Globalization, Cropping Choices, and Profitability in American Agriculture

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ABSTRACT

The paper discusses the linkages between the "globalization" of agricultural markets over recent decades and the decisions being made by individual farmers and ranchers in the United States. It is noted that technological advances lead to globalization of agricultural commodity markets and profit pressures. The continuing profit squeeze in agricultural production is having a significant effect on the cropping choices of America's farmers. When possible, acreage is being shifted out of low-revenue-generating crops and into higher-revenue-generating crops. This shift makes crop portfolios more risky over time, thus encouraging farmers to consider diversifying out of agriculture.

Key words: *cropping choices, globalization, profit, risk, safety-first.*

Economists have paid surprisingly little attention to the linkages between the "globalization" of agricultural markets over recent decades and the decisions being made by individual farmers and ranchers in the United States. The two topics have been treated separately in the literature as if there was no linkage between them. Much research has focused on the policy implications of emerging global markets (e.g. Johnson and Martin; Tweeten) while another body of literature has taken the existence of global or world markets as a given and analyzed their operations (e.g. Diakosavvas; Lee and Cramer; Paarlberg and Abbott). Farm-level decision-making in the U.S. has also been the focus of a large body of research, but the portion of that work relevant to this paper has centered on the "overproduction trap" facing farmers and has dealt with export markets only as a residual outlet for surpluses (e.g. Johnson and Quance). The literature coming closest to directly addressing the linkages are more recent efforts focusing either on the structure of world resources, markets and trade (e.g. Coyle *et al.*; Douglass) or on the "technology treadmill" (e.g. Gallup and Sachs; Levins; Smith). These two topics are part of the story, but more discussion of the direct links between them is needed. Therefore, the objective of this paper is to contribute to that discussion because the topic will be of increasing importance as global markets become the norm for agricultural commodities.

Technology is the Catalyst

Technological advances make globalization of commodity markets possible. Over time, technological advances make global trade of a product physically possible, economically viable, and then a routine market occurrence. It is advances in production that create the *need* for global markets. New production methods expand output in a local market by enabling new producers to enter the market and by en-

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abling existing producers to increase their production volume. When surpluses start to occur in the local market more distant market outlets must be sought if producers are to benefit from their increased output (Bressler and King).

Technology related to storage and transportation are key to expanding the geographic size of commodity markets. Storage expands the amount of time before spoilage occurs for an agricultural commodity. Improvements in storage methods and machines give market participants more time before their products perish. Having more time with which to work means that more distance can be covered before a product perishes, thus more places and people can be reached by suppliers of a commodity. This means that a market's physical boundaries are potentially expanded by technological advances. To realize a potential market expansion, new technology must be adopted. In today's world technology can be bought and/or copied, thus it spreads quickly, eventually even to poorer nations (Gallup and Sachs).

In summary, a global market is created when it is physically possible and economically feasible for producers to sell their output to buyers in locations across international boundaries. For many agricultural commodities improved production technology has increased the number of (possible) producers while storage and transportation technology expands the geographic reach of each seller, thus more direct and indirect competition between suppliers occurs as time passes. The resulting "global" market is dynamic, however, as described in the next section.

Globalization and Commodity Market Prices

Globalization of markets affects the profitability of commodity production which, in turn, affects the composition of those markets. In the past it was believed that ". . . what drives trade is comparative rather than absolute advantage" (Krugman p. 101). The concept of comparative advantage says that countries should specialize in the production of whatever products its resources are best suited for,

even if it does not have an absolute advantage in the production of any product (Layard and Walters pp. 113–9). It is now understood that ". . . countries may lose industries in which comparative advantage might have been maintained . . ." (Krugman p. 98) ". . . due to changes in comparative advantage and international competition" (Krugman p. 101). This is especially likely in markets for undifferentiated commodities.

Changes in comparative advantage occur as technological advances create new industries and/or substantially change existing industries within a country. 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.

International competition is now relevant to some industries in which comparative advantage once existed, such as American agriculture, because there is an *absolute* limit to how much the world needs of a commodity. Unlike the situation for branded products, undifferentiated agricultural commodities can now be produced in greater quantities than the global market can absorb. This is due to technological advances (Antle; Johnson). Food commodities, in particular, have an absolute limit to the volume that can be consumed over time because there is a physical limit to how much a person can eat, even if an infinite supply were available free. And because commodities are undifferentiated (i.e. there is no difference between the output from two producers of a standardized commodity) buyers make purchases from the lowest-cost supplier.

