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Estimating Value, Damages, and Remedies when Farm Data are Misappropriated

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Introduction

Farm data valuation has been elusive across the industry, especially within the farm gate. The concepts of privacy, security, and ownership have clouded the discussion, leading to distrust by farmers. Farmers' lack of trust regarding how other players may use data from their farms against them has led to discussions on the legal protection of farm data and what remedies exist to compensate for damages. Complementing previous work by legal specialists suggesting that farmers may claim damages reserved for trade secret violations after farm data are misappropriated, this article presents the process of the expert witness estimating relative economic losses and determining potential remedies.

For the purposes of this discussion, we consider a hypothetical situation involving a group of farmers who had data from their farms misappropriated by a data service provider. In this case, the data service provider misappropriated data by selling yield estimates to an unauthorized third party, despite the existence of prior agreements with farmers that explicitly forbade such action. The protections offered under trade secret law may allow these farmers to recover one of three types of damages as plaintiff (see Ellixson, Griffin, and Goeringer, 2016, for details): i) plaintiff's actual damages, ii) unjust enrichment by defendant, and iii) reasonable royalty rate (Fox, 2016).

Assuming farm data are recognized by the courts as a trade secret (Ellixson, Griffin, and Goeringer, 2016; Ferrell, 2016; Fox, 2016; Janzen, 2015), the farmer–plaintiff's first step in pursuing legal action would be to determine which of these damages would return the greatest expectation of substantial compensation (Fox, 2016). If the dispute cannot be resolved outside of court, opposing counsels will contest which remedies to apply to the specific case and call on expert witnesses to compare the relative damage from alleged misappropriation of the data. Successful recovery of damages through trade secret law therefore requires an understanding of i) the intrinsic value of farm data and ii) how misappropriation of data can be quantified in terms of the competing claims to damages.

Before describing how an expert witness would estimate damages, we must first discuss the different valuations of farm data within the farm gate and at an aggregated community level. Understanding how each player enjoys differing valuation from farm data at different points in the farm data lifecycle provides insights into behavior in their respective markets. First, we consider the distinctions among private, club, and public goods relative to excludability.

Farm Data as an Economic Good

For the purposes of this article, agricultural data refers to supply-side production data rather than data on consumer behavior. Griffin et al. (2016) state that farm data includes "geospatial data and metadata on production, machinery, and environmental factors" (p. 168). Metadata include supporting information such as input application dates, planting depth, and cultivar selection (Whitacre, Mark, and Griffin, 2014). Geospatial data include site-specific soil and yield data often associated with precision agriculture (Coble et al., 2018). Telematics data include machinery diagnostics, time and motion, and other data collected by manufacturers of farmers' equipment (Griffin et al., 2016). Farm data have become a hot topic in the agricultural industry recently in part because of uptake in digital technologies in general (Griffin et al., 2018) and in precision agriculture over the last decade in particular (Miller et al., forthcoming). The assumption by many agriculturalists is that farmers are in complete control of data coming from their fields and equipment, but other players in the industry do not necessarily view farm data as a private good.

The distinction between public and private goods depends upon whether a good is excludable and nonrival (Varian, 2014). Public goods are nonexcludable and nonrivalrous. A nonexcludable good has characteristics that make it costly or impossible for one user to exclude others from enjoying those goods. Nonrivalrous goods can be consumed by more than one person without diminishing their value to any other consumer. Private goods are both excludable and rivalrous.

In general, farm data are considered a nonrivalrous good since the consumption, utilization, or enjoyment of those data by one player, farmer, or aggregator does not diminish any other players' ability to consume those same data. For example, multiple people can watch the same commodity pricing data terminals without loss of value to any one viewer. Other agricultural examples of nonrival data include weather reports. In any of the aforementioned examples, the value to a given farmer is not affected by any other player acquiring that information. The same is true of digital agricultural data; a farmer and multiple other entities can consume data from an individual farm without reducing the value enjoyed by any other players.

