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How data analytics is transforming agriculture

Xuan Pham *, Martin Stack

Helzberg School of Management, Rockhurst University, 1100 Rockhurst Road, Kansas City, MO 64110, U.S.A.

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Data analytics;
Competitive analysis;
Big data;
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Abstract Two discussions about the interaction between data analytics and competitive analysis have been taking place in the past decade: one focusing on micro-level firm capabilities and the other on macro-level industry competitiveness. We seek to integrate the micro- and macro-level analyses via the lenses of firms in agricultural input markets. Agriculture is undergoing a tremendous transformation in the collection and use of data to inform smarter farming decisions. Precision agriculture has brought a heightened degree of competition for input supply firms, forcing greater interactions among friends and foes.

> *"We are on the cusp of a third revolution in agriculture—the digitization of the farm."* — Mike Stern, President and COO, The Climate Corporation (Bell, Reinhardt, & Shelman, 2016, p. 1)

> *"Farmers and entrepreneurs are starting to compete with agribusiness giants over the newest commodity being harvested on U.S. farms—one measured in bytes, not bushels."* (Bunge, 2015)

1. The rise of precision agriculture

In 2015, investors poured $661 million into 84 agricultural startups designed to help farmers transform agriculture into the next big data industry (Burwood-Taylor, Leclerc, & Tilney, 2016). Farm machines equipped with sensors and cameras are capturing minute field-level data like soil moisture, leaf greenness, temperature, seeding, fertilizer and pesticide spraying rate, yield, fuel usage, and machine performance. Agriculture, the oldest sector of the U.S. economy, is quickly becoming a data savvy domain. The rise of data analytics in farming is commonly referred to as precision agriculture (PA). While the data analytics trend is occurring at all stages of the agricultural vertical chain, the most noticeable changes are happening in the upstream input markets. Our focus for this article is the suppliers of machinery, seeds, fertilizers, and

* Corresponding author
E-mail addresses: xuan.pham@rockhurst.edu (X. Pham), martin.stack@rockhurst.edu (M. Stack)

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chemicals. We begin by synthesizing two recent discussions of data analytics in the competitive analysis literature: the first emphasizing micro-level firm capabilities and the second focusing on macro-level industry competition. We then provide capsule summaries of the agriculture value chain and conventional agriculture—the period that came before PA. We next describe how PA is reshaping competitive dynamics in the agricultural input markets. We conclude with implications of the data analytics trend for agricultural input markets and beyond.

2. How big data is impacting competition

In 2014, *Business Horizons* published a special issue highlighting the significance of data analytics in today's business environment. The guest editors, Frank Acito and Vijay Khatri, chose three case studies—healthcare, supply chain management, and financial accounting—to illustrate how organizations in a growing array of fields are adroitly employing analytics in their operational and strategic decision making (Crawley & Wahlen, 2014; Souza, 2014; Ward, Marsolo, & Froehle, 2014). The discussion was limited to micro-level firm capabilities, however, because the authors focused on innovative ways firms in these sectors are reducing costs, increasing revenues, and managing risks.

In their seminal work, Mayer-Schonberger and Cukier (2014) introduced the big data value chain and discussed its three sets of players: data holders, data specialists, and data strategists (i.e., those with the big data mindset). Data holders are firms that have the capabilities to generate and/or collect data. Data specialists mine the troves of data for informational gold nuggets that can strengthen firms' competitive positions in markets; however, the most important (and the rarest) players in the value chain are those manifesting a big data mindset: firms that take advantage of what Mayer-Schonberger and Cukier called the 'option value' of data. Data has three value options: (1) reuse for different purposes, (2) recombine with other data to create new insights, and (3) extend to new applications that are not yet defined. The big data mindset firms are flexible creatures. These firms are fully informed regarding data analytics in their markets today, but they are also actively keeping their options open in case innovations require organizational and strategic changes down the road. Mayer-Schonberger and Cukier were open to the possibility of big data creating new competition within and across industry boundaries, but they did not entertain the idea in depth.