Figure 1 illustrates the effects of absolute cost advantages in global commodity markets. Assume that there is only one country (such as the U.S.) supplying the market for a commodity with supply curve S_1. The world demand curve, D, intersects S_1 at point A, resulting in price P_1 being charged for quantity Q_1. Then assume that technological advances enable a new, lower-cost supplier (such as a less-developed country) to enter the market. The new producer has a supply schedule shown as the lower portion of S_2 (that section of the curve becomes almost vertical at Q_2^*
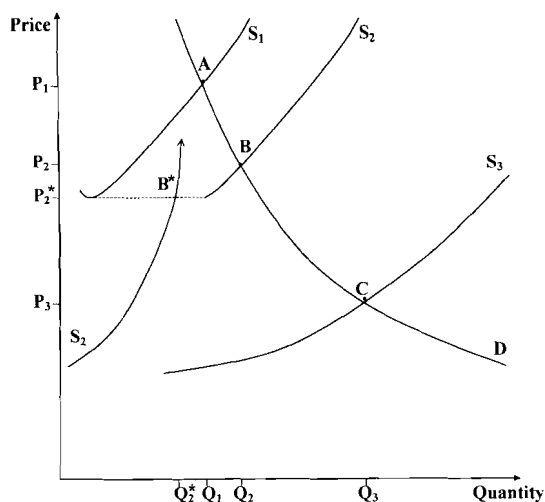
Figure 1. World market for an agricultural commodity: from one supplier to competitive market

because resources limit the production capacity of the new supplier). The new total market supply is found by horizontally summing the supply schedules from the two suppliers, giving S_2 which has a jump at price P_2^*, the lowest price at which the original supplier is willing to participate in the long run. The intersection of the new supply schedule and the world demand schedule is at point B, resulting in price P_2 being charged for quantity Q_2. The introduction of competition from the new supplier will cause the original supplier to scale back its production in response to the lower market price, P_2. Also, depending on the nature of sales in the market (i.e. whether they are made in competitive spot markets, through multi-year contracts, or influenced by personal contacts developed over time between people in the marketing channel), the original supplier may lose additional market share to the new supplier because the new supplier could drop its price to compete for sales and, by dropping its price to P_2^* or slightly less, it could ultimately force the original supplier out of the market. However, in the long run consumers would bid up prices to P_2, leading to total output of Q_2 with the new supplier producing Q_2^* and the original supplier producing the difference $(Q_2 - Q_2^*)$. Finally, as continued adoption of technological advances occurs in less-

developed countries, new suppliers become able to enter the market, making S_3 the total supply curve and moving the equilibrium to point C where P_3 is the unit price for quantity Q_3. In this example, the high-cost original supplier is forced out of the market entirely due to falling prices. The lower-cost suppliers are still profitable at P_3 and consumers benefit because plentiful supplies are available at lower prices. The more inelastic the demand for the commodity the faster the process leads to the exit of higher-cost suppliers.

Technology and Individual Farmers

It has long been understood that individual farmers react to technological advances (Johnson and Quance pp. 24–5). With the globalization of markets, technological advances affect the profitability of individual crop markets whether or not producers in a local market adopt the new technology. This, in turn, keeps pressure on for (1) new technology to be developed and (2) changes in cropping choices of individual farmers. Figure 2 illustrates these points.

Panel A in Figure 2 shows that there is clearly an incentive for a farmer to adopt some new technology for a single commodity. The farmer's original situation is to produce quantity Q_1 at market price P because that is the profit-maximizing output given the farmer's supply schedule, S_1. When a new technology becomes available it expands the farmer's productive capacity to S_2, but price P is still available in the short-run because the individual farmer's output is not enough to affect prices (he/she is a price-taker). Therefore, Q_2 is the new profit-maximizing output for that farmer at that time.

Panel B shows the aggregate effect of all production increases from all farmers adopting the new technology for the single commodity. At the global market level total quantity produced increases from Q_1 to Q_2 over the adoption period and the global market price drops from P_1 to P_2.

