



## ABSTRACT

The promise of “big data” has been praised by the popular media. Concepts and impediments surrounding big data are discussed relative to both the current status and anticipated direction of the industry. Rural property professionals, such as farm managers and rural appraisers, have an opportunity to position themselves and their clients to make effective use of big data. Topics relevant to big data in agriculture include farmland values, lease arrangements, data ownership, data as an asset and its valuation, and the ramifications of wireless connectivity. The challenges that rural property professionals may encounter when integrating big data into their portfolio of services are described.

## Big Data Considerations for Rural Property Professionals

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## Introduction

There has been considerable media attention on big data in the agricultural industry and its potential value. Big data are often described by four V's: it takes too much "volume" to move the data by conventional methods; it grows at a "velocity" too fast to analyze by conventional methods; it is contained in a "variety" of unstructured formats; and has uncertain "veracity" or quality. In this application, big data are a natural progression resulting from precision agriculture technology with the capacity to hold substantial value, especially when aggregated into a community for pooled analysis. Agricultural data fit the criteria set forth by the four V's of big data, although the term may inaccurately, but acceptably, refer to small data or medium data at the farm level. Data from any one farm is not likely to meet all four V's, but when aggregated into a community it is assumed that the agricultural dataset truly becomes "big".

Agricultural big data includes, at least in part, geospatial data and metadata on production, machinery, and environmental factors. This so-called metadata includes management information such as seeding depth, seed placement, cultivar, machinery diagnostics, time and motion, dates of tillage, planting, scouting, spraying, and input application. Geo-spatial data are the site-specific data typically associated with precision agriculture such as site-specific soil and harvest yield. In addition to data on the products and how those products are applied, information on external environmental circumstances such as weather including precipitation events, evapotranspiration, and heat unit accumulation help to round out the complete big data package.

The valuation of agricultural data has been elusive, whether it is precision agriculture data from a single

field, or big data aggregated in near real-time across many farms. The value of data relies upon how the data are utilized rather than who possesses it. Data from a given field has a finite value to that specific field, but a community of aggregated data suitable for pooled analyses has much greater potential value. Currently, only limited quantitative evidence exists regarding the value of assembling data from precision agriculture technology. However, several concepts should be considered given the status of the industry.

In this paper, rural property professionals are challenged to think about data in non-traditional ways, to spark increased discussion of the topics, and to prepare to make the most of this opportunity. In particular, from the perspective of rural property professionals such as farm managers and rural appraisers, they should consider these issues, as well as position themselves and their clients to prepare for capitalizing on the big data opportunities in the short term. The following are common questions about data which will be covered in this paper:

- How do the characteristics of data differ from those of physical goods such as grain?
- How can big data impact competitive dynamics in agriculture?
- Is ownership of data tied directly to the farmland or can they be separated?
- What impact will big data have on farmland values and rents?
- What issues should be considered in a written farmland lease?
- How should data sharing agreements with service providers be managed?
- Will agriculture data ever be considered an asset on the balance sheet?

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- How should data security be managed?
- What impact will wireless connectivity have on big data adoption?

Precision agriculture is an “information technology” that has empowered farmers to collect unprecedented amounts of data. Yield monitors on combines and cotton pickers mated with global positioning systems (GPS) have been used on millions of acres across the United States since the mid-1990s (Schimmelpfennig and Ebel, 2011) providing site-specific measure of yield. Automated and manual soil sampling technology provide site-specific nutrient and physical characteristics. Similar technology that applies varying rates of an input also records as-applied data along with meta-information on date, rate, and product. Today, the farmer’s smartphone is an integral part of their farming operation linking not only voice communication but allows for real-time monitoring of employees, irrigation, and imagery.

Raw data in its original form often has no value at least until it has been converted to information suitable for making decisions. Data, or at least the control of data, is deemed valuable, but data valuation is elusive and determining that value is not straightforward. Agricultural value is usually expressed as land values or production such as grain and animal products. But with the evolution of big data out of precision agriculture, agriculturalists must think differently about the storage, analysis and value of the data.

### How do the characteristics of data differ from those of physical goods such as grain?

Agricultural practitioners must accept data for what it is rather than attempt to impose the characteristics of physical goods such as commodities, machinery, and

farmland to which they are more accustomed. Clientele, too, should be aware that data are not like these physical goods. For instance, a farmer can retain ownership of grain even when that grain is stored in an elevator commingled with other producers’ grain. Digital data are electronic in nature and have dissimilar characteristics from physical goods. When copies of electronic data are made, the copies are indistinguishable from the original and are considered identical. Essentially, once a copy of the data has been made available to another party, the original owner of the data has minimal control over what happens to the data from there. Also, multiple entities may have access to viable copies of the same data, unlike farmers’ grain stored in an elevator.

