not change the key result that all three slope dummies have significant negative coefficients. This finding indicates the long-run trend in the industry's profit has been negative for over half a century.

Therefore, the real profit data are consistent with hypothesis H_{D2} and the profit portion of H_{M2}, and inconsistent with H_{I2}, H_{G2}, and the profit portion of H_{M1}. These results partially signal that American agriculture is past the *introduction*, *growth*, and "early" *maturity* stages of its life cycle. Whether it is in its "late" *maturity stage* or its *decline stage* can be determined only after sales tests.

Tests of Sales Hypotheses

The real sales data [final crop output plus final animal output, as reported by the USDA (2003)] are plotted in figure 3. Those data were used to estimate equation (9). The Cochrane-Orcutt transformation was applied to correct for the ARMA(1, 0) process found during diagnostics checking. In general, the sales models all give consistent results: the profit margin and capital expenditure variables are both significant and have the expected positive signs, while the lagged sales variable is insignificant.

Table 3 presents the regression results for five models estimated. Model 1 has negative coefficients on the two slope variables, but neither is statistically significant, thus indicating a flat trend line for the entire period. Model 2 was estimated using an

Table 1. U.S. Agricultural Sales and Income, 1950–2002 (nominal)

Year	Total Crop & Livestock Sales ($ billions)	Net Income ($ billions)	Direct Government Payments ($ billions)	Adjusted Production Income (API) ($ billions)	Total Capital Invested ($ billions)	API as Percent of Sales (%)
1950	31.3	13.6	0.3	13.4	4.0	42.7
1955	31.4	11.3	0.2	11.1	3.6	35.3
1960	35.5	11.2	0.7	10.5	4.0	29.6
1965	41.2	12.9	2.5	10.4	5.6	20.8
1970	51.3	14.4	3.7	10.6	6.8	20.8
1971	54.9	15.0	3.1	11.9	6.8	21.6
1972	62.9	19.5	4.0	15.5	7.5	24.7
1973	91.4	34.4	2.6	31.7	10.2	34.7
1974	92.0	27.3	0.5	26.7	11.4	29.1
1975	93.4	25.5	0.8	24.7	12.4	26.5
1976	95.0	20.2	0.7	19.4	14.0	20.5
1977	98.5	19.9	1.8	18.1	15.0	18.3
1978	115.5	25.2	3.0	22.2	17.9	19.2
1979	137.9	27.4	1.4	26.0	20.1	18.9
1980	134.7	16.1	1.3	14.9	18.0	11.0
1981	149.3	26.9	1.9	24.9	16.8	16.7
1982	142.3	23.8	3.5	20.4	13.3	14.3
1983	126.9	14.2	9.3	5.0	12.7	3.9
1984	149.8	26.0	8.4	17.5	12.5	11.7
1985	142.8	28.6	7.7	20.9	9.2	14.7
1986	134.1	30.9	11.8	19.1	8.5	14.3
1987	140.2	37.4	16.7	20.7	11.2	14.8
1988	147.9	38.0	14.5	23.5	11.5	15.9
1989	165.3	45.3	10.9	34.4	13.1	20.8
1990	173.5	44.6	9.3	35.3	14.1	20.4
1991	168.3	38.5	8.2	30.3	13.1	18.0
1992	176.0	47.7	9.2	38.5	12.6	21.9
1993	174.3	44.3	13.4	30.9	13.9	17.7
1994	190.0	48.8	7.9	40.9	13.9	21.5
1995	183.4	36.9	7.3	29.6	13.8	16.2
1996	207.6	54.9	7.3	47.6	15.4	22.9
1997	208.8	48.6	7.5	41.1	16.5	19.7
1998	196.3	44.6	12.2	32.4	17.8	16.5
1999	187.5	46.2	21.5	24.7	16.2	13.2
2000	193.7	48.0	22.9	25.1	17.3	13.0
2001	202.8	45.7	20.7	25.0	17.1	12.3
2002	193.5	32.4	13.1	19.3	17.1	10.0

Source: USDA (2003).
Notes: Data from 1949–1969 are presented in condensed form due to space limitations. Data for each year from 1910 to 2002 are available online at the USDA/Economic Research Service "Briefing Room" website: http://www.ers.usda.gov/Briefing/FarmIncome/fore.htm.