Finally, in Panel C is the ultimate effect of a technology advance on an individual farmer, whether or not that farmer adopted the new

Panel A: Farmer's case: incentive to adopt new technology

Panel B: World market case: technology adoption lowers global price

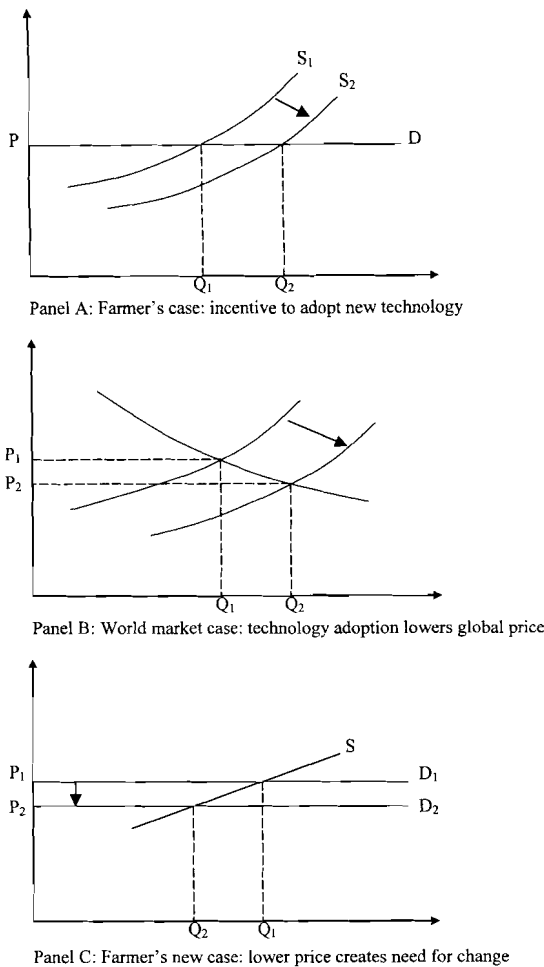Panel C: Farmer's new case: lower price creates need for change

Figure 2. Technology's effect on individual farmers

technology. As shown, demand for that farmer's output, as reflected by the market price being offered to him/her, decreases during the adoption period and settles at some new equilibrium (from D_1 to D_2). Facing a price drop from P_1 to P_2, the farmer must change. In the short-run the change might be to reduce output of the commodity from Q_1 to Q_2. In the long-run the change might be to search for another technological advance that enables his/her production to remain profitable at Q_1. Connecting the short- and long-run is the need for that farmer to change cropping choices.

Research has shown that technological advances can dramatically lower costs per unit while facilitating large increases in total pro-

duction volume. For example, Thompson and Blank showed that harvest mechanization has lowered costs in California tomato and rice production in recent decades while total production increased several times over.

However, the key factor in producers' cropping choices is the profitability of the available options. Over the last quarter-century falling prices have quickly eliminated much of the increased profit margin created by technological advances in market after market, thus resulting in relatively low and static returns on investments in U.S. agriculture. Over the last 20 to 30 years agriculture's gross profit margin has been in the 2–3 percent range, on average (Bjornson and Innes). That is relatively low— farmers could do better just depositing their money in a bank. From 1993 to 1999, the average rate of return on equity in American agriculture ranged from 0.9 percent to 3.2 percent. The average real net return to assets financed by debt has been negative every year since 1993 and was -3.8 percent in 1999 (USDA 1999). Thus it should not be surprising that the scale of off-farm investments has increased such that "on average, 88 percent of farm operator households' income came from off-farm sources in 1998" (USDA 2000a p. 37) and that number increased to 90 percent in 1999 (USDA 2000b p. 14).

Profitability and Cropping Choices

The changes in profitability of crops brought on by globalization of markets and by technological advances, as noted above, affect cropping choices made by individual growers who are seeking higher returns on their investment. In turn, the aggregated choices made by individuals affect the profitability of crop markets. Thus it is important to understand the decision-making process used by farmers when they choose which crops to produce. Viewing farmers as investors offers insights into their decision-making process through the use of a portfolio model constrained by a safety-first criterion, as done in this section.

Portfolio theory assumes that utility maximization is a person's objective. Therefore, de-

cision-making focuses on the certainty equivalent of expected profits, which Freund, Levy and Markowitz, Meyer, and others have shown is

$$(1) \quad E(U_\phi) = E(\Pi_\phi) - (\xi/2)(\sigma^2\Pi_\phi)$$

where $E(\cdot)$ is the expected value of $(\cdot)$, U is utility, Π_ϕ is profit-per-acre from crop portfolio ϕ, ξ is a risk-aversion parameter which is zero for risk-neutral farmers and positive for risk-averse producers, and $\sigma^2(\Pi_\phi)$ is risk defined as the historical variance of average profits per acre for portfolio ϕ. In general, "the expected utility model is the premier indexing rule for ordering choices under uncertainty" (Robison and Barry p. 20). When the decision involves only a single asset or some group of investments from which the resulting profits or losses are relatively small compared to the person's total wealth, the expected utility model suits most investors. However, when the scale of possible losses from an investment is significant, risk-averse investors have been shown to adopt "safety-first" decision rules. Safety-first criteria are compatible with the standard utility theory (Robison and Barry p. 201; Bigman).

