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## BLOCK CHAIN TECHNOLOGY IN FOOD AND AGRICULTURE

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The complexity of food and agricultural products continues to expand. Not so many years ago, food goods like breakfast cereals came in relatively few forms such as sugar coated or not, chocolate or fruit-flavor, etc. But today, multiple layers have been added such as organic, natural, non-GMO, high-fiber, or locally produced. Being locally grown or organic does not confer any visual difference to a food item. Thus, consumers and food processors are required to trust in a variety of claims made by farmers, processors, and retailers about these attributes. At the same time, food supply chains have grown longer as more entities are involved in providing ingredients, in reforming products, and then shipping globally.

Managing supply chains for these complex goods and longer supply chains is more costly and difficult. Paperwork involved in international shipments can include hundreds of documents and approvals, cost millions of dollars, and still is not very useful in managing today's fast-paced supply chains for differentiated and perishable products.

These complexities also create incentives and opportunity for cheating. An analysis by Ferrantino et al (2013) estimated that improving border administration and transportation and communications infrastructure just halfway toward the global "best practices" would result in a 4.7% increase in global GDP and a 14.5% increase in exports. As supply chains get longer, the ability to monitor food safety and quality also increase. Hoffman et al (2012) estimated that the annual cost of food-borne illnesses in the United States from the 14 principle pathogens was $14.1 billion.

Technologies such as genetic modification, gene splicing with CRYSPER, precision agriculture, environmental and climate change adaptation, and shifts in global trade policy will all impact the availability of food goods of different types and from different production systems and locales. Managing these more complex supply chains will be one of the greatest challenges facing the food and agricultural sector as it tries to feed a burgeoning global population in the next 40 years. Providing more accurate, trustworthy, and real time product quality information for supply chain partners and consumers will be critical.

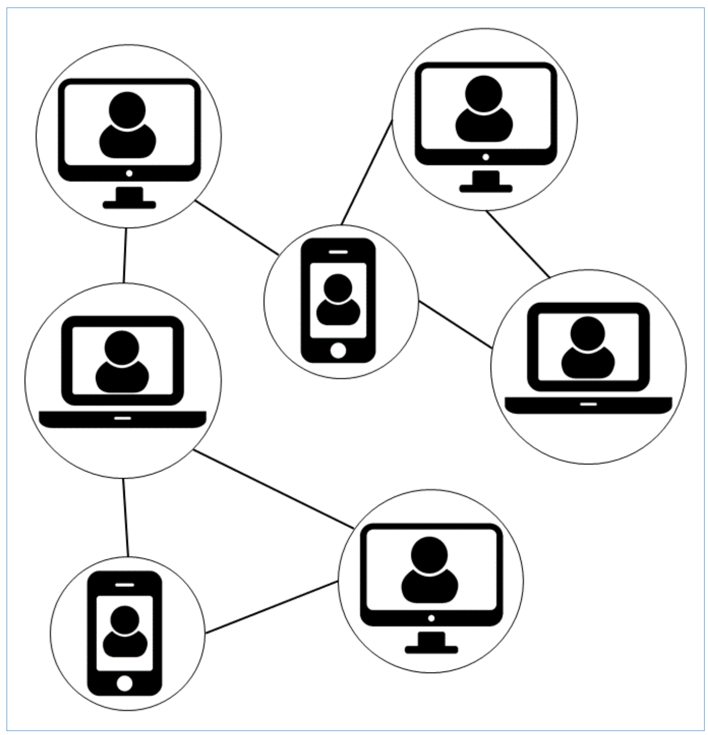
Fortunately, new technologies are emerging from the computer, internet and technology sectors that have great promise in meeting this challenge. Among these is block chain technology.

**What is a Block Chain?**

Block chains are not a new concept but broad awareness of the block chain technology is rather recent. Block chain technology was developed in the early 1990's to prevent back dating of important electronic documents. However, it was not widely used until 2009 when the electronic currency, Bitcoin, was launched. Because no government or banking entity financially backs Bitcoin, the value of Bitcoin rests entirely on the block chain that validates each transaction involving a Bitcoin. Without this block chain, there would be nothing to prevent "counterfeit" Bitcoins from being created and undermining the trust of consumers and businesses in the Bitcoin currency.

A block chain involves a sequence or chain of information that is sequentially altered or amended in a linear progression. Imagine a set of information that is established on the basis of a financial transaction or the production activities of a person or company. This block of information is associated with a code called a hash and if it is not the first block of information in a chain then it is also coded with the hash of the previous block in the chain. As this information is used in subsequent transactions or is passed along a supply chain, it acquires new information to create a new block. In the Bitcoin example, the new information regards payer and payee. When this new information is added then a new block is formed with a new hash but it also carries the hash of the previous block.

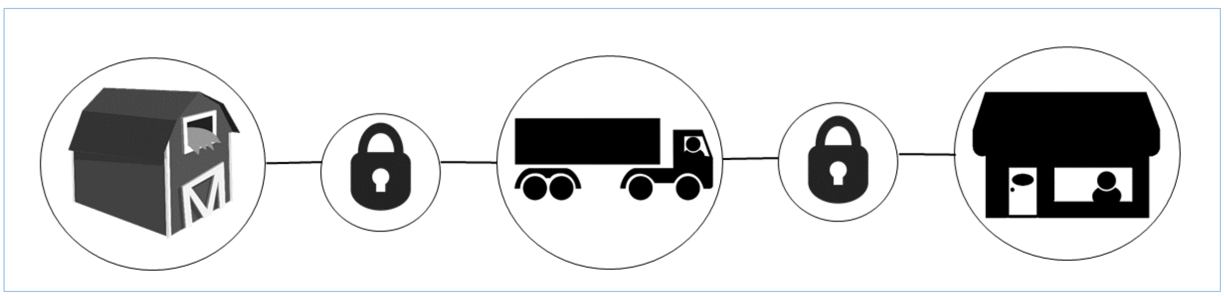
All well and good, but we read every day about large data networks being hacked so what stops a hacker from altering a Bitcoin to put it in their account or use it to buy something? To do this, the hacker has to not only alter the hash of the current block but all subsequent blocks linked to it in order to hide their crime. This is absolutely feasible with modern computers and so effective block chains contain something called "Proof of Work" that slows down the creation of new blocks and makes it far more difficult to tamper with a block chain.