Furthermore, data are considered a “non-rival” good because the consumption or usage of data by one person does not alter another person’s ability to consume or use the same data. A classic example of this is books and movies. Multiple people can watch the same movie or read the same book without any loss of value to any subsequent viewer or reader. There is no loss of utility in the next person enjoying the same volume. Agricultural examples of non-rival data include accessing weather reports or commodity market information on a website. In this example, the value of the information by the initial farmer is not affected by another farmer accessing the information. The same is true of data. A farmer and multiple, subsequent entities can consume the farmers’ data without reducing any of the initial value enjoyed by the farmer.

While we have established that data are a non-rival good, we must further consider whether the data are “excludable” or “non-excludable” in nature, depending upon ownership, or more specifically, who has access

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rights to the data. Ownership of goods which are excludable carries a right of the owner to exclude others from having access to them. Thus, most privately held goods typically are excludable. Using the non-rival example from above, not all commodity market information is available to the public. In some cases, there are trades between grain merchants which do not get reported to the public in any form, even though the entities may have websites with posted bids. The transactions not reported to the public are deemed to be excludable. However, if all trades between entities were publicly reported in a manner similar to a futures exchange, such as the CME Group, then the data would be considered non-excludable. An example of this would be data provided by a commodity broker. Privately held agricultural data can be excludable while it is solely in the possession of the party that generated it. However, once it has been shared with other parties or aggregated, that excludability is likely significantly reduced or eliminated.

Another characteristic of data is that it is an irreplaceable good. Similar to family heirlooms, specific farm-level data may not be recovered if lost during data transfer or equipment malfunction. The manual transfer of data is one common way data are lost (i.e., if memory cards are destroyed before being transferred to another storage device). Data transfer over cellular communication systems is becoming an increasingly available feature with ancillary benefits of avoiding data loss, but this feature is still limited by the quality of the cellular data connection (Whitacre et al., 2014) and relatively low adoption rates (Erickson and Widmar, 2015). As with any other digital data, it is recommended that agricultural data be backed up frequently in multiple locations. The loss of data could diminish the value of the total dataset especially if multiple years of data or layers are lost.

So where does agricultural data fit on the grid of “rival” versus “non-rival” and “excludable” versus “non-excludable” dimensions? This is an interesting question, because both dimensions are actually linked in ways different than physical goods. For example, one is tempted to think that others’ use of farm data could reduce the value the data has to himself or herself, thus making the data a rival good. As a result, farmers and consulting professionals may be concerned that their competing peers, landowners, retailers, manufacturers, or other groups may gain competitive advantage if they are able to access the given farmer’s data. Farmers may perceive the need to exclude others so that those entities will not disproportionately benefit from the farmer’s data. In so doing, they seek to convert their intangible resource into one which is more excludable in form.

### **How can big data impact competitive dynamics in agriculture?**

Early adopters of big data in industries such as healthcare, transportation, and retail are shown to have gained a competitive advantage within their industries and have realized significant increases in operating margins (Manyika et. al., 2011). There is an emerging discussion in the agribusiness industry and its literature about the potential of big data and its capacity to change the basis of competition in agriculture (Sonka, 2014). This belief is based on the previous trends in the history of innovations powering productivity and enhancing competitiveness in the agri-food supply chain, enabled by information and communication technology (ICT). Among such examples is precision agriculture powered by GPS, remote sensing, and variable rate technology (VRT) technologies in crop farming. While the adopters of ICT-based applications in agricultural production were primarily motivated by the efficiency gains, they also have

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laid the foundation for the big data infrastructure within agriculture. As a result, modern farms are generating, or have a capacity to generate, a substantial amount of agricultural production data. This data becomes an important intangible resource alongside the physical and human resources, which if managed effectively, can produce substantial value for the farming operation. The important question to ask is under which circumstances the data, as an intangible resource, can become a source of competitive advantage?