At roughly the same time, Michael Porter and James Heppelmann (2014, 2015) published two related essays in the *Harvard Business Review:* "How smart connected products are transforming competition" and "How smart connected products are transforming companies." The 2014 article focused on how internet connected products were redefining and rewriting traditional industry boundaries, while the 2015 essay discussed how firms could utilize these new developments to improve their operational arsenals. Porter and Heppelmann encouraged firms to step back and broadly assess how their competitive environments were changing: former foes could become allies (and vice versa) and what was irrelevant may become immediately important. Macro-level implications for competition are just as important, if not more, in industries affected by big data technologies.

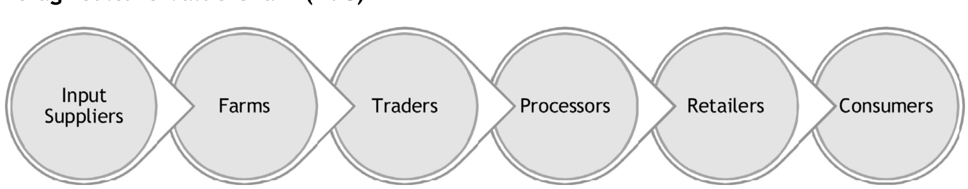
Our intent is to integrate both discussions of micro-level firm capabilities and macro-level industry competitiveness. We frame our discussion in the context of the agricultural input markets, which are experiencing significant transformations thanks to the rise of big data, Internet of Things (IoT), and data analytics.

3. The agriculture value chain

Agriculture, like healthcare, is a very broad term that encompasses a series of connected but discrete markets. Figure 1 illustrates the string of markets that form the agriculture value chain (AVC).

Big data and intensive use of analytics have begun to impact every node in this chain and, in the process, are redefining competition, operations, and strategy within and between these various circles. In the same way that hospitals and healthcare providers have downstream and

Figure 1. The agriculture value chain (AVC)



upstream value chain relationships, farmers and farms play the central organizing role in the AVC. Consumers tend to focus on the downstream dimensions of the AVC, as they can more readily visualize the connections between farmers, traders, processors, and retailers. The focus of our article, however, is on the upstream connections that link input suppliers and farmers.

There are currently about 2.1 million farms in the U.S. today, a considerable decline from the record high of 7 million in the 1930s (Budzynski, 2012). The more successful farms are concentrated at the very large and very small endpoints. Small farms can take advantage of niche markets for higher priced organic and local products, while large farms have economies of scale. In fact, only 4% of U.S. farms have more than \$1 million in sales but they account for 66% of the value of goods sold (USDA NASS, 2014). Many midsize farms have struggled the most with changing market conditions and they have experienced the highest closure rate (MacDonald, Korb, & Hoppe, 2013).

The four most valuable crops in the U.S. are corn, soybeans, hay, and wheat, which together account for 83% of harvested acres (MacDonald, Korb, & Hoppe, 2013). Farmers make key decisions about what and how much to plant for the next growing season during the winter months (except for winter wheat, which is planted in the fall). They engage with input suppliers, shown on the extreme left of Figure 1, to purchase farm machinery, fertilizers, seeds, and chemicals. The input markets are dominated by a small number of firms and these markets are becoming increasingly concentrated. As we discuss later, the desire to use and integrate data analytics has been a key driver of recent changes in the input markets.

4. Conventional agriculture: 1940s—2000s

Budzynski (2012) divided the history of U.S. agriculture into three stages: Ag 1.0 (colonial era—1940s), Ag 2.0 (1940s—2000s), and Ag 3.0 (late 2000s—present). Each stage has been associated with different production methods and levels of productivity.

Ag 1.0 was characterized by high labor input and low productivity; it took 25% of the U.S. population to feed the country in 1930 (Conkin, 2008). Over this long era, the sector's annual growth rate was only 1% (Conkin, 2008). Ag 2.0 gave rise to the Green Revolution, a period during which farmers used synthetic fertilizers, pesticides, and genetically modified seeds to steadily increase yield. During these years, the agricultural workforce declined by half while the sector's annual growth rate doubled (Conkin, 2008). Ag 3.0 refers to the current period when an array of firms is collecting data from a variety of farm sources. Farmers and input suppliers are using these data to boost productivity, address environmental and water concerns, and lower costs. In this article, we use the term conventional agriculture (CA) to describe Ag 2.0 and PA to describe Ag 3.0.

