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Big Data in Agriculture:
Property Rights, Privacy and Competition in Ag Data Services

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Abstract

The transition from precision agriculture to *big data* opens a variety of concerns among both farmers and ag data service providers about the privacy, ownership and use of farm data. This paper discusses the nature of those concerns as well as an attempt to establish industry guidelines concerning data privacy and security. I argue that the proposed guidelines likely do little to protect any real privacy concerns and run the risk of negative consequences for competition in ag data services and of reducing valuable information flows in commodity markets.

Keywords: big data, ag data services, property rights, competition

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Introduction

While some may picture farming as a bucolic enterprise, far removed from big data and the information economy, modern farming practices are intensely data-driven. Precision agriculture practices have implemented "embodied-knowledge" technologies such as GPS-guided equipment and variable-rate planting and spraying equipment, while "information intensive" technologies such as on-board yield monitors and grid soil sampling generate an enormous amount of site-specific data that can be analyzed to assess input needs and output performance (Griffin et al. 2004). According to the USDA's 2012 Agricultural Resource Management Survey, over 62% of corn and soybean acres in the US were harvested with yield monitoring devices and 73% of acres were farmed using some type of precision agriculture practice.

However, despite the enormous amount of data already generated across tens of thousands of farms each year in the US, the promise of big data remains largely unfulfilled. While the volume, velocity, and variety of data generated in production agriculture have been available for years, the ability to aggregate, analyze, and distill value-creating decision support tools from that data is still in the early stages. Much of the data generated over the past decade sits on the computers of individual farmers who have little ability to make use of it independently. Whitacre et al. (2014, 3), argue that "[b]efore 'big data' will be widely accepted by farmers and others across the agricultural industry, its collection, processing, on-demand analytics, and decision making must become passive to the user." In other words, until a new sector of data service providers is able to harness and commercialize the revenue-generating correlations to be discovered in these fields of data, the full productivity-enhancing potential of big data will remain but a promise.

But it's a promise worth a lot of potential value and several traditional agricultural input providers have been working to develop data services with the hope of capturing a share of that promised value. John Deere, one the industry leaders in providing data-generating technologies on their farm machine equipment, and Monsanto and DuPont Pioneer, which together control the majority of the US corn and soybean seed markets, are competing to provide farm-specific decision support tools using big data analytics. The industry has also attracted smaller, start-up enterprises seeking to exploit specific niches of data-driven decision making tools. In announcing its 2013 acquisition of The Climate Corporation, an atmospheric data science company developing micro-weather forecasts to aid farmers' management decisions, Monsanto estimated that the data science market in agriculture could be worth as much as $20 billion.

As more agricultural technology providers (ATPs) enter the market and as there is more focus on aggregating famers' data, farmers have raised concerns about data ownership and privacy.[1] Who owns the data? Who is entitled to the value of the data? How will that data be used or potentially shared? These concerns are particularly strong when dealing with large players such as DuPont Pioneer and Monsanto who have an interest in selling their own agronomic products in addition to the data services themselves; will ATPs engage in

[1] The term "agricultural technology provider" or ATP generally refers to a company that aggregates famer's data, combines it with other relevant data sets, and applies algorithms to analyze the data. Farm input providers like John Deere, Monsanto (Climate Corporation), and Pioneer that provide data-driven agricultural support services would qualify as ATPs due to their use of big data to supplement their farm input businesses.

discriminatory behavior either in pricing or product recommendations based on their knowledge of the local farm operations?

A more general concern is whether these large companies have an unfair competitive advantage, or an ability to foreclose the market for data services, by collecting and controlling data for large percentages of US farm operations. An even greater concern among some agricultural producers is whether the continued development of automated agricultural equipment, driven by big data analytics, may fundamentally change the organization and management of production agriculture.

Some of these concerns were addressed, at least in principle, in an industry-negotiated set of guidelines announced November 13, 2014. These “Privacy and Security Principles for Farm Data” were negotiated by national farmer organizations such as American Farm Bureau Federation, National Farmers Union, and the national trade groups for soybean, corn, wheat, and rice growers; and by several leading ag data companies including John Deere, Monsanto’s Climate Corporation, DuPont Pioneer, and Dow AgroSciences. These principles outline expectations with regard to ownership, portability, disclosure, use/sale, and retention of data as well as contracting practices. It’s unclear how these provisions will work in practice. It’s also unclear whether, or how, the practice of these principles will address concerns about the value of famers’ data and the ability of data service providers to gain monopolistic advantages based on their data repositories. Moreover, some of these principles may run counter to ATPs’ proprietary interests in the information services they provide.

This paper attempts to examine the nature of concerns about big data applications in agriculture and their implications for the market for agriculture data services. The paper will explore the nature of “ownership” of data in the context of information-based products, and how property rights between farm data owners and data service providers may be in conflict. The paper will then explore the potential for large, incumbent ATPs to monopolize or foreclose the market for data services and how proposed data ownership principles may affect that ability. In the process, the paper will address alternate organizational mechanisms that may mitigate any anticompetitive potential.

The Shift to Big Data in Ag

Before addressing data ownership, it’s important to understand the changes in data use that have given rise to the concerns about data ownership and how those new data-driven technologies differ from the precision agriculture practices of the last two decades. Precision agriculture, as the name implies, allows farmers to more precisely manage their crop production, typically in field crops such as corn, soybeans, wheat, and rice. Using yield monitor data, GPS-based field maps and soil sampling, and/or GPS-tagged weed scouting data, farm machinery equipped with variable-rate technologies (VRT) can adjust seed planting density and application rates for herbicides, pesticides and nutrients based on variations in soil quality, topography, moisture, weeds, pests, etc., within field plots. By more precisely planting and managing crops, farmers can increase yields and lower input costs. GPS-assisted or controlled navigation of planting, spraying and harvesting equipment also helps reduce fuel costs by minimizing passes across a field, minimizing overlap of applications, and maximizing the area planted and harvested, further reducing input costs per acre.

