

A Portfolio of Threats to American Agriculture

by

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A Portfolio of Threats to American Agriculture

American production agriculture is one of the most productive and efficient agricultural industries in the world. So, why is it slowly disappearing? In pursuing that question, I gradually identified a large portfolio of threats to American production agriculture including economic, political, social and environmental issues. Each of the threats, considered separately, seemed manageable, but once I began to take a broader view and tried to consider the interrelationships between and among the threats I began to see the “big picture” and to realize that solutions are not obvious because the solution to one problem is the source of another problem. The story behind each of the numerous threats, and the interrelationships between them, is laid out elsewhere (Blank 1998). In this paper I outline some of the biggest economic issues threatening the long-term survival of American farming and ranching.

The declining trends are apparent in Census of Agriculture data reported every five years by the U.S. Department of Agriculture. For example, in Table 1 are numbers from the nine most recent censuses showing that land and farms are leaving agriculture. Both of these trends have been in place for decades and, until recently, have been explained as natural results of the “industrialization” of agriculture. Economists noted that as more technology is used in the agricultural production processes, more “economies of scale” would provide incentives for farms to grow larger (Johnson and Martin). Indeed, more large farms exist now than in the past (Table 1). However, the trend of declining acreage in agriculture seems contradictory to the trends of growing farm sizes and increasing total revenues. My recent analysis of the trends in American agriculture found that there are relatively new changes in U.S. and global agriculture that pose real threats to American producers.

In general, the threats to American agriculture are derived from the intersection of global and local scales of decision-making. International economic development, personal finance decisions and political, social and environmental issues are all part of the portfolio of threats. At the top of the list of threats is the bottom line.

The Bottom Line

Profits to American agricultural producers are being squeezed. For an increasing number of commodities, *price is global, production cost is local*. Thus, profits vary by location. By that I mean the markets and prices of commodities have become global in scope, while production costs remain local. With a single competitive “world price” ceiling affecting producers of a global commodity, it means that local costs determine the profit per unit for producers dispersed across the globe and, therefore, costs determine which producers will survive in the long-run.

What created global markets and prices? Technological advances. As research gave us new and better machines and methods of producing, storing, transporting and processing commodities, it made it increasingly possible for American and foreign producers to supply commodities to buyers in more distant locations (Antle). Within the last 25 years science has made it possible for “fresh” produce grown on one continent to be sold to consumers on another continent. In California, for example, consumers eat fruit from Chile during the winter and many of those consumers do not realize that they are eating imports, rather than the output of California’s own fruit industry. Why are American consumers unaware of the increasing amount of imported food in their shopping cart? The price, appearance and quality of the Chilean fruit, and other imports, are about same as that for local produce available during our summer. Although consumers benefit by having increased supplies available to them, the global effect of technological advances on American farmers is an increase in the competition between them and other suppliers of commodities.

Why local costs? Production costs will always be local because resources are inflexible. Land, obviously, is fixed in location and productivity, labor mobility is low for low-paying jobs

in agriculture, and local supplies of other inputs like water, fertilizers, etc., affect the prices of those resources. In other words, a farmer or rancher's costs per unit of production are dictated largely by the quantity and quality of resources close at hand.

What have been recent commodity price and cost trends? World prices, ignoring seasonality, are relatively stable or trending down in real terms due to increased total supplies and competition between suppliers. Table 2 shows the nominal prices of a sample of commodities (field crops, vegetables, and tree crops) in recent decades. Those prices reflect the increases in total supplies made possible by technological advances. These data show two things, not just that prices go up and go down over time, but that they go up and go down over time in significant swings. Recent price levels are not especially high (note that all of the prices were lower in 1992 than they were in 1982), but their degree of variability – their risk – is quite high. Bankers have noticed the risk in agriculture, relative to other industries, and they remain concerned about the lower rates of return available in agriculture compared to alternative investments (Setala).

