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External economic drivers and US agricultural production systems

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Abstract

US agriculture operates in a market driven economy, although government policies can have influence on what farmers produce and how they produce it. As with other businesses, agricultural producers respond to economic incentives and disincentives, and make decisions to maximize their welfare; usually measured as net income. We examined how external economic drivers shape the type of agricultural systems that producers adopt. Specifically, we considered the influence of technological advancements, income supports embodied in farm legislation, and changes in market structure and consumer demand. Changes in technology have often favored large-scale and specialized operations. Many of the technological advancements have required large-scale production units to justify the investment. Often the technology has been commodity specific. However, there is some evidence that more diversified production units might be able to achieve economies of both scale and scope. The influence of commodity support programs has been ambiguous. As farm legislation has evolved to decouple production decisions from program benefits, the incentives to specialize in program crops (crops that receive price and/or income benefits under federal legislation, such as corn, other grains and oil seeds) have diminished. However, wealth and risk effects, albeit small, may have promoted or inhibited the adoption of a more integrated system. The ability of producers to adopt more integrated systems has been primarily influenced by their natural resource base and proximity to markets. Changes in market structure, channels and consumer demand in the past five decades have been dramatic with consolidation and specialization in both production and marketing sectors. However, the diversity of consumer demand has also created opportunities for more integrated farm operations. There is an increasing number of consumers who have become concerned about how and where their food has been produced. Markets for organic, locally produced, free range and the like are expected to grow. While price and income supports may have been biased towards specialization (as these programs were targeted to specific commodities), the reduction in risk associated with the programs has enabled producers to expand the number and diversity of their production enterprises. Furthermore, through the use of strategic alliances, cooperation among producers on a regional basis may eventually lead to greater integration and diversification than could be achieved for the individual farm operation.

Key words: specialization, industrialization, economic incentives, Farm Bill, price and income supports, integrated systems, diversification, market structure and concentration, contracts, demand, strategic alliances

External Economic Drivers and Integrated Agricultural Systems

As stated, in the lead article of this issue, integrated agricultural systems are more sustainable and that sustainability must include long-term economic viability. Thus, we seek to identify factors that create incentives or disincentives for integrated agricultural systems. Not everyone agrees with the premise that one of the criteria for sustainability should include economic viability. For example, some suggest that sustainable systems should be based on ecological principles and the social and economic systems be modified to support these systems[1]. Another view posits that sustainable systems must enhance productivity to meet the growing demand of increased

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population growth[2]. Some argue that the wrong economic criteria are being employed, skewing the discussion in favor of large industrialized operations. They maintain that profitability may be a poor indicator of sustainability and that input balance, total energy use, and local employment associated with agriculture would be better measures[3].

The purpose of this paper is not to judge these arguments, but to evaluate how economic factors have influenced the shape of US agriculture with respect to farming practices, structural issues and the type of production systems found. We assume that agricultural producers respond to economic incentives, both monetary and non-monetary, and if producers are to adopt integrated agricultural systems, decisions will be largely based on economic incentives. Studies on technology adoption have shown that the potential profitability, compatibility and complexity, and the steepness of the learning curve have been key factors influencing adoption[4,5]. Although the use of diversified agricultural systems was already waning, the economic benefits of cropping diversity were enumerated in the early 1950s[6]. Expanding cropping diversity (or other enterprises) reduces income variability and risk as long as the enterprises are not highly and positively correlated in yields and prices. The principle is analogous to diversifying one's financial portfolio. However, the use of diversified agricultural systems was already waning as other factors created even larger economic incentives favoring specialization. In order to understand how current agricultural productions systems have developed and how they might change in the future, it is necessary to understand the economic factors shaping these systems. Our primary focus is on three external drivers; technology, farm policy and changing market conditions and structures.