Schimmelpfennig and Ebel (2011) report that adopters of yield monitor technologies, GPS mapping, and VRT fertilizer technologies for corn and soybean production produced significantly higher yields than non-adopters in 2001 and 2005, on the order of 10% to 14% higher. On corn land yielding 150 bushels per acre that suggests a revenue increase of $95 to $130 per acre at a corn price of $6.50. Considering that commercial crop operations range from 500 to 5,000 or even 10,000 acres, the value potential is substantial. They also report that adopters of GPS-mapping and VRT fertilizers had significantly lower fuel costs than non-adopters.

Schimmelpfennig and Ebel (2011, 20) suggest that precision agriculture was still in the early stages of adoption. They argue that while profitability of precision ag is likely to affect adoption rates, they point to research by Fernandez-Cornejo, et al. (2001) finding that college educated producers are 15% more likely to adopt precision ag practices. Griffen et al. (2004), argue that precision ag is “human capital intensive”, which would suggest older farmers are less likely to make the investment given their shorter expected time horizon.

However, while precision agriculture practices began taking off in the early 1990s, the data themselves have traditionally stayed close to the farm. Yield monitor data and fields maps are typically generated by the farmer or by a local customized service provider who delivers the data to the farmer. VRT fertilizers may use data generated by soil sensors as the equipment is crossing the field. VRT herbicide and pesticide applicators may use GPS-coded field scouting reports generated either by the farmer herself or a contracted scout who provides the data to the farmer. The data were not aggregated with data from other farms to develop new products, services, or management analytics. In any of these arrangements, there is little doubt about the ownership of the data and little concern about data privacy since data are stored on local computers.

What’s new with big data versus traditional precision agriculture is the aggregation of data from large numbers of farms, the timeliness with which it is aggregated, a surrender of physical custody of the data from the farmer to the ATP—often using cloud technologies—and the potential use of that data for purposes beyond the farm itself.

As the market for ag data services is still in its infancy, there are different pricing models and types of services available from different vendors. In general, the farmer works with a certified local input dealer for a specific input supplier ATP. The farmer generates (or hires the dealer or a third-party company to generate) data on field-specific attributes such as GPS-coded soil sampling and field maps for selected plots of land. The data requirements for ATPs vary based on their algorithms and services offered. The nature of data security issues also differ by vendor given their services and platforms.

For instance, Monsanto’s FieldScripts® program requires two years of raw yield data in addition to soil and field mapping data to generate its planting prescriptions. The farmer also provides information on anticipated planting dates, yield goals, row spacing, and variable-rate planting ranges. Once the data are sent from the local certified dealer to Monsanto, a primary and secondary planting recommendation is developed offering two DEKALB® seed types and planting densities. A preview of the prescription is reviewed with the local dealer, at which point the farmer can choose whether to purchase the prescription, which is priced on a per acre basis ($5/acre in 2015). The farmer can then download the prescribed planting instructions for the hybrid of choice to an iPad app which will then guide the variable-rate planting equipment to plant accordingly.

Although the farmer does not have to pay until after a preview of the prescriptions is available, the farmer's data are already passed to Monsanto. The FieldScripts® program is only available through certified dealers who have an incentive to maintain their certified relationship with Monsanto and who benefit from seed and other input sales. Futhermore, only Monsanto's DEKALB® seed hybrids are available using the FieldScripts® program.[2] When the farmer accepts the prescription, she agrees to purchase prescribed seed variety at the same time, before the planting program is downloaded to the farmer's iPad. The rationale for the product bundling is that Monsanto's prescription algorithm is based on its agronomic knowledge base of its own varieties. The dealer and Monsanto's field agents help monitor performance through the season and advise on field management needs. At the end of the season, the farmer submits yield data to help improve future prescriptions for the field, which Monsanto can incorporate to update its basic algorithm as well.

Pioneer's Field360™ program and WinField's R7 program provide an even greater array of data-driven decision support tools. In addition to hybrid selection and variable-rate seed planting recommendations for specific fields, each offers additional in-season analysis for farmers using the company's seed products through web-based subscription service platforms to support farmers' crop management practices. Pioneer offers field-level weather updates so the farmer can track precipitation without having to visit remote field locations as frequently, as well as crop growth estimators based on climatic, genetic and agronomic characteristics to help the farmer identify potential deficiencies in growth that may be due to nutrition, moisture, or infestations. Pioneer's system allows the farmer not only to house all of their data in one easily-accessible location in the cloud, but to share notes (including GPS-tagged field notes) and progress data with employees, agronomy consultants, and other service providers. WinField's R7 service pairs farmers' planting and field data with satellite sensing data to help identify moisture and nutrition imbalances that allow the farmer to more efficiently apply the appropriate inputs using variable-rate systems. Like Monsanto, both operate through a network of certified dealers.

The dealer network plays a substantial role in the value chain. In their survey of commercial farm operations in the US, Alexander et al. (2009) found that 57% of respondents claimed that purchasing inputs has become a more time-consuming activity in the farm businesses. This is particularly true for the large farm operators (67%). At the same time, farmers generally trust their local dealer more than manufacturers' sales personnel and consultants as a source of information. While 50% of crop farmers claimed to be loyal to a brand of seed, 39% negatively valued information from manufacturers' salespeople and 59% negatively valued information from manufacturers' technical personnel. Roughly 2/3 of respondents claimed to value their relationship with the local dealer more than the company the dealer represents, suggesting that much of the brand loyalty reported may be driven as much by relationships with the local dealer as with the products themselves.