The block chain approach to a supply chain hinges on the creation and evolution of a "digital ledger" of transactions, transfers of ownership or possession, monitoring of product quality measures, transformations of form, and production practices. These digital ledgers would be validated in many cases by electronic sensors (IoT devices) (IoT is "Internet of Things") and the information would be transparent for all supply chain members including final consumers. In some cases, like production practices, third party validators would still be required but they would create blocks of information about farmer compliance. Furthermore, the digital ledgers would be rapidly searchable electronically for key information about products, quality indicators, and activities that occur along the supply chain.

**Block Chain in Food and Agriculture**

Block chain technology has the potential to validate and maintain key information about food products and their ingredients as they pass through the complex food supply chain. Consider an organic corn tortilla that relies on production activities at the farm level and segregation activities during storage, merchandizing, transportation, and processing. A block (a genesis block in this case because it is the first in a chain) of information concerning the key production processes used to produce a "block" of organic corn is created at planting.



New blocks are created as new activities such as weed control, fertilization, harvesting, etc. are undertaken. Each block, including the genesis block, receives a hash. Subsequent blocks are also labelled with the previous hash to create the string of information about production activities that ensure the corn is organic when harvested and each subsequent block is validated by a peer network to ensure that no information is tampered with during the growing and harvesting period.

A new block might be created if the corn goes into on-farm storage to ensure it is segregated and not treated with pesticides. The next block would be created when the product is transported to ensure that it is not comingled with non-organic grain or otherwise contaminated and another when its ownership is transferred to a processor or merchandizer.

Every transfer and every step in transforming the corn into a tortilla will generate a new block that will receive a hash and contain the new information contained in that block about production, handling, and processing. Furthermore, all the information is validated by observation or IoT monitoring devices. The information is recorded in the digital ledger such that when a consumer buys tortillas at the supermarket, they can scan a QR barcode with their smart phone. Consumers no longer need to vest trust in agribusiness, food processors and farmers. They vest their trust in the nearly tamper-proof block chain, the technology of IoT devices and third party validators.

The long supply chain of agricultural products, differences in product attributes, long periods of storage for some crops and perishability of others, and increasing consumer interest in production practices, food quality, and conservation give rise to many potential applications of block chain technology in agriculture. Below are just a few to ponder.

*Traceability*

Some larger retailers, processors, and exporters like Walmart, Louis Dreyfus Commodities, and Cargill have experimented with the use of block chains to increase both the quality and the rapidity of traceability in the food and agricultural supply chains. It has not gone mainstream yet, but the potential is starting to reveal itself. Not only can block chain increase the accuracy of claims about production and product attributes, but it can dramatically reduce the time it takes to search backward in the supply chain when problems occur.

The use of digital ledgers and real time quality measurement would likely reduce the frequency of such events. Imagine a shipment of lettuce, for example, with real-time temperature and humidity sensors or Phicrobe (see Applegate and Bae, 2018) sensors that deliver information about container temperature, humidity, and e.coli presence on a regular basis to a cloud-based digital ledger. In all likelihood, contaminated products will be intercepted before reaching consumers but in the rare occasion they do, traceability back to the source of the problem could be accurate and nearly instantaneous.

*Problems in Agricultural Contracts*

The so-called "hold-up" problem occurs when there are advantages for supply chain members to collaborate but due to the lack of trust, they do not. For example, it is impossible to determine upon inspection whether corn has been grown organically or not. Farmers may have to acquire specialized machinery for weed control and human capital for managing the fragility of an organic production system. Much effort gets expended to write contracts for such crops, but as the recent revelations about fake organic grain from eastern Europe demonstrates these contracts are necessarily incomplete and ultimately depend on trust.

Another possible adverse outcome is when the farmer produces the crop according to contract specification but is undercut by another producer who does not have a contract. The second producer will sell for any price above the cost of harvest. Because quality cannot be determined in real time and the product is perishable, the buyer can claim the contract grower's product fails to meet quality standards and either rejects it and buys from the secondary producer or pays a lower price to the contract grower who has little recourse.

When specific attributes are required, modern food and agriculture functions with contracts. Bogetoft and Olesen (2002) suggest improved contracting in four areas: reducing the costs of risk and uncertainty; reducing the cost of post-contractual opportunism; reducing the direct costs of contracting; and using transparent contracts. Block chains can be easily designed to incorporate "smart contracts" in each of these. Smart contracts are simply computer code that resides within the block chain and determines whether the terms of the contract have been met at any given point along the supply chain. If some key procedure or attribute is not documented in the digital ledger then the next block in the chain is not creatable and the contract is not fulfilled.

If the smart contract is invalidated for some reason, what happens? A new block could be created that branches in a new direction. For example, while the corn may not be considered organic, perhaps it is still "natural" or "low input" or "conventional" and thus continues into a different supply chain that may also require some level of validation with a new block chain. Essentially a new block chain has been created at this point but uses the previous blocks and links up to that point as its beginning.

*Commercial Grain Storage*

Farmers often store some of their grain in commercial storage. Often they contract with a local grain elevator to store their grain for future delivery. While the vast majority of these contracts function well for both parties, fraud does happen and when it does can be devastating to farmers and to state indemnity funds that backstop violations. Most often fraud involves a grain storage entity under financial pressure that sells grain that was to be in storage. Doing so allows the storage entity to generate cash flow but is typically illegal under state statutes. Block chains could be developed to validate transactions and prevent a grain storage entity from selling grain that is under contract for storage and to ensure compliance

with other legal requirements.