Local costs are rising across America. Land prices increase with capitalized investments and with pressures from non-agricultural uses such as urban sprawl, especially on the east and west coasts (USDA 2000a). In 1994, the average price for an acre of farmland in the United States was \$798, and in California it was \$2210. In 1998 those prices had increased to \$974 and \$2610, respectively.¹ Labor prices are being pushed up in the competition with non-agricultural opportunities that are increasingly available to workers. From 1994 to 1998, the average wage for hired agricultural labor went from \$6.39/hour to \$7.47. Other input prices also continue to increase.

In general, two indexes illustrate the problem. From 1990 to 2000, the USDA's index of prices received by agricultural producers for their output decreased 7%. Over the same period, the USDA's index of prices paid for inputs by agricultural producers increased 19%. So, if your prices are flat or declining (without adjusting for inflation), but your costs are continually rising, therein lies the profit squeeze.

Hence, income at the farm level is low and not improving in American agriculture despite continued growth in agricultural revenues. Recent numbers illustrate the problem. From 1994 to the most recent forecast for 1999, total U.S. farm marketings (the money received from the sale of a product) increased from \$181.3 million to \$192.5 million (USDA 1999), but what is the profit line doing? If you subtract total production expenses, you get the difference which is gross profitability. Gross income from marketings was \$14.5 billion in 1994 for the whole nation, and it was \$2.4 billion in 1999. Thus, in 1994 U.S. agriculture had an 8% gross profit margin; in 1999 the profit margin was 1.2%. Over the last 20-30 years, agriculture's gross profit margin has been in the 2-3% range, on average (Bjornson and Innes). That is relatively low – you can do better just taking your money to the bank. From 1993 to 1999, the average rate of return on equity in American agriculture ranged from 0.9% to 3.2%. The average real net returns to assets financed by debt has been negative every year since 1993 and was -3.8% in 1999 (USDA 1999). Once again, therein lies more of the pressure. 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 2000b p. 37).

Efforts to improve the profit margin for commodities focus both on prices and costs. Strategies that have been successful in raising prices range from adding value to a commodity (through processing, etc.) to using strategic alliances or integration of producers and processors.

¹ It is worth remembering that farm land prices are pushed up, in part, due to expectations of income earning potential that are occasionally shown to be overly optimistic. For example, in the mid-1980's farm land prices fell 50-60% in some regions. The USDA (2000a p. 30) reports that after 14 years, “most regions have regained all that they lost during the 1980's,” but the Northern and Southern Plains still have land prices below those observed in the early 1980's.

Unfortunately, these strategies are not often available to most producers. Therefore, farmers and ranchers have focused mostly on strategies to lower costs.

Two general cost strategies have been most successful: (1) reducing cost/unit by increasing the scale of operations, and (2) reducing cost/unit with technological advances in production and/or harvest methods and machines, as well as developments that raise yields. The first strategy is most readily available to producers, so it is used nationally, as indicated by the steadily increasing average size of farms. The second strategy has been the most successful – technological advances have kept American producers competitive, on average, with other commodity suppliers by greatly expanding yields and reducing costs per unit (e.g. Thompson and Blank). When technological advances occur, early adopters reap the greatest advantages, but those advantages erode over time as other producers catch up and adopt the technology. Also, the second strategy feeds the first because technological advantages have often come with high price tags (for harvesters, etc.) that add incentive for producers to expand farm size to fully capture the economies of size in the new technology (hence the increasing amount invested in machinery and equipment per farm noted in Table 1). Both of these cost strategies have helped to slow the cost squeeze, but they are unable to reverse it permanently.

Local Decisions

Faced with a world price ceiling and a steadily rising cost floor, individual American farmers and ranchers are being squeezed out of one commodity after another. When one product becomes unprofitable or simply less attractive relative to alternatives, producers are forced to look for another crop or livestock enterprise that offers better returns. As a result, low-revenue crops are often being replaced by higher revenue crops. This process can continue only as long as the local climate and productive resources are suitable for the production of a higher value commodity.