The discussion logically turns to how competing farmers may make better decisions using the same data. This notion of competitive advantage does not impact whether the data are rivalrous but alludes to whether other players can be excluded from accessing those data. Farm data may be considered excludable or nonexcludable depending upon several factors, but ultimately the decision rests on whether those data have been shared with another party. Stiglitz (1999) suggests that data may be excludable in principle but is likely nonexcludable in practice. Lusk (2016) builds upon Stiglitz's argument and applies that logic to publicly available data from the U.S. Department of Agriculture (USDA). Most USDA data have been obtained from farmers voluntarily responding to surveys, but the USDA maintains excludability of raw data to ensure statistical confidence and confidentiality. In particular, USDA Agricultural Resource Management Survey (ARMS) data are protected to safeguard excludability. Regardless, if data are to be considered a privately held good, then excludability must be maintained. Using the agricultural examples of nonrivalrous goods, commodity price data may be privately held and only available to the analyst until shared with subscribers, in this case a club good. If the commodity price data were reported by a government entity such as the USDA or otherwise shared such that no subscription was necessary, then those data would be nonexcludable. Privately held farm data may be considered excludable until those data have been shared with another player. In addition, several types of farm data are collected without farmers' knowledge. Many farmers were not aware that, beginning in about 2011, some machinery manufacturers began pushing diagnostic data from equipment to the cloud (Ferrell and Griffin, 2018). Ferrell and Griffin present other scenarios of farm data collection without partnering with farmers (e.g., the farmer does not retain a copy or even know data were collected). They describe how data could be collected via telematics, third-party service providers, satellite imagery, and as-applied data.

Excludable, privately held data may become nonexcludable by the farmer if those data were aggregated into a community dataset such that the farmer would no longer have complete control. The data service provider may still exclude those outside of the community, or club, such as nonsubscribers. The concept of data being nonexcludable holds since other players are consuming benefits from those data. Although the data remain nonrivalrous, the original producers of those data may be concerned that their ability to exclude others from making use of those data has diminished. Therefore, farm data are more likely to be a club or public good than a private good.

Farm Data Valuation

The value of farm data must be considered at two distinct levels, one completely isolated within the farm gate and the other within a community of aggregated data. When farm data from many farmers are aggregated into a community, they may be considered "big data" (Coble et al., 2016, 2018; Ferrell and Griffin, 2018; Griffin et al., 2016). The underlying concept is that no farm can be large enough to generate data sufficient to be its own "big data" system. Coble et al. (2018) viewed farms as individual data providers to a larger collective rather than farmers being consumers of data coming from their farm. The value of farm data within the farm gate is a function of the farm's ability to make management decisions at the field, enterprise, or farm business level. Alternatively, the value may be based on what a "reasonable investor would have paid for the trade secret" (Fox, 2016, p. 21). Using farm data may lead to an educational experience, such that the farmer learns from previous actions to re-optimize inputs to better achieve greater yields or to lower costs. As additional information is accrued at the individual level, so too are the potential benefits to the farmer. The value of farm data increases over time as additional data from additional acreage are collected. For farmers using yield monitors, analyzing 5 years of georeferenced data is expected to provide greater insights about the effectiveness of a fertilizer regime than analyzing a single year of data. Observing variation on the effects of fertilizer over time and weather patterns allows the farmer to better understand field-specific idiosyncrasies and plan accordingly. In this way, farm data can factor into a farmer's dynamic decision-making process.

The value of farm data is also cumulative. Farmers with larger amounts of higher quality information are expected to make better decisions and achieve higher levels of utility. Access to more information never makes the decision maker worse off as long as that information is costless to obtain (Chavas and Pope, 1984). These concepts assume data are of sufficient quality to be useful. Farm data used in big data contexts have different requirements on the exactitude of measurements than traditional small plot research; however, data incorrectly measured such that they are "wrong" is not permissible (Mayer-Schönberger and Cukier, 2014). Tagging farmers' fields with incorrect varieties has been a persistent example of farm data being "wrong." Even small incremental improvements in knowledge result in returns to the decision maker's utility such that positive marginal benefits exist with access to larger amounts of data (Coble et al., 2018). One paramount farm data layer has been instantaneous yield monitor data from global navigation satellite system (GNSS) equipped combine harvesters (Griffin et al., 2004). Considerable effort has been made to replace human intervention of cleaning erroneously measured data (Drummond, 2012; Griffin, Brown, and Lowenberg-DeBoer, 2007) with automated processing, especially for cloud computing (Griffin, 2018).