Table 2. Regression Results for Models of Profits (real adjusted production income, 1949–2002)

	Model 1		Model 2		Model 3	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant (μ)	1,378.80**	2.76	2,183.20**	4.27	2,092.30**	4.46
Adjusted Income Lag	0.58**	6.23	0.55**	6.47	0.42**	4.76
Revenue/Acre	0.63**	6.32	0.61**	6.76	0.53**	6.05
Capital Expend.	-1.77**	-5.06	-1.00*	-2.56	-1.29**	-3.48
T_{50-72}	-0.73**	-2.88	-1.14**	-4.41	-1.01**	-4.53
T_{73-02}	-0.74**	-2.97	—	—	—	—
T_{73-83}	—	—	-1.16**	-4.50	-4.60**	-4.12
T_{84-02}	—	—	-1.15**	-4.48	-1.09**	-4.62
D_{73-83}	—	—	—	—	6,930.50**	3.15
Adjusted R^2	0.8222		0.8543		0.8780	
F-Ratio	49.09		51.82		54.46	

Notes: Single and double asterisks (*) denote significance at the 95% and 99% confidence levels, respectively. All three models have an ARMA(0, 0) process.

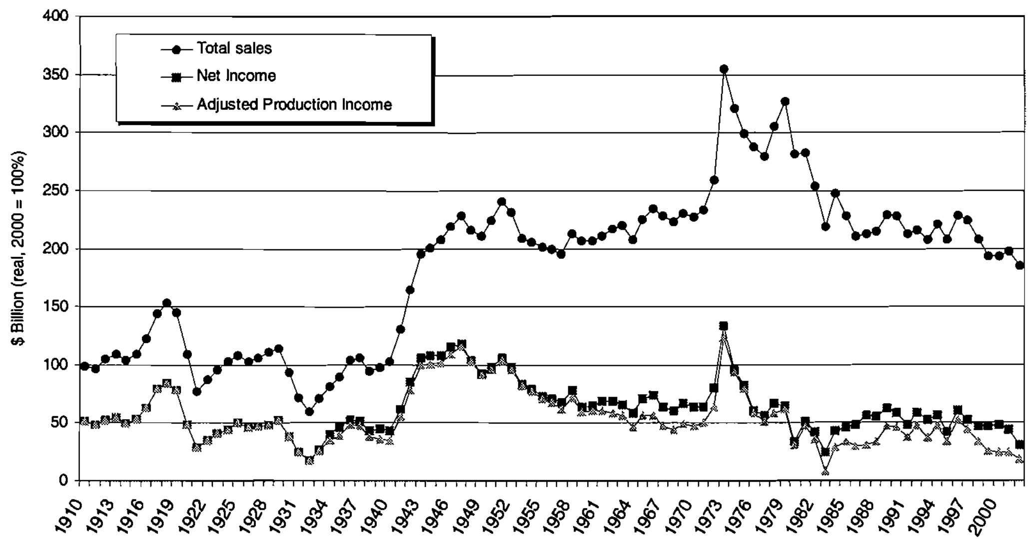


Figure 3. Real U.S. agricultural sales and income, 1910–2002

equation (7) specification to test whether 1973 was a turning point. The results indeed indicate some exogenous shift occurred in 1973 that changed an up-trend in sales into a significantly negative trend. Sales models 3, 4, and 5 repeat the tests in models 1 and 2, except the 1973–2002 period is broken into two periods for more detailed evaluation. Model 5 shows 1973–1983 was a dynamic period and appears to have been a turning point in American agriculture. The three slope variables in model 5 are all different, based on t-tests. The coefficient for T_{50-72} is significantly positive, T_{73-83} is not significantly different than zero, and T_{84-02} is negative and significant. Therefore, agriculture's real sales revenues have trended downward for at least two decades.