Dealers, then, are caught in an interesting set of incentives. Commercial farm operations want to maximize profitability per acre. For a given commodity price, that means balancing the value of the marginal product (i.e., yield) of additional inputs with the cost of those inputs. ATPs offer services that allow the farmer to increase yields and/or reduce input costs to improve profitability. The dealer is in the position of offering farmers a value-adding bundle

[2] WinField, a smaller independent seed company, announced that it would begin offering Monsanto's FieldScripts® program as a certified dealer, with plans to include options for WinField's seeds in future growing seasons in addition to Monsanto's DEKALB seed varieties.

of services that may reduce demand for the farm inputs the dealer sells. In other words, services that reduce input use by the farm cost the dealer revenue in lost sales. On the other hand, by supporting the ATP's data service programs, the dealer may benefit from a portion of program revenues and from the potential to increase margins on recommended products to compensate for reduced sales volume.

A variety of other ATPs offer less comprehensive services based on precision agriculture technologies of various types. Companies like Agrible, Conservis, and Granular provide farm management decision support and data tracking tools. Companies like AgLeader data management services to support precision planting and variable-rate chemical and moisture applications, but do not offer seed recommendations. John Deere, Case-New Holland, and AGCO are the largest of several manufacturers producing variable-rate equipment with sensors and monitors that collect data on equipment hours as well as crop input and output volumes, particularly crop yield monitors. While equipment manufacturers can use the data to provide better maintenance recommendations and performance diagnostics, they also offer data analytic software to help farmers make better use of the data that are collected.[3]

Recently, industry players have begun forming alliances to share data service resources. As noted above, WinField has contracted with Monsanto to begin offering FieldScripts®, initially limited to sales of Monsanto's DEKALB seed varieties. Monsanto, in turn, has agreed to develop FieldScripts algorithms for WinField's seed genetics, allowing WinField eventually to offer prescriptions based on their own seed varieties. Pioneer and Monsanto have each announced plans to partner with John Deere to take advantage of Deere's access to large amounts of yield monitor, and potentially other sensor, data. Such uses of farm data raise the question of who owns the data and the value created by those data's use, who has access to the data, and to what ends might it be used.

Big Data Concerns in Agriculture

In some respects, farmers' concerns about use of their farm data are no different than general consumer concerns about the security and privacy of data in the cloud: Can other people (and whom) see my data? And how are my data being used? While farm production data may not represent the identity theft risk of some consumer data, production data may be used by ag service providers not only to benefit producers by providing managerial decision support, but also to price discriminate by the nature of their recommendations. There are also concerns that data sharing rules may disadvantage farmers or at least have the appearance of creating a competitive disadvantage to local farmers.

Although farmers' concerns may not be very different than some general consumer concerns, the nature of farming and the culture of agriculture create some significant legal and policy questions. Most of the data concerns of farmers revolve around commercial use of business and business process data, not what would commonly be considered personal data privacy issues in other business sectors. Federal Trade Commission actions on data security and privacy focus are primarily based on fraud and the disclosure of "sensitive personal information." This typically includes things like names, social security numbers, bank accounts, and other financial information. Furthermore, in *Multi Ag Media LLC v Department*

[3] Given the dynamic market environment, there are undoubtedly changes in the competitive landscape in terms of specific firms and product offerings. Those selected here are simply representative and not intended to be an exhaustive listing.

of Agriculture, the D.C. Circuit Court (515 F. 3d 1224, D.C. Cir. 2008) ruled that USDA could not withhold from a Freedom of Information Act request information on "irrigation practices, farm acreage, and the number and width of rows of tobacco and cotton" or GIS database information "on farm, tract, and boundary identification, calculated acreage, and characteristics of the land such as whether it is erodible, barren, or has water or perennial snow cover." Although the Court did find that there was a privacy interest in the data, it wrote in its option that "we are not persuaded that the privacy interest that may exist is particularly strong" and ruled that the public interest in releasing the data outweighed any privacy concern. Consequently, federal policies protecting personal information likely would not apply to the kinds of data collected by ATPs.

However, the legacy and culture of "family farm" operations create an interconnected sense of identity between farmers and their farm businesses. Traditionally, the farm business and farm household were viewed as one-and-the-same economic unit, as production and consumption decisions were integrally intertwined (Heady et al. 1953; Brewster 1979). While Mishra et al. (2002) argue the economic portfolios of farm households no longer reflect such reliance and interdependence, the intertwined identity of household and farm business remains. Pritchard et al. (2007, 2) argue:

> "[T]he 'typical' family farm is now far removed from the ideal-typical family farm origins; yet neither is it akin to a corporate farm. Rather, it represents a distinct social and economic formation in its own right. … Farming may well be becoming more corporatized, but it also retains distinctive social properties (based mainly around family ownership) that separate it conceptually from other segments of the economy."

So while farm data conceptually may be akin to—and perhaps subject to the same legal treatment as—commercial data, in the minds of farm producers these data are often viewed with a personal sense of privacy concerns. That said, it is not clear that agricultural producers are at any more risk of data misappropriation or value risk than the data service providers themselves.