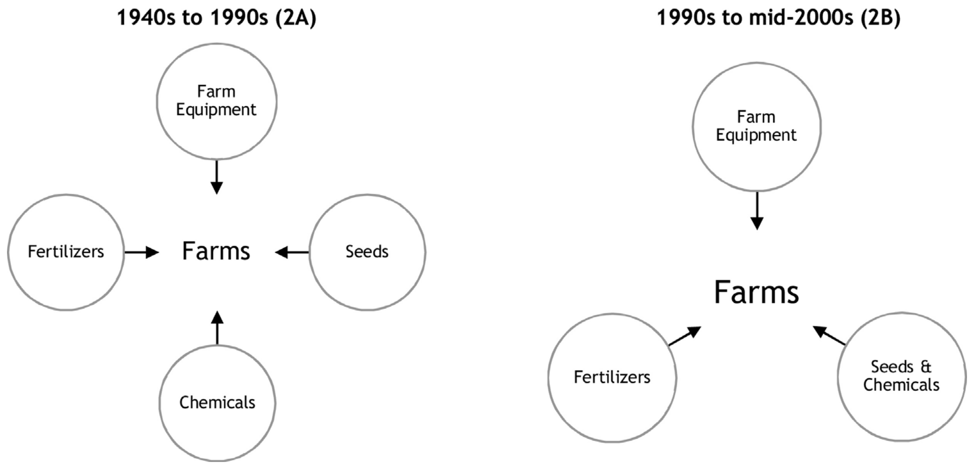
The guiding goal of CA was to steadily increase production. Farmers treated each field as a separate entity without paying much attention to the variation in elevation, access to water sources, and soil fertility within each field. They combined seeds, fertilizers, and pesticides to maximize yields on even the lesser fertile fields. Since productivity in output was preferred to input cost minimization, farmers proved to be very good clients for their suppliers. Farmers made a series of decisions about what inputs to purchase throughout a growing season. Seeds, fertilizers, and equipment were purchased at the beginning of the season, while chemicals—which may be applied at various times depending on field conditions—were purchased throughout the growing season.

Figure 2 shows the interactions between farmers and the input supply markets during the CA period. Figure 2A shows the four input markets that existed prior to the 1990s and Figure 2B shows the three input markets after a series of mergers and acquisitions led to a consolidation of the chemical and seed markets.

Under CA, farmers negotiated separately with companies in each input market. Firms typically competed rigorously against competitors within their own input market but they did not generally compete across market boundaries. The lone exception is the seed and chemical markets, which saw mergers and acquisitions beginning in the 1970s. These two input markets effectively merged in the 1990s when genetically modified crops were developed and sold as a bundle with proprietary pesticides (see Figure 2B).

Between the 1940s—2000s, there was tremendous consolidation within the various input markets. By the 1990s—2000s, a small number of firms had grown to dominate the U.S. farm input markets: the big three in farm machinery; the big six (and soon to be the big four if the recent mergers between Dow and DuPont and Bayer and Monsanto are approved) in chemicals and seeds; and a handful of firms in fertilizers. The norm of interaction in the CA era was a top-down approach. Farmers purchased inputs from suppliers in respective markets and they combined these inputs to carry out farming

Figure 2. Interactions between farms and the input markets, 1940s to mid-2000s



operations. The input suppliers had little to do with each other and they had even less to worry about from their buyers. Supplier power ruled the roost.

CA was marked by tremendous increases in output as farmers used their combinations of machinery, fertilizers, seeds, and chemicals quite effectively. Yet, the structure of the market and the nature of competition did not promote a holistic, integrated set of relationships between the input suppliers and the farmers. This, in turn, contributed to several problems. First, while applying more and more chemicals and fertilizers did increase yields in the short run, this approach contributed to a number of pollution problems. Second, farmers typically found themselves bargaining against a smaller number of larger and larger firms in each input market; these buyer-supplier interactions became increasingly one-sided, another factor which contributed to the shifting distribution away from medium sized farms and toward larger farms. Finally, competition was siloed within each input market. After all, how would a farm machinery company like John Deere compete with a seed company like Monsanto? Why would a fertilizer company like Agrium care about seeding rate on a field?

The answers, as we will show, come from the use of data. The siloed CA's input markets were giving way to a more holistic competitive environment under PA. And in this very process, PA has created a completely new set of opportunities and challenges for farmers and suppliers alike.