The same concept is one of the main reasons for the emergence of data analytics systems. As individual farmers have potential to gain by collecting more data, it stands to reason that even greater gains can be achieved when data from individual farms are aggregated into a community with many other farms. These services can analyze raw, disaggregated farm data to produce useful information such as field-level prescriptions or optimum seed variety diversification across all acreage. Data services are unique in having the ability to synthesize large amounts of data that the farmer would not otherwise have the time or resources to contribute toward these efforts. From the farmer's perspective, a secondary benefit comes in terms of time management. By sending data to a service provider to be analyzed, farmers free themselves from spending excessive amounts of time analyzing data themselves, allowing them to concentrate on daily farming operations instead.

Beyond simple aggregation, the economics of networks (i.e., network externalities) describe the additional benefits that can be obtained from participating in a community (Varian, 1999). The value of the network or farm data community is greater than the sum of the individual benefits. As the number of farms providing detailed information increases, so does the marginal benefit to individual farmers because the aggregated data analyzed by a platform encompasses more distinct production practices and decisions than any individual farm could possibly experience. As a result, the networks provide more comprehensive analyses of decisions and their associated outcomes.

It is important to recognize that, with the rise of data service providers, farm data are now being valued by players other than farmers. The value derived from farm data at the farm level likely differs substantially from the value derived by the data service provider. The farmer values the data for their ability to provide insights into the optimal decision making within the farm gate as opposed to the data service provider, which values them for their ability to maximize the provider's own profits. The data service provider can profit by providing analytic services to farms or by improving internal decisions, but it can also maximize profits by selling raw data, summarized data, or other insights to interested third parties. The example presented at the beginning of the discussion highlights the conflicting way in which farm data are valued by different agents. If selling data to commodity traders has the potential to generate much larger revenue than only providing analytics services to farmers, the data service provider would be inclined to engage in the former.

Additionally, it should be noted that the value of farm data depends upon the stage of the lifecycle of the market for farm data. This time-sensitive value changes for each of the different players for each stage of the industry lifecycle. As already discussed, some farmers may value aggregated data more than disaggregated data due to the additional insights they provide. It follows then that the incentives for an individual farm to share data with a service provider increase with the number of farms already providing data to that service provider (Varian, 2014). *Ceteris paribus*, a data service provider working with thousands of farms can generate more accurate analyses than a data service provider with only a dozen. Once a critical mass of farms has shared data with a service provider, remaining farms become more willing to participate with that specific provider (i.e., as they perceive the value of data participation to be higher). Currently, data service providers are striving to entice farmers to submit as many acres of data as possible so that a critical mass of growers, farms, and fields exists in their system (Coble et al. 2016).

Service providers view farm data over different stages of aggregation opposite to the way in which farmers view this market. When only a few farms have shared data with the service provider, the value of data from an individual farm is proportionately greater to the service provider than when there are thousands of farms. Moreover, given the nonhomogeneous characteristics of farm data and farming operations, the service provider has additional incentive to entice farmers to join the data system early in the lifecycle of the industry. Some farms may have higher quality data (e.g., yield monitors properly calibrated and cultivars accurately tagged to fields), while other farms may have farm data from substantially larger acreages, albeit higher sample size of observations. In addition to these quality and quantity aspects, some farms may be perceived as leaders in adopting new production practices in their local farm community. When these local leaders join the system, other farmers are more likely to follow. However, once a sufficient number of farms participate and the associated data have been aggregated, the marginal value to the service provider of an individual farm joining the system decreases toward $0, as each farm contributes a smaller portion of the total aggregate data. Given the aforementioned data valuation description for each player, a debate on estimating damages becomes possible.

Damages and Remedies

In the hypothetical event of farm data misappropriation, the farmer or group of farmers who have treated farm data as a trade secret must determine, potentially collectively as plaintiff, which of the following three remedies to pursue (Fox, 2016). Each of these damages is viewed through the lens of economic theory. Ellixson, Griffin, and Goeringer (2016) suggest that the plaintiff consider actual damages, unjust enrichment, and the reasonable royalty rate.

Actual Damages

When considering farm data as an intangible resource, applying resource-based theory (Grant, 1991) may make actual damages a viable option for the plaintiff's legal team. The expert witness's job is to estimate losses and determine remedies that would return the plaintiff to the state before the data were misappropriated. This builds upon the potential damages to a farm's competitive advantage that occur when data are no longer excludable (i.e., in the case presented above, this is the data service provider's disclosure of data). If the excludability of those data has been adversely impacted, competitive advantage with respect to local bargaining power may be lost (Griffin et al., 2016) such that the plaintiff has increased costs. For the individual farmer, perceived or actual negotiating power with landowners or agricultural retailers may have been diminished or even relinquished, therefore reducing value of the farm business. Even though data were misappropriated, it is assumed the farmer still has access to data from his or her farm.