Farm-Level Data Issues

A primary concern of farmers at the farm level is that the data collected and the recommendations generated by ATPs may facilitate what economists refer to as first-degree price discrimination by input suppliers, with customized pricing based on farm attributes.[4] This could be from ATPs who sell inputs themselves, or input suppliers that may partner with or purchase data from other ATPs. For instance, Pioneer's Field360™ is limited to farmers using Pioneer seed. FieldScripts® is limited, at present, to Monsanto's DEKALB seed varieties. The bundling of data services and specific input brands gives rise to concerns that the ATP may increase input costs to capture the anticipated gains from more efficient production resulting from the prescribed practices. As discussed above, dealers have incentive to increase margins on seeds that are prescribed, or eligible to be prescribed, particularly if more efficient planting practices reduce overall seed demand. However,

[4] Block price (third-degree) price discrimination is nothing new in agriculture, as large farmers may receive bulk discounts to lower the average cost per unit of input. First-degree price discrimination, however, targets the price discrimination to individual buyer characteristics, not simply quantities. This allows the seller to extract even more of the gains from trade from each prospective buyer.

because these services are only now rolling out to large regional markets, there are no data available to substantiate or dispel price discrimination concerns.

Farmers could induce competition to mitigate the potential discrimination by contracting with more than one ATP for different fields, particularly large farm operations. However, as Alexander et al. (2009) found, farmers tend to be loyal to specific dealers and input brands. Moreover, working with multiple ATPs for inputs—particularly for seed—would increase learning costs of using the different systems in different fields. Finally, the pricing of services may also reduce the incentive to use multiple vendors. While FieldScripts® charges by the acre, Field360™ is a flat annual subscription which can be averaged out across larger numbers of acres. Given that complexity of input decision making is one of the motivations for using these data services, using multiple platforms would seem counter-productive.

Given the general skepticism farmers seem to hold against input manufacturers (Alexander et al. 2009), it is not surprising that farmers are concerned about manufacturers using the farm's data to create additional value beyond the farm without compensating the farmers for the data and to potentially gain competitive advantage over other potential industry entrants. ATPs use client farms' performance (yield) data to improve their algorithms, much like Google, Amazon or Facebook improve the value of their algorithms based on individual users' searches and consumption decisions. Given the annual nature of growing seasons and the rate of change in production technologies, data aggregation across a large number of farms is critical to developing improved crop forecasting models and production recommendations. Individual farm-level longitudinal data would not generate sufficiently large data samples to estimate useful models. This gives rise to concerns about the ability of large incumbent ATPs to hold a competitive advantage over any potential entrants that do not have access to the breadth of data (i.e., data from a large number of farms).

As in the case of Google, Amazon or Facebook, it is difficult to imagine that any one farmer's data has material value at the margin in the development of data analytic algorithms. However, unlike the large internet companies that have millions of users providing data, Monsanto may have only tens of thousands. Moreover, increased consolidation in the operation of farmland means a smaller number of farmers operate a large percentage of the acres being farmed. Thus, the marginal value of a particular large farming operation to a company like Monsanto, while small, may represent a significantly larger share of the company's data than any one user of Google, Amazon or Facebook. This is especially true given the geo-climatic-specific nature of farms, since soil characteristics and climate both vary regionally and are key determinants of crop production and farm input choice. The attributes of large individual farming operations—or a group of farms in a particular region—may add variation to the estimation sample that allows for more precise estimates of key parameters. Thus, while it is unlikely a relatively small group of consumers could collectively offer Google or Facebook a block of data with a meaningful marginal value, the same may not be true in the case of farm-level production data. Thus, the question of data ownership would seem to have competitive consequences in the ability of large growers or groups of growers to market their data to potential entrants to the ag data services industry.

Data Issues Beyond the Farm

While consumers' concerns focus on personal privacy and, potentially, price discrimination by online retailers for things the consumer wants to buy and how those retailers use their data for developing their products, farmers' concerns extend further. In addition to personal privacy issues and concerns about farm input providers potentially engaging in price discrimination for seeds and chemicals, farmers are also concerned about data aggregators using the data (or making the data available for others to use) to gain an unfair advantage in commodity and real estate markets, which have significant implications for the value of farm operations. While not strictly of a personal nature, these reflect concerns about the privacy of data that has been aggregated being used for alternate purposes.

For instance, data from yield monitors mounted on harvesting equipment may now be transmitted into the cloud in near-real time, giving the data aggregator real-time crop yield data for specific, identifiable tracts of farmland—across large numbers of farms at any given time. Companies like John Deere ostensibly use that data to diagnose their harvesting equipment's performance and recommend routine maintenance based on machine use. Precision ag service providers such as AgLeader® not only capture harvest data, but planting, application and irrigation data as well, capturing several of the key, controllable input factors of production to provide management decision support to producers. However, access to such data could be used to speculate in commodities markets with information that is not otherwise knowable to market participants, giving rise to concerns about market manipulation.

Similarly, aggregated yield data may be used (or sold to others to use) to identify the most productive tracts of farmland on a national scale, further facilitating investments by REITs into the agriculture real estate market. Farmland has been described on Wall Street as "gold with a coupon," reflecting the fact that farmland prices have historically appreciated on a consistent basis in addition to generating annual revenues (Moyer 2014). Markets and competition for farmland have traditionally been more regional between active farmers and landowners, many of whom are retired farmers. Increased competition by non-farming investors puts pressure on land prices to increase. While farming landowners' balance sheets benefit from increasing land values, high land prices are frequently cited as the primary barrier to entry for new and young farmers who do not have the resources to acquire land on a scale to allow economically efficient crop production.[5] Moreover, farmers' cash flows are negatively affected by increased land prices and cash rental rates. According to the 2012 Census of Agriculture, approximately 40% of farmland nationally is operated under lease or rental agreements, with much higher percentages in the Midwest grain belts where big data issues are perhaps of greatest relevance—and concern, as evidenced in part by the farmer associations party to the data privacy principles agreement noted above.