5. Precision agriculture (PA)

As in other industries, it is difficult to date precisely when precision came to agriculture. In part, as Carbonell (2016) argued, this reflects the lack of scholarly research detailing the rise of smart farming. While John Deere's decision to attach GPS sensors to its tractors and other machinery in the late 1990s and early 2000s was essential, PA requires not only data but also the ability to do something valuable with the data.

PA differs from CA through its emphasis on the collection and utilization of data to make decisions. As noted previously, the CA period was not a technical backwater, and toward the end of this period, more and more data were being generated to keep track of inputs and yields. Yet, there was no ecosystem to translate the data into action. The ability to capitalize on the data being generated required a very different set of capabilities by farmers and (perhaps even more importantly) by input suppliers.

With PA, firms that had peacefully co-existed were now beginning to run into each other's turf. For example, under CA, Monsanto and John Deere viewed each other rather collaboratively, each pursuing their own lines of business. Now, through their work in data analytics, these once complementary firms began to view each other as (potential) competitors. Competition was more about suppliers vs. farmers in the CA era. Competition is as much about suppliers vs. suppliers as suppliers vs. farmers in the emerging PA regime.

Before we detail how PA is unfolding, it is important to summarize some of the leading challenges facing farmers today, several of which did not exist a few decades ago. First, years of intensive farming has led to a decline in soil fertility, requiring heavier use of fertilizers; however, over-fertilization has caused serious environmental problems. Excess nitrogen leaches into waterways and becomes nitrous oxide (N_2O), a greenhouse gas, in the atmosphere. Phosphorus-based fertilizer runoffs create algal blooms and excessive vegetative growth in water (Ackerman-Leist, 2013). Herbicide-resistant weeds are now present in 65% of crop fields in the U.S. (Sfiligoj, 2016). As a result, farmers have to become more judicious in their use of inputs such as fertilizers and chemicals. Second, water availability is becoming more and more of a concern in a wider number of geographical areas. While drought-prone agricultural regions (such as parts of California) have been a concern for years, in the near future, farmers in a widening range of locales are going to need to figure out how to use their limited water supplies to greater effect. Third, the world population is expected to reach 9 billion people by 2050 (Gilpin, 2015); this increased demand presents more opportunity but it also requires greater sophistication to do more with less. Fourth, the costs of seeds, chemicals, and fertilizers are increasing, so farmers must again figure out how to increase yields without simply increasing inputs. Together, this set of challenges shows us that CA was bumping up against the limits of what it could do within its institutional and technical capabilities.

So, how exactly is PA trying to deal with these challenges in a new way? The short answer is through systematic uses of data that are arising from a rapidly expanding set of smart, connected tools.

5.1. PA major technologies

Precision agriculture depends on a suite of technologies that work together to enable data collection and analysis including (CEMA, n.d.):

- *Geographic Positioning Systems (GPS)* that record latitudes and longitudes of fields. Tractors equipped with sensors and steering guidance systems use the recorded positions to navigate.

- *Sensors* mounted on farm machines and/or stand-alone placed above and below ground level to capture data about soil moisture, soil temperature, wind direction, solar radiation, leaf wetness and greenness, rainfall level, yield calculation, location tracking, performance monitoring, and remote diagnostic services. Satellites capture spatial resolution in infrared light and images are used to estimate yield and biomass. Drones are used to scout fields and capture imagery.

- *Geomapping*, which uses the collected data to create yield, planting, and soil fertility maps.

- *Assisted and automatic guidance steering systems* that help farmers more efficiently navigate their tractors.

- *Electronic communications*, which enable farm operators to communicate with each other, suppliers, agronomists, and other stakeholders.

- *Variable rate technology (VRT)*, the last step in the integrated precision farming system. Agronomists use soil maps to create planting prescriptions, which can include any of the seeding, irrigation, chemical, and fertilizer application components. Automatic guidance systems carry out the prescriptions. John Deere advertises that its tractors can achieve pass-to-pass planting accuracy rates between ± 40 and ± 2 centimeters (or approximately ± 16 and ± 1 inches) depending on the sophistication of the guidance steering systems (John Deere, n.d., 2013).