Safety-first models place constraints upon the probability of failing to achieve certain goals of the firm. Several forms of safety-first models have been proposed as alternatives to expected utility maximization (Hatch, Atwood and Segar; Bigman). Roy suggested that in some situations, such as when the survival of the firm is at stake, decision-makers select activities which 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 "disaster level" or the "safety threshold." Telser's criterion maximizes expected income subject to probabilistic constraints on failing to achieve income goals: maximize $E(\Pi)$ subject to $\Pr\{\Pi < \Pi_*\} < \Gamma$, where Γ is an upper (acceptable) limit on $\Pr\{\Pi < \Pi_*\}$. Telser's approach is a two-step procedure whereby the person first eliminates alternatives that fail to meet the safety requirements for a given level of Γ and then selects

among the remaining alternatives the one(s) that maximizes expected utility. From these two basic models many researchers have proposed improvements (see Bigman for a brief review of the literature). What all safety-first models have in common is some safety threshold or income goal.

Therefore, in an era of decreasing profits that threaten the survival of many farms it is reasonable to propose that farmers' decisions are influenced by some safety-first criteria. In such a case a farmer's objective is to earn a profit that is expected to at least equal some designated minimum level of return, Π_* (Mahul). The designated safety threshold, Π_*, is a personal preference based on financial obligations and lifestyle goals, thus it will vary across individuals.

When only agricultural investments are being considered, a farmer's objective is to earn a profit from all production efforts, Π_ϕ, that is expected to at least equal some minimum level of return, Π_*, thus: $E(\Pi_\phi) \geq \Pi_*$. In effect this self-imposed constraint serves as a necessary but not sufficient condition in the farmer's decision to produce crop portfolio ϕ.

In this simple model a farmer is assumed to prefer having all of his/her tangible and financial assets engaged in agricultural production. Thus the farmer's sole source of income is profits derived from his/her production efforts. In this case the farmer's return is:

$$(2) \quad \prod_\phi \equiv \sum_{i=1}^{n} w_i \pi_i$$

where

$$\pi_i = R_i - C_i - K_i$$
$$R_i = P_i Y_i$$
$$C_i = \sum_j c_j x_{ij}$$
$$K_i = \sum_h k_h z_{ih}$$

and $\Sigma w_i = 1.0$; P_i, c_j, $k_h > 0$; Y_i, x_j, $z_h \geq 0$. π_i is profit per acre from crop i. R_i is revenue per acre from crop i. P_i is the unit price of

crop i. Y_i is the yield per acre of crop i. C_i is the total production costs per acre of crop i. c_j is a vector of unit costs of j variable inputs. x_{ij} is a vector of quantities per acre of j variable inputs to be applied in the production of crop i. K_i is the total ownership costs per acre of crop i. k_h is a vector of unit costs of h capital inputs (land, improvements, equipment, etc.). z_{ih} is a vector of quantities per acre of h capital inputs used in the production of crop i. w_i is the weight of crop i in the farmer's crop portfolio, and n is the number of crops in the farmer's crop portfolio.

In this model the total return per acre received by a farmer equals the share weighted sum of the returns from each commodity produced. If the farmer produces more than one crop ($n > 1$), then he/she is described here as producing a "portfolio" of crops. The financial risk faced by a farmer is defined to be the variance in returns from all income sources. For a producer of only a single crop that risk is $\sigma^2(\pi_i)$, the historical variance of profits per acre for crop i. For a producer of a crop portfolio risk is $\sigma^2(\Pi_\phi)$, the historical variance of average profits per acre for portfolio ϕ, which depends on the covariance between returns from the crops in the portfolio.

As noted earlier, utility maximization is assumed to be a person's general objective. Therefore the focus of decision making is the certainty equivalent of $E(\Pi_\phi)$, which is expressed in equation 1. As specified, it is clear that for a risk-neutral or risk-averse farmer to meet his/her financial objective it must be true that $E(\Pi_\phi) \geq E(U_\phi) \geq \Pi_*$.