Finally, farmers may be concerned about government collection and use of data, either for farm program analysis or for environmental enforcement. A recent paper by Antle et al. (2015) arguing for the utility of a new data infrastructure to exploit big data for agro-environmental policy analysis would seem to justify concerns about such uses. Antle et al. recognize that such a program would likely have to be voluntary to be "politically and socially acceptable" (2015, 5) in light of farmers' expressed concerns about data privacy and security concerns, but the authors also explain the potential short-comings of a voluntary (versus mandatory) system for statistical analysis purposes. Compound traditional privacy concerns with the possibility of Environmental Protection Agency (EPA) access to data on

[5] An economically efficient crop operation may require a minimum of 500 to 1,000 acres. Even at $5,000 per acre, entry into farming would require $2.5 to $5 million dollars just in land. Thus, a common quip that the only way for a young adult to get into farming is by death (inheritance) or marriage.

farmers' pesticide and herbicide application practices, and farmers' concerns about data access and use is not surprising.[6]

Thus, farmers have a wide range of concerns about the uses of their data and how those uses may end up putting farmers at a competitive disadvantage relative to the companies with whom they are sharing their data to begin with.

Turning Data Concerns on Their Head

While the concerns about big data in agriculture have primarily been cast from the farmer's perspective, it is also of concern to the ATPs whose algorithms embody the information generated by using those data and whose outputs reflect the nature of those algorithms. This creates a potential tension in the ownership and use of farm data. Again using Monsanto's FieldScripts® program, if the farmer owns the data on their actual planting rates and the field map data that Monsanto used to generate the farmer's prescriptions, one could imagine those data being used by competitors to backward-out Monsanto's prescription algorithm, or a close approximation. However, farmers who may want to work with a different ATP in subsequent years—or ones who work with multiple ATPs in a given growing season—may have need to share data with them in the course of using their services. Likewise, ATPs may have concerns about receiving data from farmers that the farmer herself does not own, giving rise to potential violations of intellectual property or licensing restrictions. As noted above, ATPs are increasingly forming alliances or partnerships with each other to access one another's data or knowledge bases. While on the surface these arrangements may be intended as value-adding for the various participants, the arrangements may also be defensive in nature to prevent disputes over data ownership and use.

Principles of Data Privacy and Security in Agriculture

Given the attributes of and issues associated with big data in agriculture discussed above, it is clear that both sides of the data equation have an interest in developing clear property rights over agricultural production data and its use. In November 2014, several agricultural producer organizations and leading ATPs announced agreement on a set of principles to govern data use and sharing.[7] The principles outline an agreed upon approach to dealing with data issues and an agreement to continuing dialogue as new technology and data issues evolve.

In terms of ownership, the principles state that farmers retain ownership of "information generated on their farming operations." This definition creates a clear delineation between data or information generated using the farmer's data and information generated on the farm itself. Thus, the principles suggest a farmer would not own data reflecting the recommendations of ATPs, such as planting guides and rates, despite those planting data being used on the farm operations.

[6] One might just as reasonably argue that application data may provide a defense against EPA claims. However, that would be equally valid without giving *a priori* access to the EPA to use in identifying potential sources of violations.
[7] The participating organizations include American Farm Bureau Federation®, American Soybean Association, Beck's Hybrids, Dow AgroSciences LLC, DuPont Pioneer, John Deere, National Association of Wheat Growers, National Corn Growers Association, National Farmers Union, Raven Industries, The Climate Corporation – a division of Monsanto, and USA Rice Federation.

The principles further state "it is the responsibility of the farmer to agree upon data use and sharing with the other stakeholders with an economic interest, such as the tenant, landowner, cooperative, owner of the precision agriculture system hardware, and/or ATP, etc." In the case of owners of precision agriculture system hardware and ATPs, data must be shared between the farmer and the service provider as a fundamental aspect of the transaction. For data sharing between the farmer and landowner, tenant, or cooperative, there is no *a priori* reason that data should be shared as a matter of principle. Landowners, farmers or tenants may have reason to withhold information about their productive efforts either in negotiating or implementing cash rent or share contracts.

Allen and Lueck (1992, 1993) argue that the choice of cash rent or share contract, and the amount of the share, are based in part on the information asymmetry between farmers and landowners. Farmers have incentive to exploit soil quality, underinvest in maintaining or improving soil quality, and misreport input use and output yields to landowners from whom they rent. Depending on the type of farm operation (e.g., irrigated or non-irrigated; more or less volatile annual yields, etc.) and the cost of measurement, the optimal form of contract (share vs. rent) and the amount of share or size of rent payments would be different. As new technologies improve the ability to objectively verify input use and yields, one would expect parties to request access to this data as part of their contract negotiations and for contract terms to reflect the reduced information asymmetry between parties. But one would expect these terms to evolve naturally as a matter of competition between potential tenants and landowners.

The principles statement further stipulates the expectation of privacy, informed consent, transparency, and the ability to choose the level and type of information that can be collected and used by ATPs. The agreed upon practices mimic the kinds of privacy agreements seen among most online service providers' end-user license agreements (EULAs): contractual consent documents, including disclosures of how data will be used and the third parties with whom data will be shared, "whether signed or digital." This means producers could be presented with a standard privacy agreement as part of the ATPs EULA and asked to "Click Agree" to continue, thereby consenting to the privacy terms without having to physically read and sign the document. The principles further state the contract should also outline the ATP's options for farmers to limit use or disclosure of their data, and should provide for famer's individual, identifiable data to be retrieved from the ATP's records and returned to the farmer in a format that is portable or compatible with other data systems, allowing the farmer to share it with an alternate ATP.