Table 3. Regression Results for Models of Real Sales, 1949–2002

	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant (μ)	1,020.5	0.62	-7,063.9**	-3.90	1,539.8	0.85	2,135.3	0.92	-6,396.6**	-3.69
Sales Lag	-0.009	-0.14	-0.022	-0.37	-0.003	-0.05	-0.001	-0.01	-0.016	-0.27
API / Sales	3.271**	9.35	3.065**	9.06	3.195**	8.66	3.253**	8.22	3.154**	8.12
Capital Expend.	2.443**	6.09	2.222**	5.92	2.464**	6.08	2.517**	5.97	2.443**	6.03
$T_{50\text{–}72}$	-0.472	-0.57	3.640**	3.95	-0.736	-0.81	-1.041	-0.89	3.294**	3.73
$T_{73\text{–}02}$	-0.450	-0.54	-1.429*	-2.38	—	—	—	—	—	—
$D_{73\text{–}02}$	—	—	10,043.3**	4.17	—	—	—	—	—	—
$T_{73\text{–}83}$	—	—	—	—	-0.714	-0.79	0.368	0.15	0.368	0.21
$T_{84\text{–}02}$	—	—	—	—	-0.710	-0.78	-1.010	-0.87	-2.082**	-2.83
$D_{73\text{–}83}$	—	—	—	—	—	—	-2,737.9	-0.46	5,810.1	1.41
$D_{84\text{–}02}$	—	—	—	—	—	—	—	—	10,672.9**	4.68
rho	0.899		0.710		0.901		0.898		0.677	
Adjusted R^2	0.8468		0.8713		0.8453		0.8423		0.8748	
F-Ratio	57.39		58.55		47.45		39.91		45.56	

Notes: Single and double asterisks (*) denote significance at the 95% and 99% confidence levels, respectively. All five models have an ARMA(1, 0) process.

As noted above, regression analysis shows a positive trend in the real sales data prior to 1973, a flat trend line over the 1973–1983 period, and a negative slope in the trend thereafter. Thus, 1973 (or the 1973–1983 period) appears to be a turning point when the historical up-trend reversed to create a down-trend.

The sales hypotheses test results indicate the past half-century has been a period of great change for American agriculture. The real sales data for the *entire* 1949–2002 period are not consistent with any of the hypotheses. The data series certainly is not all trending up, as required to accept hypotheses H_{I1}, H_{G1}, and the sales portion of H_{M1}. Also, it is not consistent with the flat trend line specified in the sales portion of H_{M2}, even though models 1 and 3 may indicate so. In addition to the different signs on slope coefficients β_{50-72} and β_{84-02} in model 5, the significant intercept dummy, D_{84-02}, reveals the recent period is different than the 1950–1972 period due to some intervention occurring between 1972 and 1984. The 1973–1983 trend in model 5 is flat, as required by the sales portion of H_{M2}. The recent real sales data (1984–2002) are trending downward, as described in H_{D1}. Overall, the real data have not been consistent with the sales portion of H_{M1} since 1973. Clearly, markets for America's agricultural output have been different since 1973–1983.

Life Cycle Stage Determination

The empirical determination of which life cycle stage American agriculture currently occupies depends on the hypotheses test results and which definitions and propositions are consistent with the data. A summary of the evidence is presented in exhibit 2. The summary includes expanded definitions for the *maturity* and *decline* stages to create more precise hypothesis tests. The need for these expanded definitions became apparent when specifying the hypotheses, as noted earlier in the discussion of exhibit 1.

It is proposed here that the *decline stage* of the LCM be treated as having "early" and "late" periods, similar to the *maturity stage*, to facilitate more precise hypothesis tests. The *early decline stage* is defined to begin when HD1 and HD2 are supported by real data. The *late decline stage* begins when total unit sales start trending downward.

Based on the overall results of this study, American production agriculture has clearly passed its *introduction*, *growth*, and *early maturity* stages, and is probably in the *early decline stage* of its life cycle. The results are consistent with the argument that 1973 (or the 1973–1983 period) was a turning point signaling the transition from agriculture's *late maturity stage* into its *early decline stage.*

Concluding Comments

The empirical results of this study indicate American production agriculture appears to be in the *early decline stage* of its life cycle. The industry's economic output is declining in real terms and the industry faces an increasingly difficult future due to the competitive structure of the expanding global markets for commodities.