A grain storage block could be created when grain is placed in storage and future sales would create a new block in the chain. Regulatory agencies will be able to validate these future blocks because the digital ledger will facilitate more rapid and verifiable oversight. The validation would include linkages to the previous blocks as well as to the total inventory of grain at the storage facility. All of this would happen in real time and prevent the falsification or delays in processing of regulatory paperwork that typically underlies fraud in these cases.

*Conservation and Habitat Markets*

Consumers and interest groups increasingly desire changes in the way agricultural products are produced with respect to conservation, habitat preservation, and sustainability. Farmers respond by saying "if consumers are willing to pay for it, then we will produce it" while interest groups contend that farmers are not doing enough to protect important habitat or reduce adverse effects on biodiversity related to their field practices and land use.

The Conservation Reserve Program (CRP) is a market where farmers with approved fragile lands bid for the government to buyout crop production on those acres. The problem is that the limited government funds do not go very far toward establishing wildlife habitat incentives. At the same time, it would be difficult or impossible for a farmer to obtain higher prices for products produced on a farm where they did sustain wildlife habitat.

What is needed is a market for conservation or habitat preservation. Principally, because it is difficult to pair the limited number of parties willing to pay for such practices with the farmers who are willing to accept those payments. There are two impediments. The first is that the numbers of buyers may be small or individually unable to pay for large tracts of land in habitat preservation. An individual may have sufficient funds to purchase only one acre of habitat but it is unlikely that a farmer is willing to maintain such a small area for a reasonable price. The second is that the buyers and sellers of habitat preservation are likely to be in different geographies where they are unaware of each other and have no ability to validate each other's commitments.

Block chain technology could create a direct market for conservation activities or habitat preservation. It would be a sort of private CRP market – perhaps the government could even create and organize it but private funds would drive its operation and create the boundary on its size. This creates a platform in which individuals with limited means can aggregate their funds to offer more appealing and larger opportunities for interested farmers. Environmental interest groups could also bid in such a market as a means of aggregating individual interests. Again sensors, satellite or other imaging, and IoT devices can be used to validate compliance and performance to make sure that farmers are meeting their obligations. At set points during the year, new blocks of compliance information would be created and validated in real time in transparent electronic ledgers. Farmers would not be able to substitute failed acres due to late planting or weather events for the committed acres (unless allowed in the contract) and would have to validate the establishment of habitat plants rather than a weed patch.

**Who Pays for the Block Chains?**

Which supply chain participant (farmers, processors, retailers, or consumers) will bear the greatest portion of the added costs? As noted earlier, there is substantial hope for reducing transactions costs with the use of block chain technology. In order for block chain to be adopted, these cost reductions plus the increased willingness to pay by consumers must exceed the

cost of implementation.

The economic rule is that the entity or person with the fewest options pays the greater share. In the very short run, farmers have few options. Once a crop of a particular type is planted or animals are bred, there is little that the farmer can do other than market that crop or animals. On the other hand, when consumers go to the supermarket they have many alternatives for their food dollar. If the price of pork is high they can buy beef, chicken or some other protein source.

This means that generally farmers have probably been bearing a greater share of transactions costs in the supply chain in the short run. Processors and retailers generally lie somewhere in between farmers and consumers. Thus, reducing transactions costs with effective block chains should benefit farmers relatively more than other supply chain participants in the short run although all parties must be compensated initially for the investments in technologies that they must make. Notice the emphasis on short-run. Adoption of block chain and the associated costs is likely to turn into a break even proposition for farmers over time, but it will also become a requirement for participating in the market. Thus, early adopting farmers may get the benefits for a short while but longer term can expect participation in block chains to become a contract requirement.

**What are the Benefits of Block Chains?**

Block chains could provide consumers and processors assurance that the products and goods they are buying actually have the attributes they are willing to pay for. Many of these attributes are not visible such as organic, natural, humanely raised, antibiotic free, etc. and so block chains provide a nearly tamper-proof mechanism to validate product claims. There are two economic benefits. Consumers should be willing to pay more to have these assurances and successful block chains are expected to reduce costs. These gains will be distributed to the farmers, processors, shippers, and retailers in the value chain to offset their cost of block chain implementation. Consumers may also benefit from the production of new goods that would have been too difficult to provide without sophisticated validation technology like block chains.

Where are the benefits to farmers? Often farmers feel frustration with new technologies like block chains because it is difficult to connect adoption to higher product prices or lower costs. It is possible that properly designed block chains could result in lower record keeping costs and other transactions costs to farmers. If consumers demand block chain assurances then a benefit to farmers of adopting them is simply access to the market.

There is always the risk that a party in a contract will not perform. This is called counterparty risk and block chains may reduce or eliminate some of these risks. The development of new agricultural products is littered with stories of broken contracts. Farmers can seldom match the volume and scale of their contractual partners in the processing and retail sector. Farmers may work in a contract for several years but face competing farmers producing the specialized crop without any contract. Processors looking for the opportunity to lower costs search their contracts for loopholes to invalidate their previous contracts – unless of course the contracted farm is willing to accept lower prices. Litigating such disagreements is costly and time consuming. Generally, the farm does not have the legal resources to fight such battles and even if they prevail, the final results may not provide a significantly better outcome than the option to sell at lower prices. Block chains could provide real time independently verified information about the quality of the product and the degree to which terms of the contract have been met. Block chain based contracts using IoT devices and other verification technologies would virtually bind the processor or retailer to fulfill their contractual obligations to the farm and eliminate current season counterparty risk. Of course, subsequent year contract renewal risk would remain.

Society also can benefit from block chains because they provide more latitude for farmers, processors, and countries to capitalize on comparative production and processing advantages. Consumers can trust in the block chains and not worry about driving by the local farm to assess whether it is fulfilling its product claims. Transparency and simplicity of block chain based digital ledgers can create increased trust as well as cost savings.