To begin the crop selection process a farmer in a particular market must first identify the opportunities available in that market. Those opportunities can be plotted on an expected return-variance (EV) graph to facilitate analysis. This is done for a hypothetical market in Figure 3. The concave line labeled EV_1 represents the initial opportunity set available to crop producers within some geographic market. Each point on EV_1 is a crop or portfolio of crops that is efficient in terms of its return/risk relationship. The location and shape of any EV is determined by the data used to calculate expected returns for all portfolios.
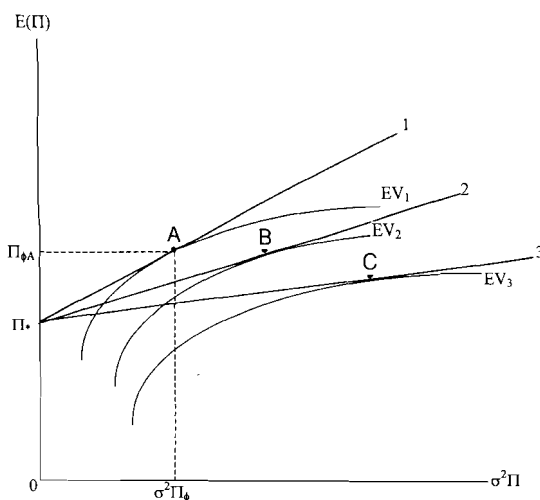

Figure 3. Cropping opportunities in a declining market

A farmer would choose to produce the portfolio represented by the point on the EV which is tangent to one of his/her indifference curves (not shown here). Thus even if two farmers in the same market had identical expectations about cropping opportunities (i.e. they identify identical EV curves) they will produce different crop portfolios if they have different risk attitudes. For example, assume that one farmer's indifference curve is tangent to EV_1 in Figure 3 at point A. That farmer would produce the crop portfolio represented by point A on EV_1 and would expect returns of $\Pi_{\phi A}$ with variance of $\sigma^2\Pi_{\phi A}$, as shown. Also, extending the linear tangent line from point A to the vertical axis identifies the certainty equivalent of the expected returns from portfolio A (hence, it is called the "certainty equivalent line," Robison and Barry, p. 73). As it is drawn in Figure 3, $E(U_{\phi A}) = \Pi_{*A}$, so the farmer would be willing to produce portfolio A because its returns are adequate. On the other hand a second farmer with a lower degree of risk aversion would have an indifference curve tangent to EV_1 at some point to the right of point A. The crop portfolio identified by that point would have higher expected returns, higher variance, and a higher certainty equivalent. Assuming that the second farmer has the same Π_*, he/she would clearly be willing to produce that crop portfolio be-

cause its returns are more than adequate to meet his/her financial objective.

If a risk-free investment exists, the opportunity set available to farmers is altered. In this paper a risk-free return (π_f) to land is defined as the return from cash leasing it to others. During the period covered by a cash lease the landowner is guaranteed a specific return that will not vary. Such a risk-free return is available only if an active market exists for cash leases on land (Robison and Barry). Leasing out land is analogous to investing in a risk-free asset which has a return of π_f, and would be plotted as a point on the vertical axis of an EV graph.

When leasing is possible the separation theorem indicates that all landowners who have the same returns expectations will produce the same crops, although the composition of their selected portfolios will still vary with their risk attitudes; more risk averse producers will lease out a larger portion of their land (Blank 1993; Turvey *et al.*). Using the risk-free return a single optimal risky portfolio and a farmer's cropping opportunities line (COL) can be identified. The COL represents the opportunity set available to landowners in a market (given some returns expectations). It is plotted as a straight line which passes through the point representing the risk-free return and is tangent to the EV. The COL dominates the EV at all points except where the two frontiers are tangent. The point of tangency represents the market's "optimal" portfolio. The portfolio selected by each farmer is found at the point of tangency between this linear COL and an indifference curve for that person. The selected portfolio is a mix of the market portfolio of crops and the risk free asset. The only difference in composition of selected portfolios between farmers will be the relative proportions of land each chooses to lease in or out, which is calculated using the first-order conditions for equation 1. This result comes from the separation theorem that suggests that the selection of the crop mix does not depend upon the decision-maker's risk preferences, since it is constant along the COL. Instead, the amount of land leased in or out is the variable affected by risk preferences.

The inclusion of a minimum return, Π_*, adds a constraint to utility maximization (as noted by Telser). If $\Pi_* < \pi_f$, then the farmer may lease out some portion of his/her land. If $\Pi_* \geq \pi_f$, then the farmer will produce on all available land. Taken together these constraints lead to Proposition 1.