The aggregate result of these individual decisions is that American agriculture is moving up the “Farming Food Chain.” A detailed explanation of the individual decision process is presented in the appendix. Figure 1 shows the four general categories of crops and that movement from one to another category is virtually always in the upward direction, meaning from lower to higher value crops.² High-value perennial crops, like tree and vine commodities, certainly generate more revenue per acre than low-value annual crops, like grains, but there are drawbacks to moving to higher returning crops. First, more money per acre must be invested for higher value crops. For example, it is common for tree or vine crop producers in California to invest \$10,000 to \$20,000 per acre in improvements to land. Second, that investment goes into assets that are much less flexible than those used for lower value crops. Thus, higher returning crops are much more risky.

² Figure 1 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, like 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, like 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 like 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 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.

Table 1 documents America's climb up the Farming Food Chain. Nationwide, acreage of vegetable crop production increased 8% between 1959 and 1997 despite the 17% decrease in total acreage in agriculture. More impressive, there was a 25% increase in orchard crop acreage between 1959 and 1997.³

Unfortunately, the nature of tree crop production and markets can cause growers' efforts to backfire. For example, because of the lag between planting and production in tree and vine crops you often see the problem we are now observing in the California almond industry. Almonds were very profitable a few years ago, attracting growers and leading to significant increases in acres planted. Now, as that new production hits the market, there is not sufficient demand to absorb the increase; hence market prices for almonds are very low. The result is that new and previously existing acreages are not generating the expected levels of profits, but growers cannot afford to pull out productive trees. Thus, prices will remain low for several years as demand slowly grows to absorb the higher supplies being produced. This same phenomenon is being reported in the California walnut industry and elsewhere. So, agriculture is in a situation of continued pressure on profitability.

For individual farmers and ranchers, profitability pressure creates the *need* to take on more risk (Blank 1998), while government policy creates the *willingness* to take on more risk (Skees). Farmers are moving up the Farming Food Chain and counting on Uncle Sam to be there if disaster strikes. So, the profit squeeze is pushing producers to change the composition of their crop "portfolio."

Eventually, farmers and ranchers are *choosing* to leave agriculture out of personal economic necessity – it is an investment decision. The fact that "good" producers are leaving agriculture surprises people because of the following assumption mistakenly believed by many in agriculture: "the most efficient producer will be the last to disappear." That assumption is not true! Being efficient is not sufficient for survival as a farmer or rancher. Consider these conditions:

1. Being *profitable* is necessary, but not sufficient for survival.
2. Being profitable and able to under-price all direct competitors are necessary, but not sufficient for survival in the long-run.
3. Conditions 1 and 2 above plus being willing to accept agriculture's low returns on investments are sufficient conditions for long-run survival.

To illustrate the point, consider the case of a farmer in California's Central Valley. He may want to grow wheat, just like most farmers in the region did during the decades before the large-scale irrigation projects were built. However, the cost of the irrigation systems and other improvements to land has helped push up his land costs such that he cannot make a profit in wheat despite the high yields that could be produced. He is forced to grow high-value annuals, like tomatoes, or perennials to generate enough revenue to have a reasonable chance of being adequately profitable in the long run. The producer must choose between those risky crops and the non-agricultural investment opportunities available to him. In California, urban sprawl is pushing land values up to levels that cannot be matched by any agricultural product. Thus, the farmer may *want* to stay in agriculture, and may choose to hang on as long as he can make some profit in tree and vine crops, but eventually he has to think of his family's wealth. At that point, the best investment of his land and other assets may be outside of agriculture.