Technological Drivers

In the early 20th century, farms employed close to half of the total work force. In 1930, agriculture accounted for about 8% of gross domestic product, today it stands at $<1\%$[7]. As the number of farmers has fallen by 63%, the average farm size has increased by 67%. This transformation has largely occurred as farmers have become more specialized. In 1900, an average farm produced about five different commodities. Today, the average farm produces one commodity. Specialization has been driven by technological advance[7]. Mechanization replaced draft animals and chemical inputs replaced those produced on the farm. Improved breeding and genetics increased the productivity of both plants and animals.

While some of these advances were size neutral, many of them, especially mechanization, favored larger operations. Tractors, harvest equipment and other equipment require a minimum usage (either acres or hours) in order to achieve optimum efficiency. Thus, as usage increases, producers' per unit costs decrease over a wide range of output. This phenomenon is commonly referred to as economies of size. Furthermore, much of the new technology has been geared toward production, harvesting and handling of specific crops. The adoption of new technology and the accompanying economies of size created incentives for larger farms and more specialized and less diversified farms. However, some studies have shown that larger operations, which achieve economies of size, are also able to achieve economies of scope[8]. That is, costs can be reduced when producing two or more products jointly, rather than strict specialization. It has also been observed that smaller farms tend to compensate for the lack of economies of size by seeking off-farm employment, and that greater off-farm employment has been associated with greater use of technologies that reduce on-farm management time, such as conservation tillage and use of herbicide-tolerant crops[9]. The literature has been unclear whether economies of scope can be achieved on smaller sized integrated operations.

US Farm Policy

Although other aspects of agricultural policy influence the design of agricultural production systems, price and income support programs have had the most direct impact on production systems due to the targeting of specific commodities. Modern US agricultural policy was initiated during the Great Depression of the 1930s to address low market prices and low farmer income. The initial act entitled the Agricultural Adjustment Act was adopted in 1933. The major tools were price and income supports and supply controls. In general, program benefits were linked to a farmer's historical acreage of supported commodities and historical yields[10]. The initial program covered wheat, cotton, corn, hogs, rice, tobacco and milk[11]. The program was subsequently expanded to include rye, flax, barley, grain sorghum, peanut, cattle, sugarcane, and sugar beet in 1934 and potato was added in 1935. However, with successive Farm Bills the list of eligible commodities increased and now includes oil-seeds and peanut, which formerly operated under a quota-based system.

The linkage of benefits to production created powerful incentives for farmers to produce crops covered under the farm program. Since the number of commodities has been limited, producers naturally followed the incentives to continued production of program crops. In addition to the direct income effects of price supports, there were also risk reduction effects[12]. These combined effects, as well as planting rigidities forced by supply control and an inclination for producers to protect their acreage bases, tended to increase technology driven specialization. Just and Schmitz[13] in their investigation of cropping diversity noted that relatively few economists had examined the potential impact of farm policy on cropping diversity versus specialization. Their findings were ambiguous. In many cases reducing support prices or acreage diversion increased specialization, perhaps reflecting attempts by producers to concentrate their efforts on their most profitable enterprise. A shortcoming of their analysis was that only major crops covering a relatively broad

geographic area were analyzed, so diversification occurring at the local level or other enterprises would have been missed in the analysis. By including livestock and off-farm investments in their analysis, Mafoua-Koukenbene et al. 1996[14] found reducing acreage diversion led to more diversification and higher off-farm investments. In a more recent study, researchers examining crop diversity along the US–Canadian border found that cropping diversity in the US region increased when acreage 'set asides' for wheat were imposed[15]. In 1996, the decoupling of subsidies from base acres resulted in a numerical shift to oilseed acreage, but it was not statistically significant. The lack of increased cropping diversity may have again reflected the regional aspect of their work. Perhaps the impacts could have been larger in the Corn Belt region where there is higher potential for increased diversity due to the natural resource base, better growing conditions and proximity to large population centers.

