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How Might Big Data Impact Industry Structure and Enhance Margins?

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How might *big data* impact the agricultural sector and food industry? The impacts on the structure of the industry and the profit margins of individual businesses are numerous, but two critical impacts are: 1) improvements in supply chain linkages to enhance efficiency and effectiveness of the food production and distribution industry; and 2) improvements in on-farm production practices. This commentary provides a brief synopsis of these two impacts.

Supply Chain Linkages

Consumers, particularly those in the developed economics, are becoming increasingly demanding in terms of the attributes and characteristics of the products they consume. Traditional attributes of plant and animal protein products such as nutritional content, taste, texture, affordability, and safety are still mainstays of consumer's expectations, but their expectations of predictability and reliability have increased. With a specific focus on food safety and quality, it is argued that a whole chain traceability system can reduce exposure to hazardous foods and reduce quality deterioration across the chain from producer to consumer. Big data driven quality/safety/traceability systems provide the capabilities to respond to these increased consumer expectations. Such systems have significant benefits in terms of disease control and management of food contamination as argued by Adam et al. (2016) in this issue.

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Other attributes have become more important in shaping consumer buying behavior as well as society's expectations from the food industry—attributes that economists call "credence" attributes are generally harder to measure and often a function of how the product is produced and processed along the entire value chain from breeding/genetics, to retail outlets (traditional grocery stores, restaurants, food service providers, and on-line vendors such as Amazon.com). Such attributes include: additive or antibiotic free, organic production systems, locally and/or family-farmer grown, animal treatment/welfare production practices, sustainable production/processing/distribution systems, etc. Given that many credence attributes are not characteristics of the final product but instead processes and activities that do or do not occur across the value or supply chain, documentation and certification often can only occur through systems of whole-chain tracking and tracing. As a consequence, data and information systems are required that monitor and measure these processes and activities at each stage of the supply chain. Equally important, this data and information must be tagged or linked to the physical product (boxes of cereal, cuts of meat, etc.) that flows along that supply chain so that the final product can be credibly marketed and certified as having the attributes that consumer's desire. Some have argued that the incentives of enhancing food safety, product quality, and traceability to guarantee credence attributes and responsiveness to consumer demands and societal expectations of the food production /processing /distribution system may be more important than production efficiencies at the producer level in incenting adoption of big data technologies/systems in the food industry (Sonka 2016).

But are consumers willing to pay for "credence" attributes that require different and more costly production processes as well as unique and costly (tracking/tracing, segregation, storage and handling, and inventory) management processes along the supply chain from producers to consumers? Numerous studies indicate that at least a segment of meat and animal protein consumers are willing to pay for unique attributes. For example Olynk, Tonsor and Wolf (2010) estimate that consumers would pay a $1.74 per pound premium for pork chops that are USDA – PVP verified that individual crates and stalls are not permitted in the production process. Olynk (2012) also found that consumers are willing to pay for pasture access, non-antibiotic use and non-use of crates and stalls in dairy production. Wolf, Tonsor and Olynk (2011) found that consumers were generally willing to pay substantial premiums for milk produced without the use of rbST, on local family farms, with assured food safety enhancement, when claims are verified by the U.S. Department of Agriculture.

In addition, more systematic alignment along the supply chain from input supplier and manufacturing to food retailer has the potential to increase efficiency through better inventory management and product flow scheduling in both differentiated products and commodity supply chains. This alignment will be facilitated by big data technologies and information systems. For example, the logistics and inventory management challenges across all stages (from grain and livestock production through processing and distribution) have the potential for costly stock-outs as well as excess inventories and (waste/spoilage/ quality) deterioration unless the system is well coordinated. Information and communication systems that facilitate alignment and improve the ability to fulfill current product flows and more accurately predict future shortages, bottlenecks, or excess stock will be increasingly driven by big data analytical programs and systems.

While the verification discussion is primarily relevant in developed countries, extended supply chains are increasingly important in developing country agriculture where urbanization is rapidly redefining how food reaches consumers. Coordination of delivery of inputs to farmers and the collection, distribution, and transformation of agricultural products into food is relatively ineffective and inefficient in the developing compared to developed economies. The phenomenal increase in availability and adoption of cell phones, however, offers a means by which communication and coordination capabilities can be greatly strengthened. Distribution and logistics systems are improving with increased investment in logistics/transportation infrastructure, storage and handling, and cold chain distribution systems. Coupled with big data analytics, systematic improvements in supply chain performance are now potentially available.

On-Farm Production Practices

How might big data technologies/systems enhance the ability of producers of agricultural products to be more precise in their production practices and thus improve efficiency and profitability? This concept of precision farming—using information technology to add exactness to the quantity, quality, timing and location of the application and utilization of inputs in crop and livestock production and to produce specific attribute products/outputs—has been discussed and debated for years. But after more than two decades of innovation in this area, our ability to capitalize on this concept has fallen far short of the potential. For example agricultural retailers in the US estimated in 2015 that 41% of the acres in their market area utilize grid or zone soil sampling procedures. While this is up from 12% in 2000, it's still well below full-adoption levels. Furthermore, agricultural retailers estimated in 2015 that, on average, 32% of acres in their market area utilized variable rate technologies for multiple-nutrient fertilizer applications. While this is up from 3% in 2001, technology adoption has been slow (Erickson and Widmar 2015).

Will big data driven technologies/systems have the ability to cost effectively provide the prescriptions that precision farming requires? Recent advances in measuring / monitoring / sensing technology combined with continued improvement in nutritional and biological technology and process control input application technology make more precise input application and measurement of physical output possible. But do we have adequate precision and accuracy to fulfill the promise? More specifically do we have the scientific and numerical evidence based answers to the following questions?

1. What are the fundamental drivers/determinants/constraints of plant/animal growth and what are the specific structure and parameters of the underlying growth model?

2. What technologies are available to accurately real-time measure/sense/monitor the growth process?

3. How regularly and in real-time can growth conditions, drivers, determinants, and constraints on growth be measured?

4. What are the accuracy and measurement errors in measuring outputs (yield, production) and inputs (seed, nutrition, location/spatial, etc.) in biological growth processes?

5. What are the characteristics of the output distributions (i.e. normal, skewed, etc.)?

6. What are the alternative (application/process) control technologies that can be used in real-time to manage and intervene in order to enhance and control biological growth process?

7. What are the errors/accuracy in "application" technology (seed and fertilizer placement, spray patterns and dosage, tank or batch composition and concentration, etc.)?

8. What data aggregation and sharing is needed to obtain essential insights at the appropriate level of granularity given the long cycle-time in biological manufacturing?

9. What information insights are essential to supply chain partners (buyers and suppliers) to increase producer efficiency and profitability while reducing their risk?

10. How might Bayesian/stochastic/systems dynamics with feedback numerical decision models and "options" modeling concepts that focus on the "tails" of the output distributions be used to assess risks and rewards and obtain insights for improved decisions?

The more accurate and positive the answers we find to these questions, the higher the prospects that big data driven technologies and systems will enhance farmer's profit margins and thus be more widely adopted.

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