5.2. Data

Collectively, these new technologies are generating enormous quantities of data. The types and amount of data that can be collected from farming operations are wide ranging. In a parallel to the Electronic Health Record (Electronic Medical Record), some commentators now refer to the Electronic Field Record (EFR). Startup Farmobile listed 22 categories of data generated by farm machines and 21 categories of seasonal agronomic data on its website (Farmobile, n.d.). Examples of machine data include fuel rate, speed, direction, hydraulics, and diagnostics. Examples of agronomic data include planting and fertilizing target and actual population, spacing, total acres, moisture levels at harvest time, and grain temperature.

The input suppliers fully appreciate the potential of data analytics. Monsanto recently called data analytics "agriculture's next major growth frontier," estimating it to be worth \$20 billion (Monsanto, 2013). DuPont Pioneer, a subsidiary of DowDuPont, announced that farm-related data services could generate \$500 million a year in revenue in the next decade (Bunge, 2014). John Deere also stated in 2011 that it plans to double revenue by 2018 and cited farm machinery as a core business with growth potential; the company then backed up its commitment by introducing a suite of smart, connected machines and analytic services called FarmSight later that year (John Deere, 2011; Tita, 2009).

5.3. Data analytics as a firm capability

Using the same terminologies as Mayer-Schonberger and Cukier (2014), many firms have established themselves as data holders and data specialists in the emerging PA era. These firms range from startups to the dominant players in machinery, fertilizers, chemicals, and seeds. The startups are focusing on serving specific market needs. For example, Farmobile wants to create an online agricultural field data store to allow farmers to sell their data the way they do their crops. FarmLogs, Granular, and Prime Meridian are all selling farm management software, data storage, and farm prescription services.

Similarly, some of the large input supply firms are also developing their data holding and data specialization capabilities. Two of the big three farm machinery firms, CNH and AGCO, have developed their own branded data analytics platforms that promise open connectivity between their machines and competitors' brands. CNH advertised its Advanced Farming Systems (AFS) as a do-it-all precision farming solution: "Generate yield maps, prescription maps . . . create soil sampling maps, create and print reports and import satellite imagery. No matter your data source . . . you can easily import and manage the data" (Case IH, 2017). DuPont Pioneer (2016) stated that its Encirca platform will provide basic services such as recording field information for either personal use or for sharing with business partners and neighboring farms; its premium-level offerings include agronomic recommendations, market news, grain trading services, fuel and fertilizer price tracking, and customized weather reports. Syngenta, Bayer, BASF, and Agrium also provide data holding and data specialization services. These are rare but not, so far, tremendously difficult to imitate capabilities, as evidenced by the entrance of small startups and well-established firms alike.

Mayer-Schonberger and Cukier (2014) asserted the most valuable skills in the big data space are those associated with data strategy—that is, those firms that are able to create a big data mindset. Within the farm input markets, two companies have distinguished themselves in developing this deeper and harder-to-imitate capability: John Deere and Monsanto. Following its pioneering work in introducing sensors and GPS trackers into its farm machines, John Deere was an early mover in the data analytics space. In 2011, the company introduced an integrated line of machinery and data services under the brand FarmSight. All new tractors coming off the assembly lines would be equipped with the latest generation of sensors, making the collection of field data automatic. Data transfer from machines to servers is done via a system called JDLink. A mobile application called Mobile Farm Manager and its desktop counterpart called Operation Center served as a farm management platform. Weather tracking, prescription services, and electronic communications are also available either tractor cab-side or on the company's website.

Monsanto's entry into the data analytics business dated back to 2012 when it acquired several key firms including Precision Planting, a manufacturer of advanced planters; Climate Corporation, a data analytics startup; and Solum, a soil testing startup. Monsanto used these acquisitions to bolster its seed and chemical businesses and create new complementary analytical services for customers (Bell et al., 2016). In 2013, it began selling a prescription service called FieldScripts in select corn growing states. Farmers turned over 2 years of historical field data and, in return, received a planting prescription which had seed variety recommendations and a variable planting program designed to work with Precision Plantings equipment. Once farmers had reviewed and accepted the recommendations, the prescriptions were electronically sent to their accounts. When planting season began, farmers downloaded the programs and the planters automatically carried out the planting prescriptions. Monsanto charged $15 an acre for the FieldScript service and advertised that the service could increase yield by 5 to 10 bushels per acre (Hickins, 2014). The FieldScript service has since been incorporated into Climate Corp's FieldView premium services.