Across the numerous Farm Bills, price and income supports have evolved from commodity-specific prices to flexible supports including target prices and deficiency payments, loan rates and commodity loan programs. Prior to 1996, program benefits were tied to actual production decisions, i.e. the producer had to grow the commodity in order to receive a benefit. Thus, production decisions were biased toward program crops. Besides federal expenditure exposure, a major concern was that these programs interfered with market signals and often resulted in the government holding excess supply when crops used for marketing loan collateral were turned over to the government. The 1996 Farm Bill undertook a dramatic change by incorporating a system of direct payments and much greater planting flexibility to replace price supports and supply control programs. Farmers received direct payments based on their historic production (acreage and yields) rather than their current production[10]. Thus, farmers received direct payments whether they grew the crop or not. Growers were also allowed to grow any crop they wished, with restrictions placed on the production of fruits and vegetables. Fruits and vegetables were not allowed to be planted on historical program crop acreage without a reduction in their base acreage, so production of these crops could result in permanent reduction in the base acreage used for determining program payments. This bill 'decoupled' the program support from the actual production decision in an effort to allow farmers to respond to market signals instead of program benefits.

The 2002 Farm Bill introduced counter-cyclical payments that were triggered when prices dropped below a prespecified target price. This mechanism was introduced to avoid emergency support programs that were implemented several times under the previous act. The bill did allow producers to update their historical production bases and yields, and soybean was included for the first time. However, not all program benefits were decoupled from actual production choices. Both marketing loans and the crop insurance program, which subsidize premiums, were directly tied to production. These programs created explicit incentives to expand production of specific commodities[16].

The manner in which producers have responded to these government policies has been relatively unclear. The payment provisions of the past two Farm Bills influenced producer decisions in two basic ways. First, program benefits increased the wealth of producers. With increased wealth, producers may have increased the size of their operations and thereby decreased overall farm numbers. Although no strong evidence for the effect of government payments on farm size has been found[17], there is some evidence that government payments have had a greater positive effect on farm survival for larger farms than smaller farms[18], and that larger government payments may have been associated with greater rural population loss[19].

On the other hand, producers might use increased wealth to diversify their production systems[20]. However, as noted above, depending on which crops might be added, base acreage eligible for government support could be reduced. Most studies indicated that the wealth impact could lead to increased production of program crops; however, the overall impacts would be quite small[17,21]. The wealth effect could also impact the allocation of labor at the farm level. Although, there has been a trend toward greater reliance on off-farm income, government programs have been shown to have a negative effect on off-farm labor participation[12].

The Farm Bill could also affect producer decisions by altering a producer's preference for risk. Producers can be risk-averse, risk-neutral or risk-preferring[22]. Most farmers are thought to be risk-averse and they become less risk-averse as they become wealthier[19]. Therefore, consistent with observations of US farms, an increase in wealth caused by program payments could lead farmers to take more risk[21,23]. The potential impacts of taking greater risk on adoption of more integrated production systems versus expanding the current production system remain unclear[17]. While producers may be more willing to increase their risk exposure, the move to other commodities and, particularly non-program commodities, will have to be assessed with the introduction of a new enterprise. In that non-program crops would have no safety net, the income stream from these commodities could also be viewed as more variable than from a program commodity.

Producers who currently produce program crops may be hesitant to greatly reduce production of these crops. While present program benefits are not tied to actual production, they are tied to production history. In forecasting what changes might be embodied in future Farm Bills, producers might understandably assume future benefits will still be tied to historical production. Working on this assumption, producers would have an incentive to maintain current production patterns to maintain their acreage base[24,25]. Furthermore, as in the late 1990s, the emergency programs to stabilize farm incomes were tied to the production base. A risk-averse producer who assumes future program benefits will be similar to current ones would view the

decrease in historical production base as a distinct risk to future income streams. Thus, producers' expectations regarding future Farm Bills could reduce the likelihood of diversifying the commodity mix.