**Conclusion**

Block chain technology takes advantage of improvements in computer computational capacity, the broad distribution and access to computers, electronic monitoring devices, and the wide use of the internet in our modern society. It represents a tamper-proof and transparent method of validating product claims when they are not visible to consumers and/or food processors. It does however require trust in the technology.

Consumers would have access to QR barcode information by smartphone that allows them to explore the product claims and their validation at each step in the value chain. Other participants in the value chain such as farmers and processors gain greater assurance that contract obligations are met whether that be in terms of quality and quantity guarantees or in payment. Government regulators, supply chain partners, and interest groups would find the real time trusted information valuable in assessing compliance with rules and commitments.

We outlined several applications of block chain technology to food and agriculture. Namely, real time traceability, food safety validation, smart contracts, markets for conservation land uses, and commercial grain storage regulation. Many other potential applications exist.

Upcoming innovations such as genetic modification and gene splicing promise to bring even greater specificity to food and agricultural products. The demands for segregation of these products in the supply chain as well as validation of product quality and attribute claims is only going to grow in the future. In order to meet these challenges and to capitalize on the opportunity they represent methods such as block chain technology will be necessary.

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# INDIANA ANIMAL AGRICULTURE: ON THE GROW!

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Animal agriculture is making a comeback in Indiana. The long run trends in the state have been for crop agriculture to become more economically important relative to animal agriculture, but there are some signs of reversal in the past 10 years.

Prior to 1970, the dollars of receipts from Indiana animals exceeded the dollars of receipts from crops. In those earlier years, most Indiana farms were diversified having both grain and animal enterprises. Much of the corn and forages produced on the farms was fed to animals and the animals were the cash generating enterprise. In addition, farms tended to be more similar in size than today.

The 1970s grain price boom helped foster rapid changes on farms. Some farms began to specialize in grain production and to exit their animal enterprises. Technologic changes were rapid in both grain and animal agriculture in the 1980's and 1990's requiring more intensive management skills thus favoring more specialization in either grain or animal production. Economies of size favored larger specialized operations which tended to cause some families to allocate their capital to either grain or animal production. The movement to the industrial production model (large scale) was also an influence in more specialized animal farms. Poultry and cattle feeding had shifted heavily toward the industrial model in the 1950's and 1960's and dairy and pork production began shifting to the industrial model in the 1990's.

Indiana reached a low point in animal production about the year 2000 when the states sales receipts from animals fell to just 1.7% of U.S. animal receipts. More recently Indiana animal receipts have risen to around 2.2% of the U.S. in recent years. This means that Indiana animal agriculture has been increasing more rapidly than the country as a whole.

**Source of Indiana Animal Expansion**

So what is the source of the rise in Indiana animal agriculture? Data from the USDA's National Agricultural Statistics Service (NASS) is used to help find the answer. The four growth enterprises are turkey, pork, eggs, and dairy.

In Figure one, the four panel diagram shows the expansion of these enterprises in Indiana from 2000 to 2017. The number of turkeys produced in the state has risen to 20 million head representing a 47% increase in the past 10 years since 2007. The number of hogs marketed in Indiana rose to a record 9.5 million head in 2017. This was an increase of 39% in ten years. Egg layers rose to a record 32 million head representing a 32% increase over the past 10 years. Finally, milk cow numbers rose to 185,000 head, an 11% increase over ten years.

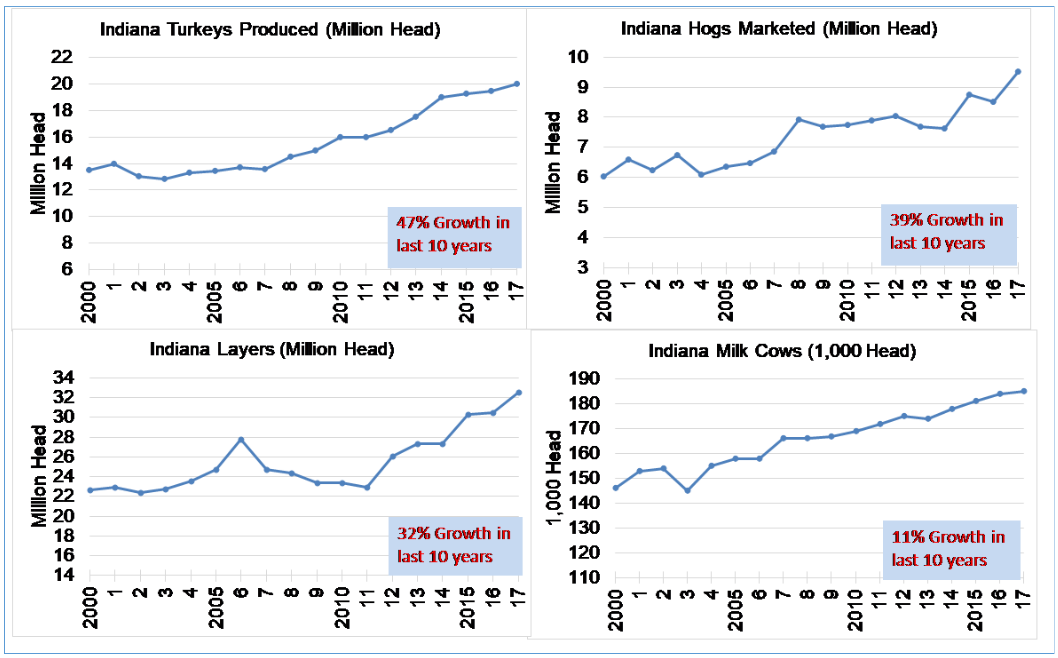

Figure 1. Growing Indiana Animal Enterprises

Table one shows Indiana's rank among the states for each of these enterprises. Indiana ranks are as follows: Layers #2; Turkeys #3; Hogs #5; and Milk Cows #14.