Overall, a number of firms—some established, some new—have developed PA capabilities regarding data holding, data specialization, and data strategy. The first two categories are easier to enter, and there are many more firms operating in those spaces. Thus far, John Deere and Monsanto are the best exemplars of being data strategists, and though the bar to enter here is much higher, we will likely see more entrants into this space in the coming years. As Carbonell (2016, p. 1) argued: "Agribusinesses, such as Monsanto or John Deere, have high stakes in big data, as it gives them the ability to construct an unprecedented predictive business model over each aspect of farming." As rivals come to appreciate the rewards from constructing such models for themselves, there will likely be new data strategist firms in the near future.

5.4. Data analytics redefining competitive dynamics

In addition to redefining the nature of firm capabilities, PA and data analytics are reshaping industry and market boundaries and interactions. In CA, there had been a decades-long move toward supplier consolidation, which effectively reduced choices for farmers. The power of data in PA is complicating this process as it sets about to blur the 'silos' of the agriculture input markets while also potentially empowering farmers in their interactions with input suppliers. As the CEO of Farmobile argued recently: "Farmers have gotten the short end of the stick for too long. It's time to understand the value of farm data, harness its power, and leverage it to [their] advantage. It's time to turn the tables" (Tatge, 2016). Bilateral flows of physical inputs and electronic data are becoming the norm between farms and input suppliers. According to Porter and Heppelmann (2014, p. 66), the big data and analytics trend will also force firms to reevaluate a series of long-standing assumptions:

> Smart, connected products raise a new set of strategic choices related to how value is created and captured, how the prodigious amount of new (and sensitive) data they generate is utilized and managed, how relationships with traditional business partners such as channels are redefined, and what role companies should play as industry boundaries are expanded.

By redefining industry boundaries, firms are being forced to review their basic operations and to answer this fundamental question: "What business am I in?" (Porter & Heppelmann, 2014). Figure 3 illustrates this rapidly changing world. In contrast to the world depicted in Figures 2A and 2B, the competitive landscape in agriculture is getting much more complicated with more competition across input markets and greater ability by farmers to harness data in their interactions with their suppliers.

As data analytics and PA are blurring the boundaries between traditionally discrete input markets, this is giving rise to new possibilities, new complementarities, and new threats that did not exist a decade ago. Perhaps not surprisingly, John Deere and Monsanto—the two firms that we argue are prime examples of data strategists—illustrate well this era's new opportunities and challenges.

A year after entering the data analytics market, Monsanto signed nonexclusive agreements with CNH and AGCO—John Deere's top rivals—to put the Climate Corporation's FieldView mobile application on their tractors. FieldView is a popular data storage and analytics platform already being used on 92 million acres in the U.S. (Monsanto, 2016). CNH and AGCO utilized the new alliances to promote themselves as supporters of the open connectivity movement in agricultural technology. Monsanto also signed an agreement with the fertilizer firm Agrium to sell FieldView subscriptions at its 900 retail stores, which is housed under the brand Crop Production Services.

John Deere quickly responded to Monsanto's moves by signing agreements with DuPont Pioneer, Bayer, and BASF to allow data sharing between John Deere and these companies. John Deere was at the losing end of the farm machine connectivity battle, however. FieldView is a much more popular product compared to John Deere's offerings. Sensing that they could be setting the stages for a new phase of competitive rivalry, John Deere and Monsanto changed course again when they announced a new agreement in late 2015: Monsanto would sell Precision Planting to John Deere, and in return, John Deere would open up its machinery connection to the Climate Corp. Cory Reed, senior vice president of John Deere's intelligent solutions group, summed up his company's strategic shift in one statement: "We'll connect to everyone" (Vogt, 2015). In August 2016, the Department of Justice moved to block the Precision Planting acquisition, claiming that this sale would concentrate too much power with John Deere and would not be in the interest of farmers. The companies countersued, asserting that the acquisition "benefits farmers by accelerating the development and delivery of new precision equipment solutions that will help farmers increase yield and productivity" (Kendall & Bunge, 2016). While it will be interesting to see how this suit is settled, it is also clear—as Table 1 illustrates—that there are many more alliances and linkages in the agricultural input markets.