According to the resource-based theory (RBT), the important preconditions for competitive advantage are the heterogeneity and immobility of firms' resources and capabilities (Grant, 1991; Peteraf, 1993). That is, for a resource or a capability to be a source of competitive advantage, it must vary across competing firms and competitors must be unable to obtain it from other firms or resource markets. The ability of the farm operator to extract value from data depends upon the quality of the data and its available analytic capacity, or the capability to turn data into useful actionable information. Both the data quality and analytic capability vary across farms conforming to the heterogeneity condition of RBT. The "excludable" characteristic of data, mentioned previously, ensures the immobility condition of RBT. Following the RBT framework, the farm data can serve or be perceived as a source of competitive advantage. This theory is consistent with the observed farm data management behavior of farm operators, particularly with the general reluctance to share farm data.

While the insights from the analysis of own farm data can be of value to the farmer, the true potential of big data in agriculture lies in the ability to accumulate and analyze detailed data from many farming operations. The

extent to which the information can be accumulated and analyzed to gain additional economic value is referred to in the information economics literature as aggregation potential (Samuelson, 1997). Aggregation potential is based on the concepts of economies of scale and scope, and the network effect. In practice, however, the aggregation potential is constrained by a number of issues, chief among them being the data privacy issue. The reluctance to share data or to participate in a big data community is widely seen as one of the main challenges for realizing the full potential of big data applications in general and in agriculture in particular.

Analyzing the data of many farms together may reveal patterns impossible to determine while examining the data of the farms in isolation; such analyses could suggest management decisions that could increase the profits and efficiency of all the farms, whether they collect precision agriculture data or not. Further, the information that can be derived from this sort of aggregated data analysis frequently increases with the number of parties sharing data. This "network externality" effect means that the value of participating in a network (such as a data network) increased with the number of parties participating (Sauer and Zilberman, 2012). For example, consider technologies such as the telephone, fax machine, computer modems and the Internet itself; the value of each of these is a function of how many other people utilize compatible technology. With small communities, farmers may not perceive adequate incentive to participate at until a critical mass of peers have joined. Excluding others from benefiting from one's own data usually means avoiding the community and therefore forfeiting any potential benefits as a whole.

### **Is ownership of data tied directly to the farmland or can they be separated?**

All of these considerations lead many farmers to this question: “who ‘owns’ farm data?” The notion of property ownership typically involves some form of six interests which include the right to possess (occupy or hold), use (interact with, alter, or manipulate), enjoy (in this context, profit from), exclude others from, transfer, and consume or destroy. Some of these interests do not fit, or at least do not fit well, with data ownership. Excluding others from data, for example, is difficult, particularly when it is possible for many people to “possess” the property without diminishing its value to the other possessors, so just like in our previous example, the value of a book to one person may not be diminished by the fact other people own the same book. Thus, the better question may be “what are the rights and responsibilities of the parties in a data disclosure relationship with respect to that data?” (Peterson, 2015).

Considering the previous establishing statements about data, in what ways may data ownership be transferred? One thought is that data ownership could perhaps be separated from farmland much like mineral rights. However, minerals are physical as opposed to digital. In their treatise on how big data may impact farmland values and rents, Griffin and Taylor (2015) compare and contrast data to mineral rights. They suggest that data may be separable from the land, analogous to how mineral rights and surface rights can be sold separately in the United States. Just like landowners sometimes retain the mineral rights when they sell the surface rights of farmland, the access rights of data may be retained and/or sold in a different transaction. This scenario most likely applies to land purchased by a farmer who then would have to negotiate separately the purchase of the

data. For rural appraisers this would create a whole new level of property rights that would have to be evaluated.

### **What impact will big data have on farmland values and rents?**

In addition to describing the separability of data from farmland, Griffin and Taylor (2015) presented how big data could impact farmland values and rental rates. Griffin and Taylor (2015) state that: “It remains unclear whether the ‘data premium’ will be a true premium (an amount added to the market price of land) or a penalty (an amount deducted from the market price of land). In the short-run, early movers who choose to provide data to land buyers may see a premium. However, as the transfer of data with a land sale becomes more common, a penalty to land parcels without data may become more common.” They also describe how biophysical data, such as historical yield, soil test results, and other production data have been included in farmland sales and/or rental agreements, but they suggest these data have not substantially influenced farmland values nor are sufficient to be considered “big.” These historical data could be annual whole-field yield written on paper or site-specific geospatial data including GPS yield monitor data or grid soil samples in either electronic form or printed maps. Although the above mentioned data may provide evidence of historical productivity and soil amendment utilization, they do not impact farmland values directly. Farmland values and rental rates will likely be a function of both quantity and quality of geospatial metadata once the big data sector of the agriculture industry matures.