In some regions of the United States, competition for farmland has been so fierce that many farmers fear they may not successfully retain crop-share rented arrangements if data are disclosed with landowners or with neighboring farmers. A similar scenario with an agricultural retailer indicates how data disclosure could damage a farm's competitive advantage by altering the ability to negotiate on prices paid for inputs and for services provided. A farm may also face legal ramifications if the disclosed data show that the farm has been in violation of regulatory or compliance laws. In these examples, the disclosure of data to a third party could result in serious financial repercussions to the farmer (i.e., loss of farmland acreage, loss of discounts on input purchases, legal fines and penalties). These losses are the "actual damages" that expert witnesses would estimate during litigation, most likely using some calculation of net present value of the future change in farm revenue.

Unjust Enrichment

From the farmers' perspective, the defendant's "unjust enrichment" may be the easiest damage to prove and therefore the most likely remedy to claim. The legal concept of "unjust enrichment" refers to situations in which one party is unjustly enriched at the expense of another. This may result from what the farmer (i.e., the plaintiff) views as an intentional breach of contract on the part of the service provider (i.e., the defendant). Examples of how third parties can generate increased revenue include commodity market manipulation, supply chain management, improvement of products, and so on. The service provider may profit from the sale of data since they did not have to endure expenses associated with data collection and therefore saved time, which allowed them to enter the market more quickly. Although these examples are not malicious on their own, contract agreements between the farmer and service provider may preclude the aforementioned from being allowable, assuming a bilateral contract exists. In this case, the party that has misappropriated the data can disproportionately gain from its unauthorized use.

At the current stage of the farm data lifecycle, many companies compete to be the first to attract a critical mass of growers, farmers, fields, and acreage. However only a very few service providers are expected to be successful in the long run, and there is value to the service provider in using farm data to accelerate its position within the industry. Farmers' comparative advantage relative to data service providers changes as the number of farms joining the system increases. In the same way, the marginal benefits to each player change over time as the system matures over its lifecycle. In the infancy of the farm data system, numerous service providers strive to attract farm data. Given the relatively large number of service providers attempting to attract farm data, these service providers must be farmer-friendly, which means easing farmers' fears with respect to data ownership, privacy, and security. During the market's infancy, farmers have the opportunity to choose which service provider to join and may have some bargaining power (Mayer-Schönberger and Cukier, 2014), which they will likely lose as the market matures.

Reasonable Royalty: Willingness to Accept vs. Willingness to Pay

Reasonable royalty is used less frequently and may be the most difficult of the three types of damages to settle in court, although it may be useful when the plaintiff's losses (i.e., direct damages) or the defendant's profits (i.e., unjust enrichment) cannot be calculated. In making the argument for "reasonable royalty" compensation, the farmer would contend that, had the breach of contract not occurred, the farmer and service provider (or a third party to which the service provider misappropriated the data) would have entered into a hypothetical negotiation (where the farmer's bargained-for price to share farm data was determined). This scenario is problematic because the value of farm data is expected to be starkly different for the two parties. Economic theory suggests that, once the data system has a critical mass of growers, farms, fields, or acreage, the farm data community places very little value on data from any individual farm and therefore would not negotiate any non-zero price. In other words, the marginal value of an additional acre of data is nearly zero. The farmer, who values farm data as at least an intangible resource, and the data service provider would not come to an agreement. An individual farmer's reservation price, or strictly positive willingness-to-accept for farm data, distinctly differs from the near-zero price that service providers would be willing to pay.

The legal team may opt to debate the hypothetical negotiations between the group of farmers and the third party to which the data service provider misappropriated the data. For the specific purpose of the third party, obtaining a subset such as a few dozen farms of the data community may have been sufficient for their purposes. In the case of farms with specific characteristics, the third party would negotiate with those specific farms up to and possibly greater than the value paid to the data service provider for access to those data. However, it should be noted that the data service provider contributed to this hypothetical negotiation by connecting the third party to the relevant farms providing data. A strictly positive and possibly substantial price may be negotiated in this situation with a finite group of farmers and the third party. If farmers have full knowledge of their legal rights with respect to farm data, then they may never willingly enter into an agreement with a data service provider knowing that reasonable royalty would be difficult to estimate.