There is more to the states animal industry beyond turkeys, hogs, layers, and milk cows and Table 1 provides this information. First broiler chickens and ducks are also important poultry enterprises for Indiana, but NASS does not report numbers because there is just one major producer in each category. So, broiler and duck numbers are estimates and not official USDA numbers. However, Indiana is commonly known as the #1 state for duck production.

The state's beef sector has experienced some recent reductions, see Table 1. Beef cow numbers in 2017 at 210,000 are down 10% over the past decade and calf numbers are down 7%. Indiana's rank among the states for beef cows has dropped to 34th. Indiana has a number of smaller animal industries that NASS tracks as well from sheep and goats to honey bees.

Table 1

Indiana Enterprise Changes 2007 to 2017 and Current State Rank

| | | % Change 2017 vs. 2007 | State Rank |
|---|---|---|---|
| Hogs | Head Produced | **+39%** | 5 |
| Beef Cows | Inventory | -10% | 34 |
| Cattle On-Feed | Inventory | 0% | 17 |
| Calves | Inventory | -7% | |
| Milk Cows | Inventory | **+11%** | 14 |
| Layers | Inventory | **+32%** | 2 |
| Pullets | Inventory | +19% | 2 |
| Turkeys | Head Produced | **+47%** | 3 |
| Broilers-Estimate | Head Produced | +14% | |
| Ducks-Estimate | Slaughtered | 1% | 1 |

**Summary**

Indiana's animal agriculture has been growing faster than the nation's animal sector as a whole since 2000. The fastest growing sectors over the past 10 years have been turkey, pork, eggs, and dairy. The growth in these sectors has primarily come by the industrial model of large scale production units. The beef cow industry has never industrialized and has not shared in Indiana's animal industry growth.

The growth can be attributed to Indiana's natural resources and location. Indiana's land resource is the foundation of agriculture and its location is advantageous to a large share of the country's consumers. Indiana and western Ohio are in the surplus grain production region that is closest to the large human population base of the east coast and southeast. This provides advantages in lower transportation costs.

Indiana has been able to accommodate environmental concerns that came with industrial production somewhat more successfully than some other states. They have also been able to help Indiana leaders and citizens consider the economic advantages of expanded animal production and processing in adding jobs and economic activity in rural communities. In this way, livestock and livestock processing add value to the basic crop production of the state. Finally, there is a strong infrastructure and knowledge base that supports our major animal industries.

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# FARM GROWTH: CHALLENGES AND OPPORTUNITIES

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*This article is a reprint from FarmDocDaily and the source of the original article is in the references.*

Farm size and growth are often discussed in the context of economies of size. Previous research suggests that the average cost curve in production agriculture is downward sloping or at a minimum Lshaped (Langemeier, 2013). Thus, in general, larger businesses have lower costs of production. Other motivations for farm growth are: to provide opportunities to more fully employ the skills of managers, to add family members to the operation, and to receive better prices on inputs and products sold. In fact, farm growth is a "natural phenomena", in part because successful farm businesses have earnings that they must deploy, and using these earnings to expand the farm business is a logical choice.

Today's environment in which risk and uncertainty are dominant forces may seem like an odd time to think about farm growth. Risk is perceived by many individuals to be something that is "bad". However, entrepreneurs and business owners realize that without some risk and uncertainty, there may not be much return or reward. Also, it is important to note that risk and uncertainty have both an upside and a downside (Boehlje, 2015). The key management challenge is to mitigate downside risk and try to capture the upside associated with risk.

This article discusses ten questions that should be addressed when examining the challenges and opportunities associated with farm growth.

**1. Why Grow?**

There are numerous reasons why a farm may want to grow including the following: reduce costs, improve profit margins, improve asset utilization, bring in new family members, invest retained earnings, and more fully utilize the skills of key managers. Before growing, it is essential for an operation

to think about their strategic direction. Is the operation interested in a commodity based strategy or a differentiated product strategy? A commodity product strategy focuses on cost control. In contrast, a differentiated product strategy focuses on value-added production or receiving an above average price for the farm's products. As an operation continues to think about growth, how growth impacts strategic direction needs to be addressed.

**2. What are My Options to Grow?**

There are at least six growth alternatives available to farms. These include the following alternatives: focus or specialize, intensify or modernize, expand, diversify, replicate, and integrate. Specializing in one activity (e.g., grain production rather than grain and swine production) can improve efficiency, reduce cost, and increase profit margins. Intensifying pushes more production through the same fixed asset base, which can lead to spreading fixed costs over more output and an increase in the asset turnover ratio. Expansion, one of the most commonly used growth options, involves increasing enterprise size. This option should be explored only after exploiting all of the efficiencies associated with the current operation. Diversifying, the opposite of specialization, involves the addition of new enterprises. This option is typically considered risk-reducing. However, in many cases, this option can also lead to economies of scope (i.e., improved asset utilization and reduction in cost). Replication involves expanding the operation through the development of multiple sites or plants. This option allows for decentralized management in smaller units. Integration involves moving forward or backward into production or processing. This option can ensure access to key inputs or outputs, but can also lead to efficiencies and cost reductions.

**3. What Strategic Issues Should Influence My Growth Choices?**

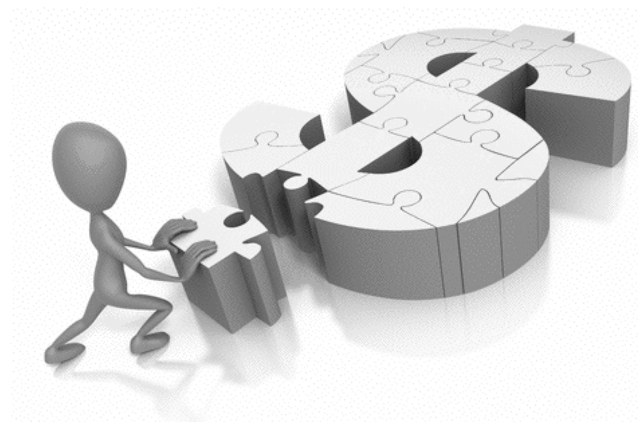
When evaluating growth options, it is important to conduct an internal and external analysis of your farm business. An internal analysis identifies key resources, capabilities, and core competencies. One of the ways to assess resources, capabilities, and competencies is to ask yourself whether your operation has unique resources or core competencies that lead to a competitive advantage. As a farm grows, it needs to make sure that it is fully utilizing these unique resources and core competencies. It is also important to examine the external environment or scan the horizon. What is the social environment and industry environment that the farm faces? How does the current environment and expected changes in the environment impact my growth options? Another way to grapple with the external environment is to think about the key drivers facing the markets for the products being produced by your farm.