This foresight into farmland valuation is based on the premise that in a mature “big data” system – where critical mass of farm-level data are aggregated into a community dataset – the management of an individual tract of land

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will depend upon in-field data along with data from fields within some proximity or neighborhood characteristics. Data availability of fields within the potential community influences the farmer's optimum decisions; therefore, the presence or absence of data from a specific field may impact their whole farm system. In certain scenarios, a farmer without any fields that have historical data sufficient to participate in a "big data" system may pay a premium to secure an additional field that includes an adequate quantity and quality of data.

## What issues should be considered in a written farmland lease?

Rural property professionals often deal with contractual agreements between farm operators and landowners (Griffin and Baird, 2010). If not already an explicit part of the written farmland lease, a well thought-out agreement on data control and access will be important to how the agricultural industry moves forward. As already discussed, data control may be separable from farmland, implying that the data may be retained by farmer, current landowner, or remain with the land itself.

A landowner and farmer have three basic ways they can address the ownership of data generated on farmland: a) the person farming the land, normally the tenant, can own all data generated on the land; b) the landowner can own all data generated on the land; or c) the landowner and tenant can share, or co-own any farm data generated.

Regardless of who the landowner and tenant determine will own the data, a lease should address at least three data issues. First, a lease should define what "Farm Data" is since there is no widely recognized legal definition that fills in this blank. Second, the lease should establish, who is the default owner of the defined "Farm Data." Finally,

the lease should spell out what happens to "Farm Data" generated during the lease, when the lease expires, or is terminated.

Here is an example of what these provisions could look like when added into a farmland lease. This particular example assumes that the tenant will own the data, but when the lease ends the tenant has an obligation to transfer such data to the landowner. Note that in this example tenant's ownership rights are absolute, but it would be possible to add certain restrictions on ownership, such as a prohibition on sharing farm data with certain third parties:

1. Landowner and tenant recognize that tenant's farming of the leased farmland during the term of the lease will generate agronomic data, including information related to soil, water, seed variety, crop health, crop maturity, disease, nutrients, fertilizer, herbicides, pesticides, yield etc., in various digital forms, including files, imagery, records, video, photos, etc. ("Farm Data").
2. Landowner assigns all rights and interest to Farm Data to tenant and relinquishes landowner's rights in the same. Tenant is the exclusive owner of all Farm Data generated on the leased farmland during the lease term. Tenant shall have all rights associated with Farm Data ownership, including deletion, transfer, sale, and disclosure rights.
3. At the conclusion of the lease, tenant shall assign and transfer all Farm Data from the prior crop year to landowner, or at landowner's election, the subsequent tenant.

Depending on the landowners interest in the farming activities on his or her land, a landowner may also want to

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require periodic uploads from the tenant of the current farm data. Today's online cloud-based data sharing tools would facilitate this transition as a landowner could be granted permission to access a tenant's files remotely. In the long run, the data will certainly be an asset of the landowner as it will assist with establishing the proper rental rate, productivity, and nutrient content of the farmland.

### **How should data sharing agreements with service providers be managed?**

In large part, the legal obligations of parties to a lease are governed by the terms of the lease itself. But what about the rights and responsibilities with respect to farm data in other contexts, such as sharing data with service providers like equipment vendors, consultants, and data aggregators? The legal rules with respect to farm data are not entirely clear, and traditional principles of intellectual property law such as trademark, copyright, and patent may not be directly on-point. Thus, while the concept of the "ownership" of farm data remains unsettled, the most prudent course may be for farmers to treat data they hold confidential as if it were a trade secret, although there remain significant questions as to whether farm data could indeed be a protectable trade secret.

At the farm level, carefully crafted agreements with employees, service providers, and landlords, coupled with practical security measures, can maximize the available protection of farm data. Before sharing data with another party, farmers may want to enter a form of "non-disclosure" agreement with the party (or parties) receiving the data. Such agreements should include at a minimum: 1) a definition of what portions of the shared data are to be regarded as a secret (and

what portions of the data are not); 2) establish the duties of the receiving party in keeping the data secure, i.e., what measures should be taken to prevent the data (as individually identifiable to the farmer) from being disclosed; 3) specify any other parties to which the data may be disclosed; 4) specify what uses for the data are allowable, and perhaps even more importantly, what uses are not allowable; and 5) establish what damages are to be paid if the agreement is violated (since determining a damage amount in litigation may prove extraordinarily difficult). An overarching consideration that should guide the agreement is that some sharing of the data (so long as it does not compromise truly confidential, personally-identifiable information for the farmer) is likely necessary to realize the full potential of the data, as discussed above.