³ Some might argue that the increase in vegetable and orchard acreage is due simply to expanding demand for fruits and vegetables in the diet. However, that argument is inconsistent with the decrease in total acreage in farms. Clearly expanding demand contributes to the relative profitability of fruit and vegetable crops, but that only helps partially explain why some acreage is shifted from low-value crops to the higher-value crops (a "substitution effect"), it does not explain why acreage is taken out of agriculture. The *absolute* (low or negative) level of profitability of low-value crops also forces some acreage to shift into higher-value crop production or, if that shift is not possible or desirable, to shift out of agriculture.

Global Developments

Technological advances have wide-ranging effects over time. First, they lead to more efficient agricultural production and the globalization of markets by increasing total production and creating methods of transportation and storage that enable those supplies to be distributed worldwide. These trends, in turn, fuel international economic development. What we are now seeing is that economic development pushes countries up the “Economic Food Chain.”

Figure 2 shows that countries move up the “food chain” as they develop. “This means that countries go through a series of development stages, each with a different focus. Ultimately, nations withdraw their resources invested in lower stages as those resources are needed for new investments in higher stages. Stated more directly, economic development starts by focusing on *food*, then it focuses on freeing labor and other resources from agriculture for use in other, more profitable production as opportunities arise. Food is the entry level, the base industry” (Blank 1998, p.13). This shift is apparent in U.S. Gross Domestic Product data that show about 8% of GDP coming from farms in 1947 and only 1.1% coming from farms in 1997 (Lum and Yuskavage). All developed countries exhibit the same trend of declining importance for agriculture in their GDP (Antle).

Eventually, some developed countries will *choose* to leave agriculture due to efficiency concerns – it too is an investment decision. At some point, it will be inefficient for a country to invest resources in agricultural production when more profitable investments will contribute more to the nation’s wealth (i.e., deadweight losses will occur if resources remain in agricultural production). No country has reached that point yet, but several small western European countries, Japan and the United States are getting close enough that the idea must be faced. Debertin documented that despite the massive introduction of productivity-enhancing technologies, real cash receipts from the sale of American crops and livestock in 1995 remained almost exactly where they were in 1949. Much of our labor, capital and management resources that remain in agriculture are there by choice but could be better invested elsewhere. For example, there is a need for skilled workers in American hi-tech positions. Ballon reported that “U.S. companies will have openings for more than 1.6 million information technology workers this year. But more than half of those jobs will go unfilled in the U.S. because of a lack of qualified employees.”

Global competition is a two-edged sword for America. It is a source of economic pressure on U.S. agriculture, but it is also America’s future source of raw agricultural commodities. Our farmers and ranchers are disadvantaged by higher production costs when trying to compete with less developed countries in global commodity markets. Yet, those developing countries will continue to be able to deliver commodities to us after our own producers have left the markets. This raises two important questions that are discussed in the next two sections.

Can the U.S. Leave Agriculture Entirely?

America is moving into stage 4 of the Economic Food Chain along with Japan and some European countries. Our increasingly wealthy and educated country now invests much of its resources in stage 3 industries and is poised to make significant strides into stage 4. To reach this point we have pulled all but 1.3% of our population out of farming and ranching for use elsewhere, and we import significant amounts of food. For America to leave agriculture entirely, two conditions must be met.

First, the world must be able to supply its total population with adequate quantities of food. There is a sizeable literature that says total world production of food will not be a problem in the future, despite population projections of up to 12 billion by the end of this century (e.g. Antle, Coyle *et al.*, Rosegrant and Sombilla, Tweeten). How is this possible without American farmers? As America removes resources from agriculture and stage 1 and 2 industries, the resulting gaps in world output are filled by less-developed countries moving up into those stages

of their development.⁴ For example, China is expected to shift from being an importer to an exporter of wheat (Rozelle and Huang).