**4. How Should Growth Ventures Be Evaluated?**

Successful farms have numerous growth options from which they can choose. The key question is how does a farm choose which growth option to pursue? The following eight criteria can be used in making the choice: strategic fit, expected returns, risk, capital required, the cost and ease of entry and exit, value creation, managerial requirements, and portfolio fit. Many of these criteria are self-explanatory, but we would like to briefly elaborate on the first and last criteria. Strategic fit refers to whether the growth option being explored leverages the current resource base and core competencies of the operation. Does the new growth option require resources or skills that are currently not part of the operation? If so, how will these skills or resources be obtained? Portfolio fit refers to how the growth option being explored fits into the current farm activities. Does the new growth option increase risk or stretch the current management team too thin?

**5. What Skills and Competencies Do I Need to Grow?**

This question elaborates on the importance of conducting an internal analysis of the farm business. In addition to identifying core competencies, it is important to conduct a skill assessment of the current employees. How strong or weak are the workforce's production management skills, procurement and selling skills, financial management skills, personnel management skills, strategic positioning skills, relationship management skills, leadership skills, and risk management skills? How will the growth strategy leverage these skills, or will new skills be required to be successful? For self-assessment checklists of skills see Boehlje, Dobbins, and Miller (2001).



**6. How Do I Finance the Growth of My Operation?**

Besides using debt and equity (retained earnings), growth can be financed through leasing assets or joint ventures. Leasing assets rather than purchasing them can increase potential growth rates. However, when leasing assets, it is important to compare the relative impact of leasing on production cost and risk. Joint ventures or strategic alliances are a common business model used to combine the resources of two or more businesses. This business arrangement may involve entire businesses or specific business activities (e.g., machinery sharing).

In addition to thinking about the funds needed to acquire assets, it is important to examine working capital funding. Many growth opportunities lead to significantly higher working capital requirements, particularly in the start-up phase.

**7. What Business Model Do I Use to Grow?**

There are numerous business models that can be utilized to implement a growth strategy. For example, the following models can be used to implement growth: organic or internal growth, merger or acquisition, franchise, joint venture or strategic alliance, service provider, asset or service outsourcer, agricultural entrepreneur, or investor. Traditionally, most farms have used the organic or internal growth model. With this model, assets are acquired and added to the business through purchases or leasing arrangements. More information pertaining to business models can be obtained from Boehlje (2013).

**8. How Will Expansion Impact My Current Operation?**

When evaluating growth options it is important to gauge how each option will impact the farm's balance sheet and income statement. This can be done using pro forma statements or projections. It is prudent to use at least three scenarios (worst case scenario, most likely scenario, best case scenario) when evaluating each growth option. Particular focus should be given to how each growth option impacts the profit margin, the asset turnover ratio, and returns on investment and equity under each scenario. In addition to examining the impact of each growth option on future financial performance, it is also important to gauge how each option will impact managers' attention and oversight.

**9. What are the Start-Up Challenges?**

Growth options typically face challenges pertaining to construction delays, cash flow shortages, depleted working capital, and short-term operational inefficiencies and management bottlenecks. It is particularly important that differences in these challenges between growth options be explored. Cash flow and working capital requirements can vary substantially between growth options. If a particular growth option creates large cash flow shortages and depletions in working capital, a plan needs to be put in place to deal with these issues.

**10. What is My Sustainable Growth Rate?**

The sustainable growth rate is the maximum rate of growth that a farm can sustain without having to increase financial leverage or look for outside financing. The sustainable growth rate can be computed using information on earnings, retained earnings or savings, and business withdrawals. Once this rate has been computed, it is often helpful to see how this rate changes with the use of borrowed funds. When computing a rate with borrowed funds it is extremely important to gauge how the use of borrowing funds increases risk.

**Final Comments**

Growth enables farm businesses to increase revenue and earnings, take advantage of economies of size, and to more fully utilize the skills of current and future employees. This article briefly discussed ten questions that should be examined when thinking about farm growth.

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# THE ROLE OF GRAIN MARKETS IN THE BOOM-MODERATION CYCLE

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An early lesson in economics is that commodity markets, and the prices they help generate, send signals to producers of how much to produce, what to produce, and when to produce. A good illustration are the signals sent to the world's grain producers during the recent boom-moderation cycle that all farmers are familiar with.

The boom period began with the 2006 crop as grain prices began to rise. This was the 2006/07 marketing year. The moderation period began with the 2014/15 marketing year with prices falling sharply and were generally below total costs of production for many.

During the boom phase, grain prices and revenues rose quickly. Costs were also rising but at a slower rate. Rapid rising revenues and slower rising costs meant that profit margins were extremely favorable.

During the moderation phase starting with the 2014/15 marketing year, grain prices and revenues fell quickly. Costs on the other hand were slow to decrease, but did eventually move lower. In the moderation phase rapidly falling grain prices and slower falling costs meant large losses.

**Acreage Response: How Much to Produce**

Market economics suggest that strong profitability during a boom phase should cause a “supply response” among producers. High profitability encouraged grain farmers around the world to increase production. There are two primary ways to increase production. The first is to intensify production by applying more technology on existing acres to increase yields per acre. The second is extensive, and that is to simply bring more acres into production. The focus of this article is on the global acreage increase due to high prices and profitability.