Farmers are also given *de jure* residual control rights over the use of their data beyond the original terms of use with the ATP. The principles state that "[a]n ATP will not sell and/or disclose non-aggregated farm data to a third party without first securing a legally binding commitment to be bound by the same terms and conditions as the ATP has with the farmer. Farmers must be notified if such a sale is going to take place and have the option to opt out or have their data removed prior to that sale." On the surface, this allocation of rights would seem to protect farmers' privacy interest and would make the sale of data to third parties extremely costly for ATPs who have to obtain consent from every farmer customer. However, given the data from any single farm is unlikely to be of much value to a third party, the *de facto* rule is that ATPs can sell or disclose aggregated data to any third party that is willing to abide by terms similar to the ATPs original consent disclosure agreement. Notably, this provision does not distinguish between aggregated and farm-identifiable data, as with the farmer's retrieval policy. While the latter specifically refers to data "that has been made anonymous or aggregated and is no longer specifically identifiable," the residual control rights apply only to "non-aggregated farm data." Consequently, the terms offer little meaningful protection for farmers' privacy. However, this is probably in farmers' best interests as a whole.

Finally, the data privacy principles specifically prohibit the use of data "for unlawful or anticompetitive activities, such as a prohibition on the use of farm data by the ATP to speculate in commodity markets." Obviously, a prohibition against unlawful use is superfluous, except insofar as to frame the restriction on behavior that may be deemed anticompetitive but not otherwise be unlawful. Speculative trading in agricultural commodities is subject to regulatory limits imposed by the Commodity Futures Trading Commission's (CFTC) Regulation 150.2. The CFTC's regulations are based on volume limits, regardless the source of a speculator's information, since it is the size of positions that moves market prices. Consequently, it is unclear whether the concerns around speculative trading using farm data are well-founded and whether prohibitions against otherwise-legal speculative trading would in fact benefit farmers. I'll return to this below.

Competitive Implications of Ag Data Ownership and Privacy

The Principles statement is an attempt by industry to implement a privately ordered set of norms in the absence of (or to preempt) specific formal regulations governing ag data privacy and security. The questions, however, are whether any such norms are necessary and whether the proposed restrictions—much less any federally-imposed restrictions—may themselves result in anticompetitive effects and a reduction in competition and innovation in this growing industry for ag data services. In this section, two areas of competitive concern are addressed: restrictions on data transfer, and restrictions on use of data beyond the farm.

Data Ownership and Restrictions on Data Sharing

The proposed data ownership and sharing rules limit the ability of farmers to share all the data they have available from their farming operations with potential service providers, potentially limiting the quality of services that can be offered from competing ATPs. While farmers own data generated on their farming operations, such as soil maps, weed maps, and harvest data, application data for seeds or other inputs may not belong to the farmer if those data were prescribed and provided by ag data service companies. In cases like Monsanto's FieldScripts® program, in which application rate and guidance data are provided on a tablet device that is simply plugged into the farmer's (or farm equipment owner's) machinery, the farmer may never have access to the precise application data itself unless that data can be downloaded to the farmer's computer. At best, the farmer would know only the total amount of inputs applied over a given number of acres (average application rates).

Since the prescription data does not belong to the farmer, the farmer cannot transfer the data to a third party ATP outside the relationship with the generating ATP. Moreover, contractual restrictions may further limit the ability of the farmer to use the data for herself. As an example, Monsanto's service agreement specifically states that "FieldScripts® and the related algorithms and documentation are the intellectual property and proprietary information of Monsanto. Grower may not transfer FieldScripts® and its related information to any third party for reverse engineering FieldScripts®. This provision shall survive termination of this Agreement." In addition to limiting the sharing of data with third parties, the service agreement also prohibits farmers from using the FieldScripts® data on fields not contracted for the program, effectively limiting the farmer's use of data that may traditionally have been owned and used by the farmer for her own analytics.[8]

While the principles statement stipulates that farmers own their own data, the guidelines limiting ATP's ability to share that data leave open a wide range of uses provided they are consistent with the ATP's original data privacy and collection notice. In theory, the ATP could license use of the data to other ag data service providers to develop technologies and algorithms that would enhance or expand the ATP's product and service portfolio. While this would create an opportunity for new entrants to gain access to data, it clearly places large, incumbent ATPs in a roll of gatekeeper for new product development that relies on historical farm data.

The competitive advantage of the ATP incumbent when it comes to potential new market entry is twofold. First, the large ATPs have access to a broad cross-section of farm data aggregated across their many farm customers. As argued above, this is likely more important than a long history of farm-level data. Sonka (2014) argues that the idiosyncratic nature of agricultural production resulting from the biological production process limits the salience of older data for forecasting future yields. Add to that, changes in agricultural technologies and the limitation of annual observations, and it quickly becomes evident that cross-sectional variation over a limited number of seasons provide better data for identifying relationships between important input factors and practices. Second, given the limitations on the kinds of data farmers can share or may even have available from their operations, potential entrants may not be able to acquire as much data directly from farmers as would be available to (and from) the ATP, since the ATP is able to use both the farmer's data and its own in refining its algorithms and developing new products and services.