It is recognized that individually-negotiated data sharing agreements may be impractical when dealing with large national or multinational corporations. This comes primarily because those companies will generally seek to have a standardized agreement for many services or products. Continued discussion of these issues at a national level is encouraged to create proactive, negotiated solutions between all parties – service providers and farmers alike.

### **Will agriculture data ever be considered an asset on the balance sheet?**

One debated topic across multiple industries is whether data should be listed as an asset on the balance sheet. The balance sheet indicates the financial valuation which a firm places on the set of assets and liabilities at a specific point in time. Assets can be tangible (inventory, livestock, and machinery) or intangible (algorithms, copyrights, and patents). Intangible assets cannot be

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seen or touched. Although farms typically do not have any intangible assets on their balance sheets, this may be changing as farms generate data that can be used either by the farm directly to make better decisions or by a third party that can make use of the data.

In the first situation, farms that use their own generated data for internal decision making probably do not have any intangible assets. While the data has value when used for decision making, the farm is using it to improve their own profitability, thus the value of the data is internalized and reflected in higher net farm income. This leads to higher equity from increased cash or reduced debt on the balance sheet. In order to list the value of data on a balance sheet, the value must be estimated. However, very little quantitative estimates exist on the market value of data or even the intrinsic value of data to a farm or other agricultural firm. The second situation, where the data are being used by a third party to improve that party's marketing, financial, production, or other services to farmers, is where agricultural data becomes an intangible asset. There are a whole range of issues that revolve around farmer generated data. First, farmer data may not have much value to a third party when used in isolation. However, when farm-level data are combined across many farms, the aggregated data may have substantial value to the third party. Therefore, the debate of including data on the balance sheet may be moot at the farm level.

The topic of data ownership must be revisited when debating data being claimed as an asset on the balance sheet. If any firm or individual does not actually own the data, then that data is probably not an asset to them. Data ownership can be argued from several viewpoints. The farmer may lay claim to ownership since the data

comes from the farm fields that they manage and thus usually pays for the collection. Landowners may have contractual agreements indicating that they are the owners. Equipment manufacturers may claim that the data were generated by their intellectual property, especially when the data were intended to provide feedback to the manufacturer regarding error codes and safety protocols, much like how newer automobiles push diagnostic data to the manufacturer. Given that copies of data are identical to the original, multiple entities may attempt to include the "same" data on their balance sheets.

The issue of how data are to be valued on a balance sheet remains to be addressed. Listing value on a balance sheet is conditional on being able to claim ownership of the data and placing an estimated value on that data. Valuing data as an intangible asset on a balance sheet is similar to the situation corporations face with intangible assets such as goodwill. The topic is receiving more and more attention as the accounting world and financial markets wrestle with the issue. The value of these intangible assets could be very large (Monga, 2014). If and when it becomes an acceptable practice to list data on the balance sheet, the debate regarding who "owns" the data is likely to resurface. Although listing data on the balance sheet is only hypothetical today, the rural property professional should be cognizant of how their clients treat data especially in relation to the other parties including farmers, service providers, landowners, and lenders. A current example may be an appraisal firm that has proprietary sales data for a specific region or niche market and another firm may desire to acquire said firm simply to acquire its database. Therefore it is intuitive that the data has value, and that the presence of this data impacts the firm's valuation. Similar arguments can be

made for how data impacts the value of a farm operation or of the farmland itself.

## How should data security be managed?

Given that data, or at least the utilization of data, may be valuable, it stands to reason that the data should be collected and stored in a secured procedure such that data loss is avoided. The majority of existing farm data resides in “data tombs” where it lies unused and at risk of being destroyed (hard drives have published probability of failure and reliability rates). Both farmers and landowners can experience negative implications in the case of data loss. Physical loss can be the result of a yield monitor being destroyed in a combine fire during harvest season or the theft of the farm office computer. Computer hardware and software failures can also result in data loss. Without a data backup solution, data loss could result in a negative situation given the irreplaceability of data. Given the investment of time and money to collect farm data, it logically follows that farmers would be willing to pay a modest fee for security measures that prevent data from being destroyed or lost.

A key characteristic to a data backup solution is the location in which the backup resides. A local or redundant backup is still susceptible to physical loss such as fire or theft. An offsite backup is limited to the quality of the internet connection transferring the data. From the farm office, this data is considered upload data. Upload speeds are scaled compared to download speeds, affecting cloud backup performance (Whitacre et al., 2014). Disproportionate connectivity speeds also impact utilization of big data and the valuation of farmland.