To do this we looked at the number of acres harvested globally for 13 major crops that include the major grains, oilseeds, and cotton. The data is available from USDA: Foreign Agricultural Service in a database called "Production, Supply, and Distribution" (PS&D). The data base is updated monthly and the data for May 2018 was used for this article.

The base year was the 2005/2006 marketing year. This was the year immediately preceding the start of the crop price boom in 2006/2007. The final year in the analysis is 2018/19 which are USDA's estimates for the U.S. crops that will be harvested in 2018 and marketed into 2019.

How much did world harvested acreage expand? From the 2005/06 base marketing year to the estimates for the 2018/19 marketing year, world harvested acreage for these 13 major crops expanded by 194 million acres. For perspective, 194 million new harvested acres in the world is roughly equal to all of the U.S. acres harvested for corn, soybeans, and wheat-our three biggest acreage crops. World harvested acreage expanded by 8%.

How much of this expansion came during the boom phase from 2006/07 to 2014/15? Much like economics would suggest, 91% or 177 million of the 194 million came during the boom phase. The negative returns in crop production in the moderation phase after 2014/15 dramatically slowed and then virtually stopped growth as global acreage leveled off.

It is logical to ask the question of why crop production losses in recent years of the moderation phase did not cause world acreage to decrease. Another economic principle called "irreversible supply" helps explain this. This simply means that once crop land is brought into production, it requires extremely low prices and enormous losses to move that land out of cultivation. You can think of this in regard to clearing forest land in South America for soybean production. Once the land is cleared and put into soybean production it rarely would go back to forestation.

What is the irreversible supply? A period of high prices brings about an increase in new acres, but a corresponding period of low prices does not drive that same land out of production.

**Where Were the New Acres?**

You may be thinking there were no new acres moving into production in your neighborhood, so where did these new acres come from? The globe is a large place and there were plenty of opportunities for land investors and farmers to expand acreage by 194 million acres as shown in Figure 1.

It is no surprise that South America was the region most able to respond to the markets call for more acreage with 68 million new acres from 2005/06 to 2018/19. On the other hand, most are startled to see the area with the second largest acreage expansion was in Africa south of the Sahara Desert (45 million new harvested acres). Africa has large areas of land

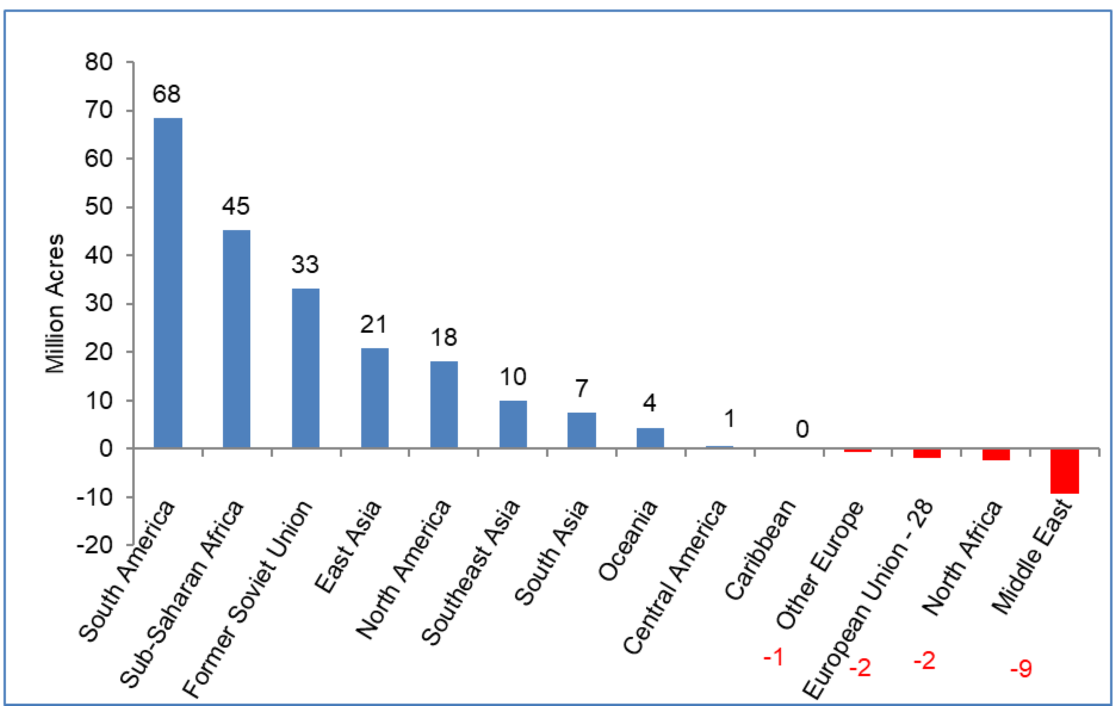


Figure 1: Change in Area Harvested for 13 major World crops 2018/19 vs. 2005/06 (Million Acres): Total = +194 million acres

that have not been developed for crop production. Lack of infrastructure, tribal disagreements, and governmental issues can make development difficult. But strong financial incentives from high world crop prices and investment capital from the Middle East and China were the drivers. Much like South America, Africa will have continued opportunities to expand acreage if financial incentives are ever strong enough again.

Countries in the Former Soviet Union were the third largest area of new acres. Collective farms were the structural model of Soviet agriculture. After the breakup of the Soviet Union in the early 1990s global crop returns were generally low in the 1990's and early 2000's. The boom period starting in 2006/07 increased those returns and provided financial incentives to more rapidly reorganize the collective farms and to get productive land into cultivation.

East Asia was the fourth largest area bringing 21 million new acres into production. East Asia is dominated by China and China is dedicated to feeding their people. China has continued to increase agricultural output. They have done that with land reform, increased intensity of production, and by adding more acreage.