While the evidence is unclear regarding the overall impact of farm programs on diversification, there are opportunities for producers to take the certainty of program benefits as an incentive to produce other crops. In an USDA–Agricultural Research Service workshop held in Auburn, Alabama, one producer noted that he had greatly diversified his cropping mix and raised feeder cattle as well. His cotton base gave him the opportunity to diversify. Program benefits, such as direct payments, were known with a reasonable degree of certainty and allowed him security to diversify his production efforts. Similarly, some potato producers in Maine have established strategic alliances with dairy producers. As part of their rotation sequences, potato producers grow silage corn as feed for dairy cattle and they use the manure from a dairy producer's operation as fertilizer[26]. The direct payment for corn under the Farm Act greatly reduces the economic risk for the potato producer. The arrangement also enables the potato producer to employ a longer rotation sequence within the potato production system, thereby improving the productivity and profitability of the subsequent potato crop.

Overall, the decoupling of benefits in the Farm Bill from actual production decisions has expanded the opportunities for producers to become more diverse. Although there may be incentives for increased production of program crops, there are also increased incentives (or reduced disincentives) for diversification.

Markets for Agricultural Products

As in agricultural production, food marketing firms have adopted new technologies that created economies of size in processing and distribution. Adoption of new technology by food marketers has also influenced the type of agricultural production systems employed by producers. Other forces such as the increased demands for variety, convenience, packaging, quality, and recently, how agricultural commodities are produced, have also transformed the food marketing system[27]. Today's consumers are demanding a wider variety of goods, higher quality, information on how and where goods are produced, and have greater concerns for food safety. Marketing costs now represent the majority of the consumer's food dollar. The increase in the marketing bill has been accompanied by a similar decrease in the producer's share of food expenditures. The reduction in food costs (both at the farm and retail level) is driven by technological advancements throughout the food marketing system.

With growing demand for convenience, eating habits of many consumers have also changed, reflected in people eating more meals away from home. According to USDA analysis, over 40% of the consumers' food dollar is now spent on meals away from home[27]. This trend has led to the development of major restaurant chains. Importantly, these chains became national in scope. They represent a significant market for US agricultural production, and have significant influence on how the goods they purchase are produced. The emergence of major restaurant chains is consistent with overall increasing consolidation of food marketing firms. Consolidation was driven by the goal of increased efficiency. Supply chain management became a driving force in the food system. The development of mass merchandisers increased the competitive pressure on traditional supermarkets that were already experiencing low sales growth in response to increased food consumption away from home[27]. One method traditional supermarkets have attempted to maintain or increase their profitability has been by reducing the costs associated with acquiring their merchandise. As food marketing firms have emphasized increased productivity through supply chain management, some of the tasks traditionally carried out by these firms have been transferred to their buyers.

The drive towards increased efficiency has led to a reduction in the number of firms and an increase in their size at all stages in the food marketing system. Food marketers beyond the farm have had a greater emphasis on supply chain management. One method to increase efficiency has been to reduce the number of suppliers. Preferred suppliers have large volumes and they carry a broad array of products. Furthermore, retailers have shifted many tasks to their suppliers. Some of these tasks include inventory management, promotional support and stocking. As of 2003, supermarket chains were relying on only three to four providers for the bulk of their produce supplies[28].

The push for efficiencies through supply chain management and the need for greater specificity in product attributes, due to food marketers catering to a wider range of consumer preferences, has led to increasing amounts of agricultural products being grown under contract production. In fact, 39% of the value of US agricultural production was governed by marketing and production contracts in 2006[29]. This was up from 11% in 1969. There are several types of contract production, but the two most prevalent types are marketing and production contracts. Marketing contracts generally specify quantities, quality levels, storage requirements and delivery schedules. The contract also contains a formula for final price determination. The formula usually contains incentives (disincentives) for superior (inferior) performance or quality. These contracts are normally negotiated every season. Marketing contracts are the most common type of contract for crops[30].

Production contracts have many of the attributes of marketing contracts. However, production contracts make production practices explicit, and the contractor often owns the commodity while it is being produced. In many cases, the buyer will provide many, if not most, of the production inputs. Production contracts are common in poultry and hog operations. Production contracts may be multi-year in length, although, they can be as short as a single growing season (<1 year) or a single flock (<2 months)[26]. More

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than half of the broiler contracts were <1 year in 2003 and another 22% of the producers contracted for a single flock. However, 37% of market hog contracts were for periods of >5 years[27].