From the perspective of the service provider, it makes very little difference whether any given farm participates in the network once a critical number of farms has joined the system. Since the service provider would argue that the value of the marginal data from one farm is $0, the parties are not likely to come to an agreement on price. The "reasonable royalty" would therefore be the most difficult of the three damages for an individual farmer to defend, and the farmer's counsel would likely avoid "reasonable royalty" as the remedy for trade secret misappropriation. However, if the service provider negotiated with all farms collectively, and particularly if the third party negotiated directly with farmers, then some value greater than $0 could be negotiated.

Defendant's Rebuttal

The defendant's legal team would attempt to negate any of the claims put forth by the plaintiff's legal team (Fox, 2016). In general, the misappropriating data service provider would claim that the plaintiff cannot connect any of their perceived losses to the actions of the defendant (i.e., any claims are unrelated to the case). Countering the assumption of trade secret protections, the defendant's legal team would attempt to show how the farmers did not treat farm data as a trade secret (i.e., the individual farmers did not actively treat the data as a secret by not keeping necessary agreements with employees or partners). One leading rebuttal most defendants would make is to state that the defendant received no substantive competitive advantage from the farm data. Specific to farm data, the defendant would attempt to negate the concept that these data are a trade secret such that any information attained was already in the public domain or at least would have been eventually attained from other sources and measures (i.e., corn is grown outside and not under secured roofs) or otherwise reverse engineered. Some defendants may state that they independently generated the same information, even if data came from specific farmers' fields, from proprietary technology such as satellites and predictive modeling. Especially with a farm data misappropriation rebuttal, the defense team would claim that any losses within the farm gate are the result of market forces and not due to the actions of the data service provider. In most periods, the defendant's expert witness would correlate farm losses to commodity prices, yields, or both.

Conclusions and Discussion

Expert witnesses for both the plaintiff and defendant have several options to consider in the hypothetical event of farm data misappropriation. Both teams will need to plan their own strategy and anticipate that of the other team. Given the three potential damages of trade secret disclosure, "reasonable royalty" may be the most difficult for an individual farmer to prove substantial value when considering whether to negotiate with the misappropriating data service provider. However, when considering a reasonable royalty rate between farmer–plaintiffs and third parties that acquired data through misappropriation, then some strictly positive rate could be estimated. The farmer–plaintiff's legal team would likely focus on a combination of farmers' "actual damages" and defendant's "unjust enrichment." The per farm value for "actual damages" is expected to be greater than from "unjust enrichment"; however, proving damages also requires more effort on the part of the expert witness, especially within the farm gate. During the infancy of the farm data industry, when there are still relatively few farms in the big data system, the farmer has a relatively better chance at "reasonable royalty," although here damages would be relatively more difficult to estimate. The largest per acre damages that an individual farmer could claim would likely come from "actual damages" if data were treated as an intangible resource. The second largest per acre damages that a farmer could claim would come from unjust enrichment.

The defense's expert witness will attempt to negate the concept that farm data in general can be treated as a trade secret in the first place, or at least show that individual farmers did not treat data from their farms as a secret. Other strategies of the defendant's legal team are to tie the farms' economic losses and benefits to factors outside of the alleged misappropriation.

For More Information

Chavas, J.-P., and R.D. Pope. 1984. "Information: Its Measurement and Valuation." *American Journal of Agricultural Economics* 66(5):705–710.

Coble, K., T.W. Griffin, M. Ahearn, S.L. Ferrell, J. McFadden, S. Sonka, and J. Fulton. 2016. *Advancing U.S. Agricultural Competitiveness with Big Data and Agricultural Economic Market Information, Analysis, and Research: Big Data Tailwinds of Future Agricultural Production*. Washington, DC: Council on Food, Agricultural and Resource Economics (C-FARE). Available online: http://ageconsearch.umn.edu/record/249847/files/10-10-2016BigAgData.pdf

Coble, K., A. Mishra, S.L. Ferrell, and T.W. Griffin. 2018. "Big Data in Agriculture: A Challenge for the Future." *Applied Economics Perspectives and Policy* 40(1):79–96.