Given the relative novelty of big data and its competitive effects, the appropriate role of antitrust law to mitigate market foreclosure concerns is unsettled. Geradin and Kuschewsky (2013), Newman (2014), and Stucke and Grunes (2015) all argue that competition law can (and should) play an important role in mitigating the entry barrier effects of large first-movers in big data sectors. Manne and Rinehart (2013) argue that argument about market foreclosure failure to understand the economics data-driven businesses. However, these papers all focus on consumer personal data in the context of social media platforms that are offered to consumers at a price of zero, which raises the question of what anticompetitive harm would even mean. That is not the case in the ag data services industry, which thus far has not received any attention in the antitrust arena. That said, the FTC follows a rule of reason approach in enforcing such anticompetitive concerns under the Robinson-Patman Act, meaning the economic efficiencies of data ownership for innovation and product development among ATPs would be weighed against any potential market foreclosure and evidence of competitive harm to farmers.

If farmers are concerned about potential ability of ATPs to foreclosure market access to new entrants, they have the ability to reduce transaction costs for potential entrants while also increasing the value of their individual data by forming agricultural data marketing cooperatives. Unlike most any other business sector, agricultural producers have exemption from antitrust laws in jointly marketing their products, including data resources. Because no one farmer's data adds significant value at the margin, autonomous data markets would result

[8] I did not find terms of use for Pioneer and WinField, but it is reasonable to believe they would include similar use restrictions.

in near-zero prices for an individual farm's data. By aggregating data from a large number of farmers, the value of the data resource would be larger and generate larger average returns than could be achieved individually.

Grower Information Services Cooperative (GISC) was originally formed to aggregate farm data and sell it to crop insurance companies to improve their risk management and pricing strategies. Since Monsanto's acquisition of The Climate Corporation in 2013, GISC has broadened its scope and marketing to potential cooperative members as an alternative mechanism to share in the value of their data for developing ag data services. Farmer cooperatives continue to control a significant share of agricultural input retail and contract services for their customer-owners. These cooperatives already have access to large amounts of data from their members, but have thus far not shown a recognition or ability to take advantage of that data access to capture value for their members by marketing their collective data resources. A limiting factor may be uncertainty over what information can legally be collected, packaged, and resold given their members' existing arrangements with ad data service ATPs. Another may be the fact that these local cooperatives are often certified dealers for the ATPs themselves.

Restrictions on Use of Data Beyond the Farm

As noted above, concerns about the use of data beyond the farm extend beyond the farm operations themselves to the ability to use that information in commodity and real estate markets. Concerns about selling data to institutional investors and REIT managers could be covered by limitations on transferring data for uses beyond the scope outlined in the ATP's original data collection agreement. However, use of data for "unlawful or anticompetitive activities" is more specifically targeted to manipulation of commodity markets. As noted earlier, the CFTC restricts any party from what it defines as excessive speculation in the market (17 CFR 150.2), including specific position limits on corn, wheat and soybeans (70 FR 24706, May 11, 2005). The limits are based on average contract volumes for each commodity's futures contracts so as to limit the ability of any one speculator from cornering or manipulating the market—regardless the source of their information.

There are two principle periods in which ATPs might have a significant information advantage based on their access to farm-level data: planting and harvest. At harvest, real-time yield data could give data aggregators earlier insights on expected harvest yields than are otherwise available. Currently, reliable yield data are not readily available in the market until sometime after harvest. Elevators may report total deliveries, but do not know the actual number of acres harvested nor how much of the harvest may have been stored on-farm. A small number of private companies also collect data from elevators and conduct field surveys to provide private crop reports. The USDA also produces harvest forecasts based on various survey instruments and data collection efforts. At each stage, there is a delay in information being made available to market participants. Real-time harvest yield data could give the aggregator a lead of anywhere from days to weeks. However, near-month contracts have the strictest regulatory limits on speculative positions; only 600 contracts in any of the major cash crops. Even if a data aggregator attempted to use its information advantage, its ability to engage in anti-competitive trading at harvest would be severely limited by existing trade limitations.

Planting data may provide a greater opportunity to engage in speculative behavior since position limits are significantly larger for longer-term positions.[9] As ATPs gather data on the number of acres planted and, for companies that also perform crop forecasting like Monsanto, projections of yields for those acres based on agronomic and climatic conditions and forecasts, they would have an advantage in taking on speculative positions. This would continue through the growing season as in-season data are collected and compared against growth prediction models, like Pioneer's Field360™ model.

However, such speculative trading provides information to the market—and for this reason; the information is arguably superior to what is currently available. This would make futures prices more accurate predictors of future prices, which would allow farmers to more accurately hedge and price the value of their crops. With increasing global demand for agricultural commodities, increasing ties between agricultural commodity prices and the energy complex through biofuels, and structural changes like moves to electronic trading, commodity prices have become more volatile. Some have raised concerns about the quality of price discovery as a result of these changes (Irwin and Sanders 2011). Allowing data aggregators to trade on their data would actual improve market conditions for all interested parties by bringing more accurate and scientifically grounded information into the market. On this point, the principles for data privacy and security negotiated by the industry are likely to work against farmers' interests.

Conclusion

As noted in the introduction, Whitacre et al. (2014, 3), argue that "[b]efore 'big data' will be widely accepted by farmers and others across the agricultural industry, its collection, processing, on-demand analytics, and decision making must become passive to the user." Agricultural technology and data service providers are quickly moving into this space to provide decision making tools for farmers that require very little analytic skill or active participation by the farmer. Data can be directly uploaded from the farm equipment to the provider's servers for analysis. The provider can return a tablet that simply plugs into the farmer's equipment and applies the results of the ATP's analysis and prescriptions. We are just on the front edge of a data-driven transformation of the agricultural sector.