Marketing and production contracts assure market access and reduce price risks for the contracting producers. They also assure supply for the contractor, enabling buyers to more efficiently schedule the use of their facilities, help facilitate traceability and ensure specific production practices. Contracting does raise some concerns. As more commodities are produced under contract, open market transactions may less accurately reflect supply and demand conditions, become more costly, and may be more prone to market manipulation[31–33]. However, evidence of market manipulation is not conclusive[34] and recent attention has focused on potential differences in the impacts of specific contract provisions[35,36]. While contracting can reduce certain risks, there is also a possibility that contractors can transfer some of their risk to the producer.

Although the literature has been unclear regarding the impact of contracting on integrated systems, most producers who contracted have been from large commercial farms[35]. This is consistent with the idea that, due to the transactions costs associated with contracting, contractors have an economic incentive to deal with fewer, larger farms. There is evidence that large farms which rely heavily on contracts have had a significant competitive advantage over small farms[8], however, there is also evidence that diversification plays an important role in this competitive advantage[37]. Although this appears contradictory to overall trends toward specialization and evidence that contracts lead to a greater degree of specialization[38], the principle has been supported by earlier observations of a positive relationship between farm size and diversification[23]. Contracting requires assets that are specific to the commodity produced on both sides of the transaction (producers and contractors). As a result, contract production has not fostered the growth of integrated agricultural systems. The economic incentives toward large-scale agribusinesses contracting with a smaller number of large farms may, however, provide incentives towards regional-scale integrated systems similar to the alliance between Maine potato producers and dairy producers noted earlier[39].

As mentioned, consumers have become increasingly concerned about how their food is produced. For example, over the past several years the demand for organic food has increased at an annual rate of 20%[40]. Furthermore, organic price premiums over conventionally produced food have been maintained[40], indicating that demand has been increasing at a faster rate than supply. This pattern is not just limited to organic production. Other food labels, such as sustainable, locally produced, grass fed and free range, have also been used to stimulate sales. Large food marketers are responding to these demands as a method to stimulate or maintain sales. The three largest fast food chains now require more humane production conditions for the animals used in their products[27]. The key to successful marketing under the various 'green' labels appears to be third party certification. Under the current Organic Foods Act, third party certification is required before the producer/manufacturer can use the USDA Organic label. Although, most trends in the food marketing system appear to be neutral or biased against integrated agricultural systems, the 'green' phenomenon could foster such systems. Third party certification is seen by some as a way to create more sustainable production and consumption systems and to incorporate ethical practices into existing systems. However, third party certification may in some cases be a requirement for market access rather than a means of obtaining price premiums, and the costs involved with obtaining third party certification can represent an economic barrier for small producers[41].

Many of the production principles used in organic or sustainable production are consistent with integrated agricultural systems. However, some organic vegetable and milk production systems have demonstrated that the industrial model already has significant influence on organic production[42]. While the presence of organic standards has helped boost markets for organic products, there are concerns that national standards may undermine the environmental and social sustainability goals of organic agriculture[43].

Several of the identified market trends, such as supply chain management and contracting, favor larger-scale and more specialized production systems. However, some emerging and established institutional arrangements could contribute to the increased adoption of integrated agricultural systems. In recent years, both formal and informal strategic alliances (arrangements that benefit both parties) have grown in use. One example involves a Maine potato producer, who produces broccoli in his rotation sequence. He has determined that in order to be competitive, a steady volume is required throughout the year. Therefore, he established strategic alliances with producers in the mid-Atlantic region and Florida. Marketing under a common label, these producers can achieve the continual presence in the market. Furthermore, this arrangement has enabled the Maine producer to grow broccoli on his neighbors' fields thus providing the neighboring potato producers with an additional, high value rotation crop. Similarly, other farmers have expressed renewed interest in cooperative marketing.