Second, other countries must be willing and able to provide America with agricultural commodities. America has helped some of the world's poorest countries develop their agriculture so that they can progress enough to become customers for our hi-tech exports. By helping these countries free up agricultural labor for investment in stage 1 and 2 industries, we help them earn enough wealth to begin buying the products of our stage 3 industries.⁵ However, in creating customers for our higher-value industries, we have hastened our departure from agriculture by aiding in the development of competitors. Now those less-developed countries can sell us their new agricultural surpluses and can do so at prices that are often lower than the breakeven price for domestic producers. Ultimately, America has created a situation of *mutual dependence* that in the future will assure us of a stable supply of agricultural commodities from countries dependent on those sales to us to fund their continued development.

"If you can't beat 'em, join 'em." American agribusiness firms are taking a global perspective and adopting the price and cost strategies noted earlier. Numerous examples exist now of how American agribusiness is maintaining its boom by increasingly seeking out the least-cost sources of agricultural commodities. That means they are using strategic alliances, direct foreign investment and other methods of securing foreign sources of the commodities they use as inputs into their processing and distribution industries (Bardhan and Udry p. 115; Gopinath *et al.* 1998, 1999; McCorriston and Sheldon; Swenson). By doing so, American firms both guarantee American consumers a steady supply of food, and they speed the economic development of the countries supplying us. It is part of an expanding system of mutual dependence that will assure America of an uninterrupted food supply.

What About Comparative Advantage?

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 (Thurow pp. 65-74). When those advances result in changes in the relative profitability between industries, it 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, like 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. 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 was 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.

⁴ In markets for agricultural commodities, there are many cases in which the causality of these shifts are reversed. In other words, it is likely that the entrance of new supplies in the global market from less-developed countries is causing the exit of American commodities in some cases, as discussed in the next section.

⁵ The World Bank's managing director said that Asian economies will contribute about 50% of the growth of global gross domestic product in this century (Agence France-Presse).

Figure 3 illustrates the effects of absolute cost advantages in global commodity markets. To begin, 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 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.

Normally, 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 input costs (e.g. wages, land prices, etc.) or by adjusting its currency exchange rates. A country can make the price of their product in which they have a comparative advantage competitive in absolute terms by forcing down input costs and/or lowering the value of their currency. However, this is easier to do in a less-developed country that is trying to export a limited variety of products, compared to a more-developed country like America that exports many different products. For the less-developed country, the relatively large impact of export sales for a single (or few) important product(s) will be felt in factor markets to a much greater extent than will the affects of export sales of any product from a more diversified, developed country. For example, when Cuba's economy centered around the production of sugar, export prices of sugar greatly influenced wages and other input costs in that less-developed country. On the other hand, sugar produced in Hawaii (although important to the local economy) had insignificant affects on the U.S. wage rate through currency changes because sugar was such a miniscule part of America's total economy. Also, factor prices in Hawaii did not fall sufficiently to lower the production costs of sugar because many alternative uses were available for labor and other resources. As a result, the Hawaiian sugar industry suffered a profit squeeze that forced it out of business. This example is typical of cases where a regional comparative advantage in the production of some commodity is insufficient to overcome the industry's absolute disadvantage in a global market.

Concluding Comments

In general, it appears that if markets are allowed to work and individual and global investment decisions are made, production agriculture in America will continue its gradual disappearance. An increasingly urban America has tired of subsidizing our farmers and ranchers. Agriculture is losing its appeal as an investment for our nation.

The difficulty American agriculture has in fighting these trends has this bottom line: *everything that is happening in this development of a global market is good for U.S. agribusiness firms and American consumers.* The fact that we now have both domestic and international producers willing to provide us with products at the same or lower prices means that we are eating better and the price is not going up. Politicians do not want to change that. As a result, in recent years American farm policy has shifted away from agriculture (Bonnen and Schweikhardt). The last farm bill, the “Freedom to Farm Act,” clearly signaled that the U.S. government intends to get out of the agriculture business which, ironically, is what agriculture has been requesting for decades. Farmers have said “let supply and demand set prices, not government policies,” and that is what is happening. What this new policy means is that U.S. producers are now less protected from the competition of global producers. Unfortunately, there are less than 2 million American producers and they cannot win any political battles against the 260 million consumers of the cheap food being provided by the global market.