PROPOSITION 1. *In a market area with a single leasing rate, farmers who only consider agricultural investments and have higher financial obligations (i.e. higher Π_*) are more likely to be active producers (i.e., use all available land for crop production) than are farmers with lower debt levels and other financial obligations.*

When a farmer has all assets invested in agriculture external shocks may cause production adjustments. For a farmer to meet his/her profit objective in the future a change in that farmer's crop portfolio composition is needed immediately whenever $E(\Pi_\phi) < \Pi_*$. Also, for risk-averse farmers a change is needed when in the long run $E(U_\phi) < \Pi_*$. In other words, when the returns from a planned crop portfolio are not expected to reach the level necessary for the farmer to meet his/her financial obligations (i.e. safety threshold), that person has no choice but to change the composition of the planned portfolio. In cases where expected returns meet financial obligations, but not a farmer's utility requirements [$E(\Pi_\phi) \geq \Pi_* > E(U_\phi)$], that farmer may choose not to make changes in the crop portfolio in the short run but must in the longer term to derive the desired degree of personal satisfaction. And when $\Pi_* > E(U_\phi)$ is expected only for the short-run, farmers without liquid assets may still be forced to change their portfolio composition because they would be unable to pay any resulting short-falls (i.e. $\Pi_* - \Pi_\phi$); for those farmers $Pr\{\Pi_\phi < \Pi_*\} = 0 = \Gamma$ so as to eliminate default risk.

Numerous factors, such as market price and/or production cost changes, cause portfolio changes. In recent years most of the observed external shocks to agriculture have triggered the need for a change in farmers' crop portfolio composition (Blank 2000). In general, real output prices continue to fall and input costs rise to reduce the return from many

Development Stage	Crop Type	Investment, Asset Fixity
4th	High-value perennial	Very high, highly fixed
3rd	High-value annual	High, inflexible
2nd	Low-value perennial	Moderate, flexible
1st	Low-value annual	Low, very flexible

Source: Blank 1998.

Figure 4.   The farming food chain

crops to below farmers' desired/needed level, creating a "profit squeeze." This forces a farmer to shift acreage into higher returning crops. New portfolios made up of crops with relatively higher return and higher risk raise a farmer's total risk exposure, thus necessitating adjustments as described below.

The available crops in which a farmer might invest can be grouped into four categories, shown in Figure 4 (assuming that all four types of crops can be produced in the farmer's location).[1] Crop category 1 (low-val-

[1] Figure 4 illustrates the "Farming Food Chain" and the relationship between crop types, investment amounts, and the flexibility of production assets. At the bottom of the chain are low-value annual crops, such as grains, which require relatively low investments per acre and which involve assets that can be shifted into the production of another crop very easily. The second stage of land development involves low-value perennial crops, such as alfalfa and other irrigated forages. These crops have a normal economic life of more than one year and require somewhat higher investments per acre, but they involve fairly flexible assets. The third stage requires relatively high investments in inflexible assets to produce high-value annual crops such as lettuce and fresh tomatoes. Finally, high-value perennial crops such as tree and vine products lock growers into the highest and least flexible investments. In general, the risks and potential returns involved increase with each step up the chain.

In a particular geographic area climate and/or agronomic constraints may limit the feasibility of growing some crops. In particular crops in categories 3 and 4 may not be feasible. In such cases land moving up the truncated Farming Food Chain of that area will have to leave agriculture to attain the higher level of returns that would normally be available from higher

ue annuals) includes crops with expected returns per acre ranging from a low of $E(\pi_{1L})$ to a high of $E(\pi_{1H})$, with an average of $E(\pi_{1A})$. Crop categories 2, 3 and 4 also each have an identifiable range of returns from individual crops. Empirical results by Blank (1992) show that, although they sometimes overlap, the profit ranges are successively higher and that expected risk levels increase also at higher stages of the Farming Food Chain: $E(\sigma^2\pi_{1A})$ < $E(\sigma^2\pi_{2A})$ < $E(\sigma^2\pi_{3A})$ < $E(\sigma^2\pi_{4A})$.

Therefore, agricultural producers seeking a higher returning crop must normally accept higher risk exposure when adding the new crop to their production portfolio to restore the portfolio's total return to the desired level. Thus producers may resist investing in higher category crops. Nevertheless, continuing market shocks will eventually force producers to add higher-return/higher-risk crops to their crop portfolio and, ultimately, to shift assets out of agriculture.