Finally, we get to North America as the 5th largest area of land expansion at 18 million acres. Remember that North America includes Canada and Mexico as well as the U.S. The primary contributor to added acres in North America came from the U.S. in the form of reductions in Conservation Reserve Program acres (CRP). Congress reduced the size of the CRP which had reached over 36 million acres in 2006 and 2007 to a maximum of 24 million acres in the 2014 Farm Bill.

From 2007 to 2018, CRP acreage was down over 13 million acres. Land owners taking land out of CRP were not required to put the land back into crop production. But, given the strong returns of the boom period, much of the former CRP land did find its way back into production. In the Dakota's as an example, harvested acres of corn, soybeans, and wheat rose by 4.5 million acres from 2005 to 2017.

**Markets Tell Global Farmers: What to Produce**

Markets not only told global producers how much to produce but what crops to produce. Figure 2 breaks out the 194 million acre global acreage increase from 2005/06 to 2018/19 by which crops had increasing acreage and which crops had declining acreage. There were two main drivers of the boom period. The first was the global biofuels expansion and the second

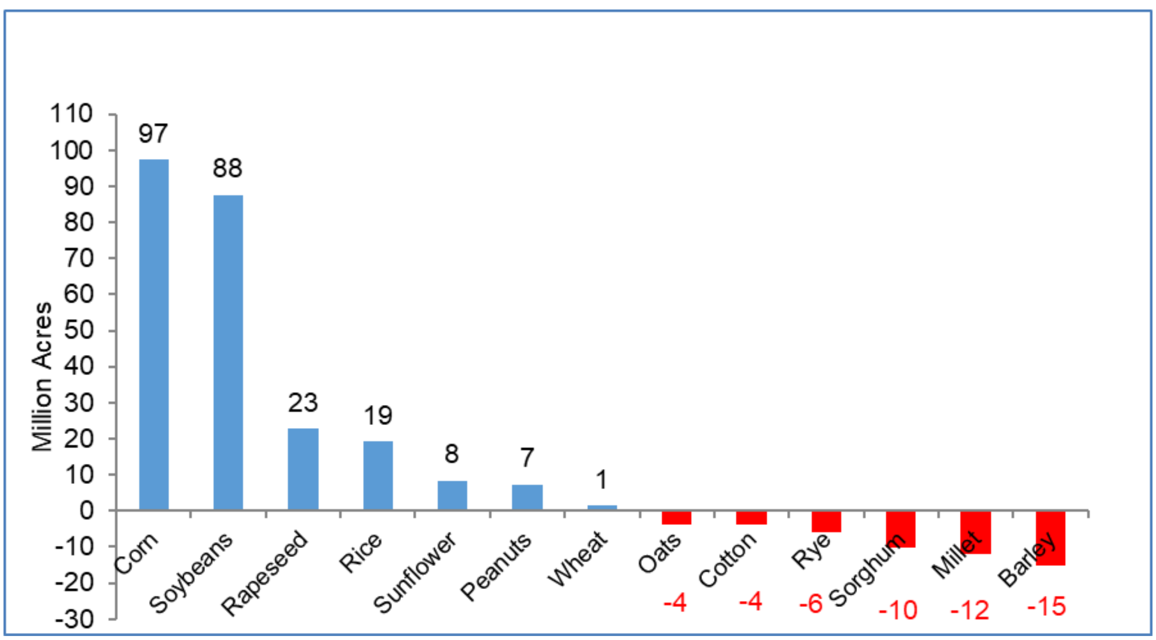


Figure 2: Change in World Harvested Area 2018/19 vs. 2005/06 (Million Acres)

was the rapid growth of Chinese incomes that drove rapid increases in soybean usage.

The biofuels expansion made large new demands for corn and vegetable oils. In the U.S. that meant the need for more corn and soybean acres, In Europe, their biofuels program was primarily based on the expansion of rapeseed to make biodiesel.

Global corn acreage increased by 97 million acres during this period, with soybean acres increasing by 88 million. Rapeseed acres increased by 23 million, the third largest of any crop.

You can also see from Figure 2 that the high demand growth crops not only encouraged 194 million new acres of these 13 crops, but that markets provided incentives to substitute higher return crops for lower return crops. Declining acreage over this time period included: oats, cotton, rye, sorghum, millet, and barley.

**Summary**

Commodity markets are powerful forces. One of the primary functions of the commodity market is to discover prices. Prices then direct global producers in what to produce, when to produce, and how to produce.

The recent boom-moderation cycle was used as an example. During the boom phase, crop prices gave global farmers and land investors the signal to expand production. This article described how global producers expanded harvested acreage in response to higher prices and strong profitability during the boom phase. From the 2005/06 marketing year to 2014/15 the grain boom stimulated new world harvested acreage of the 13 major crops examined in this analysis. The moderation phase after 2014/15 caused a rapid slowdown in new acreage expansion and then a leveling off. Total global acreage expansion from 2005/06 to the 2018/19 marketing year was 194 million acres in the 13 major crops examined. Of the total expansion in acres, 91% occurred during the boom phase.

During the moderation phase starting in 2014/15 and continuing to today, crop prices and crop returns have been weak, yet acreage growth leveled off, but did not decline. In economics this is known as the irreversible supply curve-a situation where a period of rising prices draws more land into production, but a subsequent period of lower prices does not move that same land out of production.

Markets also told global farmers what to produce. The two huge demand surges that created the boom were global biofuels policies and growth of Chinese incomes. Biofuels policies were huge stimulants to corn production and rapeseed production in Europe (biodiesel), while the growth of Chinese incomes accelerated Chinese soybean imports. The vast majority of the global acreage growth was in corn, soybeans, and rapeseed.

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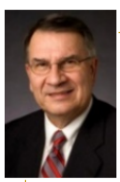

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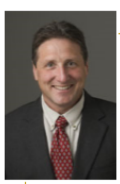

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