Drummond, S. 2012. *Yield Editor 2.0*. Washington, DC: U.S. Department of Agriculture Agricultural Research Service. Available online: http://extension.missouri.edu/sare/documents/YieldEditorManual2012.pdf

Ellixson, A., T.W. Griffin, P. Goeringer. 2016. "Ownership and Protections of Farm Data." Paper presented at 13th International Conference on Precision Agriculture, July 31-August 3, 2016. St. Louis, Missouri. Available online: https://ispag.org/proceedings/?action=abstract&id=2141

Ferrell, S.L. 2016. "Legal Issues on the Farm Data Frontier, Part I: Managing First-Degree Relationships in Farm Data Transfers." *Drake Journal of Agricultural Law* 21(1):13–57.

Ferrell, S.L., and T.W. Griffin. 2018. *Managing Farm Risk Using Big Data: A Guide to Understanding the Opportunities and Challenges of Agricultural Data for Your Farm*. Washington, DC: U.S. Department of Agriculture, National Institute of Food and Agriculture. Available online: http://agecon.okstate.edu/farmdata/files/Managing Farm Risk Using Big Data.pdf

Fox, S.D. 2016. "Calculating Damages in Misappropriation of Trade Secrets Matters." *INSIGHTS* Spring 2016: 12–27.

Grant, R.M. 1991. "The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation." *Knowledge and Strategy* 33(3):3–23.

Griffin, T.W. 2018, November 5. "Why Yield Monitor Data Cleaning Workshops Are Offered." *Griffin Consulting LLC*. Available online: https://www.spaceplowboy.com/blog/why-yield-monitor-data-cleaning-workshops-areoffered [Accessed 25 Nov. 2018].

Griffin, T.W., J. Brown, and J. Lowenberg-DeBoer. 2007. "Yield Monitor Data Analysis Protocol: A Primer in the Management and Analysis of Precision Agriculture Data." Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2891888

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." West Lafayette, IN: Purdue University, Department of Agricultural Economics, Staff Paper #04-06. Available online: http://ageconsearch.umn.edu/record/28615/files/sp04-06.pdf

Griffin, T.W., T.B. Mark, S.L. Ferrell, T. Janzen, G. Ibendahl, J.D. Bennett, J.L. Maurer, and A. Shanoyan. 2016. "Big Data Considerations for Rural Property Professionals." *Journal of American Society of Farm Managers and Rural Appraisers* 79:167–180.

Griffin, T.W., J. Shockley, and T.B. Mark. 2018. "Economics of Precision Farming." In D.K. Shannon, D.E. Clay, and N.R. Kitchens, eds. *Precision Agriculture Basics*. Madison, WI: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, pp. 221–230.

Janzen, T. 2015, September 30. "Is Farm Data a Trade Secret?" *Janzen Farm Law Blog*. Available online: http://www.aglaw.us/janzenaglaw/2015/9/30/is-farm-data-a-trade-secret?rq=trade secret [Accessed 6 Oct. 2018].

Lusk, J.L. 2016. *From Farm Income to Food Consumption: Valuing USDA Data Products*. Washington, DC: Council on Food, Agricultural, and Resource Economics, C-FARE Reports 266593, July. Available online: https://ageconsearch.umn.edu/record/266593/files/cfaredata-review-report-1-14-v4.pdf

Mayer-Schönberger, V., and K. Cukier. 2014. *Big Data: A Revolution That Will Transform How We Live, Work, and Think*, Kindle ed. New York, NY: Houghton Mifflin Harcourt.

Miller, N.J., T.W. Griffin, I. Ciampitti, and A. Sharda. Forthcoming. "Farm Adoption of Embodied Knowledge and Information Intensive Precision Agriculture Technology Bundles." *Precision Agriculture*, in publication process.

Stiglitz, J.E. 1999. "Knowledge as a Global Public Good." In I. Kaul, I. Grunberg, and M.A. Stern, eds. *Global Public Goods: International Cooperation in the 21st Century*. New York: Oxford University Press, pp. 308–325 .

Varian, H.R. 1999. "Market Structure in the Network Age." Paper presented at Understanding the Digital Economy Conference, May 25–26. Washington, DC: U.S. Department of Commerce. Available online: http://people.ischool.berkeley.edu/~hal/Papers/doc/doc.pdf

Varian, H.R. 2014. *Intermediate Microeconomics: A Modern Approach*, 9th ed. New York: W.W. Norton and Company.

Whitacre, B.E., T.B. Mark, and T.W. Griffin. 2014. "How Connected Are Our Farms?" *Choices* 29(3):1–9.

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