To illustrate the point, assume a farmer's minimum desired return, Π_*, is low enough that it can be achieved initially with a crop portfolio composed entirely of category 1 crops. Then market shocks cause portfolio returns to decline, making necessary a change in the current portfolio composition. If $\Pi_* < E(\pi_{1H})$, then the farmer's new portfolio may contain crops from category 1. If $\Pi_* > E(\pi_{1H})$, the farmer's new portfolio must contain some higher category crop(s). Likewise, if $\Pi_* > E(\pi_{2H})$ or $\Pi_* > E(\pi_{3H})$, then the farmer must produce some successively higher category crop(s). And if $\Pi_* > E(\pi_{4H})$, then some acreage (and/or possibly some other assets) must leave agriculture for the person to receive total returns that are adequate to meet his/her financial objective as constrained by the safety threshold.

The effects of external shocks are illustrated in Figure 3. Assume that the original situation has three neighboring producers with

category crops. Therefore, the number of crop categories available in a geographic area is determined by climate/agronomic conditions and land can leave agriculture from any available category, but it must leave agriculture if it is to generate returns above those of the highest returning crop available.

identical expectations about market returns (Farmer 1, Farmer 2 and Farmer 3) each producing some unique portfolio of crops represented by a different point on EV_1. All three producers are assumed to have the same minimum financial objective so $\Pi_{*1} = \Pi_{*2} = \Pi_{*3}$; however they have different risk preferences: $\xi_1 > \xi_2 > \xi_3$. Originally, Farmer 1 is producing the crops in the portfolio at point A, and $E(U_A) = \Pi_{*1}$. Thus the tangent line labeled "1" in Figure 3 is the certainty equivalent line (CEL) for Farmer 1. The slope of an individual's CEL is $\xi/2$ (Robison and Barry), so line 1 has a slope of $\xi_1/2$. Farmers 2 and 3 both are less risk averse than Farmer 1, so they would originally be producing portfolios of crops at different points on EV_1 to the right of point A. That means for both Farmers 2 and 3, the returns and risks of their original crop portfolios are higher than that for portfolio A, yet they are quite willing to produce those portfolios because the certainty equivalent of their returns exceeds the farmers' minimum objective (i.e. $E(U_2) > \Pi_{*2}$ and $E(U_3) > \Pi_{*3}$). Then some external shocks (e.g. commodity price decreases and/or production cost increases) reduce the profitability of crops in the local market, making EV_2 the opportunity set available to the three farmers. Now Farmer 2 finds that his CEL is line 2 (with slope $\xi_2/2$) in the figure and point B represents his new crop portfolio. At this point, even though all three farmers have the same absolute level of financial obligations their reactions to the new market opportunities are quite different because $E(U_1) < \Pi_{*1}$, $E(U_2) = \Pi_{*2}$ and $E(U_3) > \Pi_{*3}$. Farmer 2 is less happy, but still willing to produce (although a more risky portfolio); Farmer 3 is also less happy, but quite satisfied with the more-than-adequate returns of his new, more risky portfolio (at some point to the right of B); Farmer 1 is in the uncomfortable position of deciding whether or not to remain in agriculture. For Farmer 1, his preferred new crop portfolio would be found at the point (to the left of B) where a line (approximately) parallel to his CEL (which is line 1) is tangent to EV_2.[2]

As Figure 3 is drawn, Farmer 1's new (more risky) portfolio will generate profits such that $E(\Pi_{\phi 1}) \geq \Pi_{*1} > E(U_{\phi 1})$. This forces Farmer 1 to choose one of these courses of action: (1) produce the new portfolio in the hopes that future external shocks will increase returns to at least the original level, (2) produce the portfolio represented by point B and live with more risk than is comfortable for that person, or (3) seek higher returns by shifting at least some assets out of agriculture. Finally, assume another round of external shocks further erodes the profits offered in agricultural markets and EV_3 represents the choices available to the three farmers. Now it is assumed that line 3 is the CEL (with slope $\xi_3/2$) for Farmer 3 who adjusts into the production of the crops in portfolio C. Portfolio C is less profitable and more risky than Farmer 3's previous crop portfolio, but it still generates returns that are adequate to meet his financial objective. As Figure 3 is drawn, Farmers 2 and 3 are not happy about the prospects available to them in the current market (based on where lines approximately parallel to their CELs would be tangent to EV_3—to the left of C). Farmer 2 is now in the difficult position that Farmer 1 was in after the shift to EV_2 and Farmer 1 now faces a situation $[E(\Pi_{\phi 1}) < \Pi_{*1}]$ that is forcing him to consider immediately shifting some or all of his assets out of agriculture in search of higher returns. In general, this example illustrates two propositions:

PROPOSITION 2. *External shocks that reduce agricultural profitability cause all farmers to shift into the production of more risky crops.*

PROPOSITION 3. *Farmers who are relatively more risk averse will be the first to diversify out of agriculture, ceteris paribus.*

Proposition 2 is consistent with observed national trends. Profits per unit in agriculture have declined for decades. For example, in 1994 U.S. farm marketings totaled $181.3 billion while total production expenses were $166.8 billion, making gross income from

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[2] Indifference curves are convex, so a major change in the location of the concave EV may cause

the new point of tangency between the EV and an indifference curve to identify a new CEL that is not perfectly parallel to the original, but for small changes in the EV the old and new CELs will be nearly parallel.

marketings $14.5 billion, equaling an 8.0 percent gross margin on marketings. In 1999 farm marketings were forecast to total $192.5 billion, total production expenses were $190.1 billion, leaving a gross income from marketings of $2.4 billion for a 1.2-percent gross margin on marketings (USDA 1999). The profit squeeze has been widespread and significant: from 1990 to 2000 the USDA's index of prices paid by all farmers for inputs increased about 19 percent while the index of prices received for outputs dropped 7 percent. As shown in Table 1, total acreages of vegetables (crop category 3) and orchards (crop category 4) have increased despite the decrease in total land in farms. Many regions not known for production of these crops are adding them to their portfolios (Weimar and Hallam). Also, the decreasing numbers of farms and full-time farms show that people continue to diversify out of agriculture, first partially then entirely, as suggested in Proposition 3.

Concluding Comments

Advances in production technology make market expansion necessary, while advances in storage and transportation technology make market expansion possible. When adoption of a technology becomes economically feasible, market expansion occurs and the profitability of that market is altered. Thus technological advances are both "industrializing" agriculture and globalizing agricultural commodity markets. The link between these trends is profitability.

All of this is bad news for American farmers and ranchers. Global competition in commodity markets will continue to increase as technology changes the comparative advantages of nations, making agriculture more profitable for less-developed countries and less profitable for more-developed countries. Gradually the highest-cost suppliers will be forced to leave the markets as falling prices reduce profit margins.

The continuing profit squeeze in agricultural production is having a significant effect on the cropping choices of America's farmers. In general, that effect has been to cause acre-

Table 1. Census of Agriculture Trends

	1959	1964	1969	1974	1978	1982	1987	1992	1997
Land in farms (Million acres)	1,123.5	1,110.2	1,062.9	1,017.0	1,014.8	986.8	964.5	945.5	931.8
Farms (1,000s)	3,710.5	3,157.9	2,730.3	2,314.0	2,257.8	2,241.0	2,087.8	1,925.3	1,911.9
Full-time farms (1,000s)	2,046.7	1,695.7	1,248.0	1,302.6	1,054.5	1,053.6	972.2	932.5	869.7
Farms of 1,000 acres or more (number)	136,427	145,292	150,946	154,937	161,101	161,972	168,864	172,912	176,080
Vegetable acreage (Million acres)	3.491	3.334	3.352	3.124	3.534	3.331	3.468	3.782	3.773
Orchard acreage (Million acres)	4.120	4.251	4.234	4.190	4.464	4.751	4.560	4.771	5.158

Sources: USDA 1998 and earlier censuses.

age to be shifted out of low-revenue-generating crops and into higher-revenue-generating crops. This shift makes crop portfolios more risky over time, thus encouraging farmers to consider diversifying out of agriculture.

The fact that profits in American agriculture have remained around 2–3 percent for decades, despite farmers' efforts to improve through cropping changes indicates that prices are falling faster than are costs per unit. Unless future technologies can reverse this trend, American producers will continue being forced to make the investment decision to leave commodity markets and, ultimately, the industry.

Finally, U.S. national policies are not likely to change in agriculture's favor given the low returns to investments in agriculture. Krugman (p. 95) concludes that "if foreigners are willing to sell us high-quality goods cheaply, that is a good thing for most of us, but a bad thing for the domestic industry that competes with the imports." Since there are many more American consumers benefiting from the growth of global commodity markets than there are agricultural producers being squeezed by the increased competition, America will continue to shift its resources and policies in the direction of increasing agricultural imports. Apparently, this is viewed as a Pareto improvement in the long run and a good investment in the short run.

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