Table 1 gives meaning to the bidirectional arrows in Figure 3, which show the blurring of traditional

Figure 3. Precision agriculture (late 2000s—present)

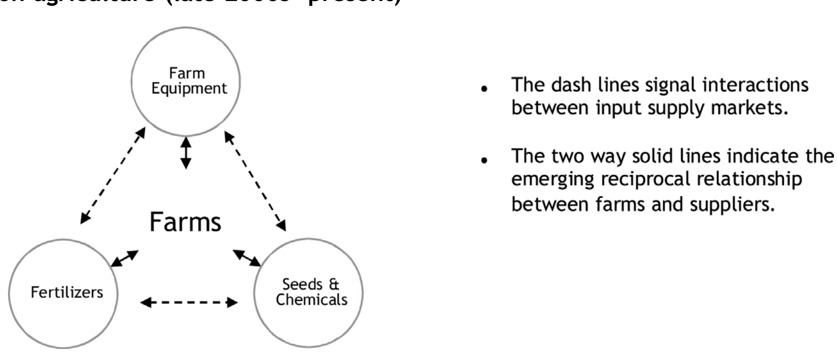


Table 1. Strategic precision agriculture partnerships among the leading input suppliers

Company	Input market	Precision agriculture product(s)	Partnership(s)
AGCO	Machinery	Fuse	Monsanto DowDuPont
Agrium	Fertilizer	Echelon	Monsanto
BASF	Seed & Chemicals	Maglis	John Deere
Bayer	Seed & Chemicals	Zoner	John Deere
CNH	Machinery	Advanced Farming Systems	Monsanto
DowDuPont	Seed & Crop Protection	Encirca(SM) (DuPont Pioneer)	John Deere
John Deere	Machinery	FarmSight	Monsanto Bayer BASF DowDuPont
Monsanto	Seed & Chemicals	FieldView	CNH John Deere AGCO Agrium
Syngenta	Seed & Chemicals	AgriEdge Excelsior	

lines between the three agriculture input markets. Or, as Dow Chemical Co. Chief Executive Andrew Liveris put it recently, “Everyone is talking to everyone” (Newman & Bunge, 2016).

And it is not just talking. Over the past year, three major mergers/acquisitions have been proposed: Dow & DuPont, China National Chemical Corp. & Syngenta, and Bayer & Monsanto. Combined, these “three entities would effectively control more than three-quarters of U.S. corn-seed sales and 70% of the world’s pesticides” (Newman & Bunge, 2016). While there are a number of reasons underlying these consolidations, it is clear that the promise and potential of data analytics have been a contributing factor. For example, Monsanto rejected Bayer’s initial bids, claiming that they did not fully value the range of Monsanto’s assets and specifically highlighted its data analytics division and capabilities (Bunge, 2016). It is particularly noteworthy, then, that shortly after Monsanto accepted the offer, Bayer (2016) published a document which highlighted ‘digital farming’ as one of the merged company’s three integrated solutions and went on to emphasize its capabilities in “extensive data collection and computation” and “predictive analytics.”

6. What’s next?

Input supply firms are facing new competitive pressures beyond their cohorts in the machinery, seed, chemical, and fertilizer markets. IBM is conducting research on real-time agricultural data collection and analysis in farm fields across the globe. Grassi (2015) reported that “IBM has a unique skill-set, a different mindset from a lot of the other ag technology companies. It could be a game-changer.” Google was involved in three of the top five venture investment deals relating to agricultural decision support technology in 2015. GE was also involved in a major venture investment deal with Clearpath Robotics, a startup specializing in drones and robotics for farming, in 2015 (Burwood-Taylor et al., 2016). We recently attended a symposium where a keynote speaker from one of the big four public accounting firms stated that his company has been tapped to create data analytics solutions for an (undisclosed) agricultural machinery company. Future competition in the PA arena will include anyone and everyone who can capture the option value of data. The inevitable question that arises from our examination of the agricultural input markets is what other markets and industries are undergoing similar experiences? Who else is being pushed to simultaneously contend with both micro- and macro-level competitive forces?

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