The difficulty in reaching conclusions about the economic health of American agriculture and the length of its life span comes from the distortions of government intervention. Direct government payments and other sorts of support that artificially raise total profits have served to slow the flow of resources out of the sector, thereby lengthening its life span. Also, domestic resources stay in the industry longer when trade barriers

Exhibit 2. Summary of Empirical Results

Definitions and Propositions	Consistent with Data?	Sources
D1: At the beginning of the *introduction stage* of the LCM, industry sales are zero and profits are negative.	No, H_{I1} and H_{I2} are both rejected.	
P1: During the *introduction stage* of the LCM, firms enter the industry based on expected profits.	No, farm and ranch numbers have declined each year since peaking at 6.8 million in 1935.	USDA 1999
D2: During the *growth stage* of the LCM, total industry sales and total industry profits increase.	No, H_{G1} and H_{G2} are both rejected.	
P2: During the *growth stage* of the LCM, agricultural commodity prices increase in most cases.	No, prices are decreasing.	USDA 2003
P3: During the *growth stage* of the LCM, the number of firms in the industry increases.	No, the number of farms and ranches is declining.	USDA 1999
P4: During the *growth stage* of the LCM, firms in the industry increase their levels of investment.	No, total capital expenditures in agriculture peaked in real terms in 1979, and have trended down since.	Nominal data in table 1, converted to real dollars
D3: During the *maturity stage* of the LCM, total industry profits and total industry sales (in that order) peak and then decrease.	Partially observed during the half-century analysis period; more detail is needed.	
D3a: During the "early" *maturity stage* of the LCM, total industry profits peak while total industry sales increase.	No, H_{M1} is rejected; profits trended downward over the entire data period.	
D3b: During the "late" *maturity stage* of the LCM, total industry profits decrease while total industry sales peak.	Not supported by current data. H_{M2} is rejected for the current period (1984–2002); H_{M2} is accepted for the 1973–1983 period.	
P5: During the *maturity stage* of the LCM, average commodity prices peak before total industry profits and total industry sales do, and then decrease.	Not supported by current data. Prices, real profit, and real sales all declined in recent decades; USDA's Index of Prices Received for agricultural output decreased in real and nominal terms in recent decades.	USDA 2003
P6: During the *maturity stage* of the LCM, firms entering (exiting) the industry are those more (less) able to innovate.	Inconclusive; average gross profit margins and firm numbers are falling, but firm-level analysis is beyond the scope of this study.	USDA 2003, and API as % of sales in table 1
P7: During the *maturity stage* of the LCM, the average size of firms in the industry increases.	Yes, average farm size has been increasing for decades.	USDA 1999
P8: During the *maturity stage* of the LCM, the number of firms in the industry may initially rise or fall, but decrease by the end of the stage.	Yes, farm and ranch numbers are declining.	USDA 1999
P9: During the *maturity stage* of the LCM, firms in the industry may initially increase or decrease their levels of investment, but by the end of the stage firms decrease their levels of new investment.	Yes, total capital expenditures in agriculture in real terms have trended down since peaking in 1979 at nearly triple the 2002 level.	Table 1 data converted to real dollars
D4: During the *decline stage* of the LCM, average commodity prices, total industry profits, total industry sales revenues, and total units sold all decrease.	Partially observed during the half-century analysis period; more detail is needed.	

(continued . . .)

Exhibit 2. Continued

Definitions and Propositions	Consistent with Data?	Sources
D4a: During the "early" *decline stage* of the LCM, product prices, total industry profits, and total industry sales revenues all decrease in real terms.	Supported by current data. H_{D1} is accepted for the current period (1984–2002), H_{D2} is accepted for the entire half-century analysis period, and USDA's Index of Prices Received for agricultural output decreased in real and nominal terms in recent decades.	USDA 2003
D4b: During the "late" *decline stage* of the LCM, total units sold decrease.	No.	
P10: During the *decline stage* of the LCM, the number of firms in the industry decreases, but may not reach zero.	Yes, farm and ranch numbers have declined steadily to less than one-third of the peak in 1935.	USDA 1999
D5: The life cycle of an industry ends when sales are no longer made in the original market, even if the remaining firms are making sales in a different market.	No.	

reduce imports. So, to a great extent, the length of American agriculture's future is a policy decision. The fact that policy interventions have occurred in agriculture since the 1930s is consistent with an industry that reached its *late maturity stage* long ago.

Note, however, the decline identified here for production agriculture does not reflect on agribusiness. The post-farmgate sector is flourishing as American consumers continue to demonstrate a willingness to pay for value-added products.

This study's contribution has been to extend the life cycle literature to include an undifferentiated commodity-based industry. It is hoped this descriptive tool will facilitate future research into the economic changes in American production agriculture's past and future. Also, future research could apply this methodology to regional agricultural industries, or local commodity markets/industries.

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