Summary and Outlook

In our discussion of economic drivers, we have concentrated on technology adoption, government programs and changes in the market place. These drivers share common elements. While some technology has been size neutral, much has not. In general, much of the technology adopted throughout the food chain has created incentives for producers or firms to expand their production to capture economies of size. In general, this effort has also included increased specialization. Previous government policy reinforced the trends of increased size and specialization

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by supporting production of specific commodities. Food marketing firms have faced some of the same incentives (especially the reduction of per unit costs), and thus have preferred to work with suppliers with considerable volume. These forces appear to be obstacles to developing integrated agricultural systems. However, examples from innovative producers can provide some insight regarding how these drivers may be used to foster integrated agricultural systems. An integrated producer in Alabama used the cotton program as a method to reduce overall economic risk, enabling him to develop a broad and diverse system of livestock and other crops. This suggests a need to identify potential rotation crops and livestock operations that are compatible within a system that includes program crops. While whole-farm profitability is important, the impact on economic risk of a truly integrated agricultural system versus a traditional program crop rotation system may be as important. A second need involves redefining the production unit, i.e. the integrated agricultural system. In some cases, the relevant area of interest may be the landscape or the community[39]. The concept of integrated dynamic systems can also be applied across ownership. The case of Maine potato producers and dairy producers cooperating to maximize the use of their land base and manure has already been mentioned regarding the benefits of federal programs[26]. In addition, the relationship enabled potato producers to grow more acres of potato and use silage corn as a rotation crop. The study found that potato and dairy systems coupled for 2 years had greater indications of profitability and sustainability than did their conventional non-coupled systems. A key to their success was the close proximity of the cooperators. The Maine potato–broccoli producer's strategic alliance noted earlier was predicated on increasing the land base, since there was a need for a 4-year rotation. The producer now 'swaps' fields with neighboring potato producers, who receive a larger return than they would from the standard barley rotation crop in the Maine potato production system. As demonstrated by these producers, researchers may be unnecessarily restricting themselves to individual farm units. Through cooperation, individual producers may be able to reap the benefits of integrated agricultural systems, although they may still maintain their identity as a potato producer or dairy farmer. The necessary conditions fostering this cooperation and the barriers that prevent cooperation must be examined.

Market trends seem to favor large-scale and specialized operations, but recent developments may foster integrated agricultural systems. A significant number of consumers are becoming concerned about how and where their food is produced. Although organically produced food currently has the greatest cachet, some predict that locally and sustainably grown products may become as desirable. Reflecting this interest, the term 'food mile' (how far the product moves from the field to the plate) has been coined. Some of this was driven by reducing fuel use and reducing the carbon footprint.

A growing number of food marketing firms are embracing corporate social responsibility policies. These policies broaden the firm's objectives beyond financial performance to include others, such as sustainable growth, equity considerations, social and environmental well-being. For example, many of these policies are focused on where and how the raw ingredients of their products are produced. These firms are responding to the concerns of their customers. This combination of consumer concern and corporate social responsibility could expand the demand for food products that are produced in a more sustainable fashion, including reduced environmental impacts.

However, other real economic benefits may result in the revitalization of rural economies and communities, leading to increased incomes and a reduction in social problems. Research in this area has been limited. Besides production research, the development of human capital and the supporting infrastructure will be equally as important to facilitate the connection between producers and their customers. Without local outlets transportation costs may keep a producer out of the market, especially for the small and medium-sized producer. Pennsylvania has addressed this issue by establishing wholesale production auctions to serve local communities[44]. In 2001, the average sales per auction was US$3.5 million.

In the beginning of our discussion, we identified economic incentives as determining the type of production systems used. A recent review of dynamic cropping systems found them to be more robust than traditional, more specialized systems[45]. Due to complementarities among the crops grown, integrated systems are better able to withstand disease and nutrient and water stresses than conventional systems. These attributes should contribute to increased profitability. Furthermore, the diversity also reduces income variability and the risk of financial catastrophe. These are real economic incentives and, combined with the changes in consumer demand, may provide the opportunity for greater adoption of integrated systems. All the economic benefits and costs (market, environmental, social and community) associated with integrated production systems need to be identified in order to foster adoption.

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