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APPENDIX

This appendix presents an explanation of an individual's crop portfolio decisions. A portfolio model constrained by a safety-first criterion is used to evaluate the investment decisions facing individual producers, leading to some general conclusions presented in the form of propositions. In brief, the model shows that whenever changing market conditions result in decreased profits from the existing mix of crops in production, a farmer will be forced to change the composition of his/her "crop portfolio" to a new mix that is expected to generate sufficient profits to meet his/her financial requirements. Over time, the crops added to the production mix in response to profit pressures will generate more revenue per acre, but will be more risky, making the farmer's crop portfolio more risky, thus adding incentive for the farmer to begin diversifying outside of agriculture, even if he/she does not want to do so. Therefore, a "profit squeeze" forces changes in cropping patterns at both the individual and national aggregate levels.

Decisions in a Declining Market

In portfolio theory, utility maximization is assumed to be a person's objective. Therefore, the focus of decision making is the certainty equivalent of expected profits, which Freund has shown is

$$(1) \quad E(U) = E(\pi) - (\lambda/2)(\sigma^2)$$

where $E(\cdot)$ is the expected value of (\cdot) , U is utility, π is profit per acre from crop portfolio, λ is a risk-aversion parameter which is zero for risk-neutral farmers and positive for risk-averse producers, and σ^2 is risk defined as the historical variance of average profits per acre for portfolio. 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 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 (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 $\Pr\{\pi < \pi^*\} < \alpha$, where α 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 α , 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,⁶ 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 , that is expected to at least equal some minimum level of return, π^* , thus: $E(\pi) \geq \pi^*$. At this point, a farmer is assumed to prefer having all of his/her

⁶ This return, or profit, can be expressed as either profit per acre or return on investment (ROI).

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:

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

where:

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

and $w_i = 1.0$; $P_i, c_j, k_h > 0$; $Y_i, x_{ij}, z_{ih} \geq 0$. 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. The financial risk faced by a farmer is defined to be the variance in returns from portfolio π .

As noted earlier, the focus of decision making is the certainty equivalent of $E(\pi)$, 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: $E(\pi) \geq E(U)$.

When Crop Portfolio Changes are Needed

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 $E(\pi) < \pi^*$. Also, for risk averse farmers, a change is needed when in the long-run $E(U) < \pi^*$. 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 [$E(\pi) \geq \pi^* > E(U)$], 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 $\pi^* > E(U)$ 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. $\pi^* - E(U)$); for those farmers $\Pr\{\pi < \pi^*\} = 0$ 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. 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 1 (assuming that all four types of crops can be produced in the farmer's location). Crop category 1 (low-value annuals) includes crops with expected returns per acre ranging from a low of (π_{1L}) to a high of (π_{1H}) , with an average of (π_{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 ranges are successively higher such that

$$\begin{aligned} (1L) &< (2L) < (3L) < (4L), \\ (1H) &< (2H) < (3H) < (4H), \\ (1A) &< (2A) < (3A) < (4A), \end{aligned}$$

and that risk levels increase also at higher stages of the Farming Food Chain:

$$(21A) < (22A) < (23A) < (24A).$$

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, r^* , 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 $r^* < (1H)$, then the farmer's new portfolio may contain crops from category 1. If $r^* > (1H)$, the farmer's new portfolio must contain some higher category crop(s). Likewise, if $r^* > (2H)$ or $r^* > (3H)$, then the farmer must produce some successively higher category crop(s). And if $r^* > (4H)$, then some acreage (and/or possibly some other assets) must leave agriculture and be invested elsewhere for the person to receive total returns that are adequate to meet his/her financial objective as constrained by the safety threshold.