## What impact will wireless connectivity have on big data adoption?

One of the primary barriers to the adoption and usage of big data is limited wireless connectivity. Before the rapid adoption and usage of big data will occur, the lack of this enabling technology must be addressed. The expansion of connectivity across the US has been a priority, but access has grown slowly. This is especially true in the major crop producing regions. The majority of data transfer occurs over cellular systems, but there are worldwide initiatives to provide wireless connectivity via satellite, balloons, and other platforms. Regardless of platform, the agricultural industry relies upon wireless connectivity to support big data systems.

Telematics allows data to be wirelessly uploaded and downloaded between farm machinery and online servers. However, limited connectivity is a barrier to adoption leading to potential economic losses (Griffin and Mark, 2014). Whitacre et al. (2014) expanded their work by addressing the current connectedness of agricultural production areas. It was these areas that were impacted by the United States Federal Communications Commission (FCC) updated definition of connectivity that could be considered broadband in January 2015. The definition changed from 4 Megabits per second (Mbps) download and 1 Mbps upload to 25 Mbps download and 3 Mbps upload. Although broadband speeds did not instantly change, the level of connectivity that service providers could advertise as ‘broadband’ changed. The faster speeds required to be considered broadband brought light to connectivity barriers, especially with respect to connectivity gaps in rural areas where agricultural production occurs. Specifically, the 25 Mbps download speed requirement negates the majority of United States wireless connections from being classified as broadband.

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However, the vast majority of data being passed between farm equipment and online servers is uploaded rather than downloaded; and upload speeds are typically only a fraction of download speeds. For some types of data such as machine diagnostics and prescriptions, current speeds may be adequate. However, yield data and specifically imagery data may require connectivity speeds in excess of what is currently available. In addition, data layers that are downloaded to farm equipment such as prescription maps are smaller relative to the larger data files collected in field by farm equipment.

Even with limited broadband connectivity, the advent of telematics and big data encouraged unprecedented use of the internet by farmers and service providers. In some situations, the farmer may not even be aware that field equipment is transferring data. Wireless connectivity is being used in the agricultural industry, in particular for telematics. Anecdotal evidence suggests that at least some farmers are actively using telemetry or telematics, where farm equipment can be tracked in near real time via cellular connectivity. Although little public information exists on the utilization of telematics at the farm-level, Erickson and Widmar (2015) report that 7, 15, and 20 percent of input suppliers utilized telematics as part of their offerings during 2011, 2013, and 2015, respectively. In part, the absence or limited wireless availability of broadband connectivity in crop production areas has restricted the perceived benefits of the technology. In addition to telematics data, technology has advanced to allow farmers to share data between vehicles operating in the same field but still relying upon cellular connectivity. Examples of data shared within the field can include field totals, coverage maps, and guidance tracking lines.

The immediate implication for rural property professionals is that farmers who expect to utilize telematics may not be willing to pay similar rental rates for farmland tracts without adequate wireless connectivity. Knowledge of anticipated wireless connectivity speed of a farmland tract will impact the land value and rental rate. Although the National Broadband Map (NBM, <http://www.broadbandmap.gov/>) provides large scale information on broadband connectivity, current connectivity may need to be assessed during a site visit to the field. Just as rural property professionals are well versed in yield history, fertility levels, and irrigation potential of farmland that they manage or potentially manage, they should also be cognizant of the connectivity speeds of the individual fields.

### Discussion

Several big data issues are presented here that the rural property professional should consider. Although agricultural big data are in its infancy compared to some other industries, services surrounding agricultural data are developing quickly. Land professionals and their clients should not think of data like physical goods such as grain, livestock, machinery, farmland or even subsurface minerals. Agricultural data will eventually be electronic, easily copied, and considered non-rival. Data valuation continues to be an area of research by economists; and some discussion regarding whether data should be listed on a balance sheet is being debated. Rural land professionals should be cognizant of the wireless availability of property they are responsible. Although the gaps in wireless broadband connectivity are likely to decline with technological improvements, it is expected that farmland values may be affected by connectivity lags until that time.

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An overview of big data implications that rural property professionals and their clientele should be cognizant has been provided. Although estimates on the value of farm data, data repositories, or intermediate systems have not been provided here, studies are underway by the authors and others to quantitatively address how the open market and society will value data using resource-based theory.

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