But with such innovation comes other concerns about a data-driven industry: who owns the data, how can they use it, and what does that mean for competition and industry dynamics? If Whitacre et al. were concerned that farmers needed *'big data'* to be served up for them, they overlooked the privacy and competition concerns of farmers about the use of their data. Industry players have attempted to outline a guiding set of principles concerning data ownership. Proposed answers to questions about ownership and use raise concerns about the implications for new market entrants and commodity market performance. An analysis of the proposed industry standards suggests that farmer groups are likely worried about the wrong things, specifically with regard to data use for speculation, rather than the dynamic consequences of data usage guidelines for future competitive market outcomes.

[9] For instance, the aggregate position limits for corn, wheat and soybeans are 33,000 contracts, respectively, compared to spot month limits of 600 contracts.

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References

Alexander, C., M. Boehlje, S. Downey, A. Gray, M. Gunderson, and M. Roucan-Kane. 2009. Serving Producers in Volatile Times: Report from the 2008 Large Commercial Producer Survey. Working Paper 09-09, Purdue University. http://purl.umn.edu/56116.

Allen, D. W. and D. Lueck. 1992. Contract Choice in Modern Agriculture: Cash Rent versus Cropshare. *Journal of Law and Economics* 35(2): 397–426.

________. 1993. Transaction Costs and the Design of Cropshare Contracts. *The RAND Journal of Economics* 24(1):78–100.

________. 1998. The Nature of the Farm. *Journal of Law and Economics* 41(2): 343–386.

Ali, Sarah. 2014. Directory of Rural—Farmer, Rancher, and Fishery Cooperatives. *Rural Development Service Report 22*, U.S. Department of Agriculture.

Antle, J., S. Capalbo, and L. Houston. 2015. Using Big Data to Evaluate Agro-environmental Policies. *Choices* 30(3). http://www.choicesmagazine.org/UserFiles/ file/cmsarticl _ 465.pdf.

Brewster, D.E. 1979. The Family Farm: A Changing Concept. Structure Issues of American Agriculture. U.S. Department of Agriculture, Economics, Statistics, and Cooperative Service, AER-438. http://naldc.nal.usda.gov/naldc/download.xhtml?id=CAT848026 68&content=PDF.

Geradin, D., and M. Kuschewsky. 2013. Competition Law and Personal Data: Preliminary Thoughts on a Complex Issue. SSRN: http://ssrn.com/abstract=2216088 or http://dx.doi. org/10.2139/ssrn.2216088.

Griffin, T.W., J. Lowenberg-DeBoer, D.M. Lambert, J. Peone, T. Payne, and S.G. Daberkow. 2004. Adoption, Profitability, and Making Better Use of Precision Farming Data. Department of Agricultural Economics, Staff Paper #04-06, Purdue University, West Lafayette, IN.

Heady, E.O., W.B. Back, and G.A. Peterson. 1953. Interdependence Between the Farm Business and the Farm Household with Implications on Economic Efficiency. Research Bulletin 398, Department of Economics and Sociology, Iowa State College, Ames, IA.

Irwin, S.H., and D.R. Sanders. 2011. Index Funds, Financialization, and Commodity Futures Markets. *Applied Economic Perspectives and Policy* 33(1): 1–31. doi: 10.1093/aepp/ ppq032.

Manne, G.A., and W. Rinehart. 2013. The Market Realities that Undermined the FTC's Antitrust Case against Google. *Harvard Journal of Law & Technology* 26(2):(Spring).

Mishra, A.K., El-Osta, H.S., Morehart, M.J., Johnson, J.D., Hopkins, J.W. 2002. Income, wealth, and the economic well-being of farm households. Farm sector performance and well-being branch, Resource Economics Division, Economic Research Service, US Department of Agriculture. Agricultural Economic Report No. 812. U.S. Department of Agriculture, Washington DC.

Moyer, L. 2014. Time to Buy the Farm? *Wall Street Journal Online* 7-September. http://www.wsj.com/articles/reits-give-small-investors-access-to-farmland-and-forest-tracts-1410120112. Accessed March 24, 2015.

Newman, N. 2014. Search, Antitrust and the Economics of the Control of User Data. *Yale Journal on Regulation* 30 (3). http://papers.ssrn.com/sol3/papers.cfm? abstract_id= 2309547.

Pritchard, B, D. Burch, and G. Lawrence. 2007. Neither 'family' nor 'corporate' farming: Australian tomato growers as farm family entrepreneurs. *Journal of Rural Studies,* 23:75–87.

Schimmelpfenning, D. and R. Ebel. 2011. On the Doorstep of the Information Age: Recent Adoption of Precision Agriculture. U.S. Department of Agriculture, Economic Research Service, Washington, D.C.

Stucke, Maurice E. and Allen P. Grunes. 2015. Debunking the Myths Over Big Data and Antitrust. *CPI Antitrust Chronicle* University of Tennessee Legal Studies Research Paper No. 276. SSRN: http://ssrn.com/abstract=2612562.

Sonka, S. 2014. Big Data and the Ag Sector: More than Lots of Numbers. *International Food and Agribusiness Management Review* 17(1):1-20.

Whitacre, B.E., T.B. Mark, and T.W. Griffin. 2014. How Connected are Our Farms? *Choices* 29(3). www.choicesmagazine.org/UserFiles/file/cmsarticle_392.pdf.

Zhang, C. and J.M Kovacs. 2012. The application of small unmanned aerial systems for precision agriculture: A review. *Precision Agriculture*. 13(6): 693-712. doi: 10.1007/ s11119-012-9274-5.