PROPOSITION 1. *External shocks that reduce agricultural profitability cause all farmers to shift into the production of more risky crops.*

PROPOSITION 2. *Farmers who are relatively more risk averse will be the first to diversify out of agriculture, ceteris paribus.*

Proposition 1 is consistent with observed national trends. 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 2 (Kimhi).

Diversifying to Remain in Agriculture

When a farmer is willing to consider both agricultural and non-agricultural investments, his/her total return, r , includes profit from all productive efforts plus profits from other assets owned. The farmer's profit function shifts from that in equation 2 to the expanded form in equation 3,

$$(3) \quad r = \sum_{i=1}^n w_i r_i + \sum_{v=1}^m w_v r_v$$

where $r_v = (f_v)$ and $w_i + w_v = 1.0$. In this equation r_v is the profit (ROI) of non-agricultural investment v and is a function of a vector of exogenous factors (x_v) , w_v is the weight (% of assets, \$) of investment v in the farmer's total portfolio, m is the number of non-

agricultural investments in the farmer's total portfolio, and other variables are as defined previously. The variance of returns to the portfolio in equation 3 is

$$(4) \quad \sigma^2(\tilde{r}_p) = \sum_{i=1}^n \sum_{v=1}^m \text{Cov}(\tilde{r}_i, \tilde{r}_v) w_i w_v.$$

When non-agricultural investments are considered along with production options, there are more incentives to move up the Farming Food Chain and to diversify out of agriculture. Empirical work has found that, on average, returns on non-agricultural assets are higher than returns to farmer-operators (Bjornson and Innes). Thus, a farmer can increase his/her level of profitability by diversifying out of agriculture. This is obvious in the case where the expected return on a non-agricultural investment exceeds the expected return on the highest-returning crop opportunity, $E(\tilde{r}_v) > E(\tilde{r}_{4H})$.

Ironically, diversification off-farm postpones the final blow of inadequate profits bringing a halt to crop production. The results of Bjornson and Innes imply that there are non-agricultural investments offering returns higher than anything available in farming, such that $E(\tilde{r}_v) > E(\tilde{r}_{4H})$. Therefore, in cases such as where $E(U_{\tilde{r}_v}) > E(U_{\tilde{r}_{4H}})$, adding non-agricultural investment(s) v to the farmer's portfolio is a necessary condition for continued production. In other words, combining a high-returning investment with lower-returning crops can result in adequate profits to meet financial objectives, even when no crop can do so alone [i.e., $E(\tilde{r}_v) > E(\tilde{r}_{4H})$].

PROPOSITION 3. *Adding non-agricultural investments to a farmer's portfolio of assets enables that person to remain in agricultural production longer.*

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
Machinery & equipment average value (\$/farm)	na	na	9,770	22,303	34,471	41,919	41,227	48,605	57,678
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

**Table 2. Sample U.S. Food Commodity Prices over Time
(farm level, not adjusted for inflation)**

	1962	1972	1982	1992
Corn (\$/ton)	40.00	56.07	91.07	73.21
Wheat (\$/ton)	68.00	58.67	115.00	108.00
Rice (\$/hundredweight)	5.04	6.73	7.91	6.10
Oranges (\$/box)	4.50	2.83	8.80	6.90
Tomatoes, processing (\$/ton)	28.42	35.21	71.57	58.04

Source: *Agricultural Statistics, Annual Summary*, USDA; *California Fruit and Nut Statistics*, California Agricultural Statistics Service, various issues.

Figure 1. The Farming Food Chain

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 2. The Economic Food Chain

Development Stage	Economic Activities	Resources Emphasized
4th	Information production	Capital and management
3rd	Hi-tech manufacturing	Land, capital and management
2nd	Base manufacturing	Land and capital
1st	Exploit natural or	Land and human resources labor
Base	Food production	Land and labor

Source: Blank (1998)

Figure. 3. World market for an agricultural commodity: from one supplier to competitive market

