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Department of Agricultural and Consumer Economics, University of Illinois Urbana-Champaign

A Big Data Revolution: What Would Drive It?

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December 3, 2015

***farmdoc daily* (5):223**

Recommended citation format: Sonka, S., and Y.-T., Cheng. "A Big Data Revolution: What Would Drive It?" *farmdoc daily* (5):223, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, December 3, 2015.

Permalink: http://farmdocdaily.illinois.edu/2015/12/a-big-data-revolution-what-would-drive-it.html

Management on the farm historically has been constrained by the fundamental reality that the cost of real-time measurement of farming operations exceeded the benefits from doing so. Sensing capabilities (from satellites, to drones, to small-scale weather monitors, to soil moisture and drainage metering) now being implemented will materially lessen that constraint. Doing so will create data streams (or is it floods?) by which Big Data applications can profoundly alter farming.

The purpose of this article is to explore how application of Big Data could foster the creation of value in agriculture. Three pathways to value creation are identified. Application of sensing tools to measure and monitor agricultural activities – at extremely low cost – is the first. Data analytics, which can integrate data from diverse sources to generate novel insights, is the second. The third factor focuses on external pressures to better monitor agricultural activities that, in so doing, create sources of data that potentially can lead to strategic change. This is the fifth of a six-part series on Big Data and Agriculture.

Measurement as an Economic Activity

"You can't manage what you don't measure!" is a phrase attributed to both Peter Drucker and W. Edwards Deming (Brynjolfsson and McAfee 2012). This phrase is as applicable to farmers as it is to managers at Toyota or Amazon. The relationship between measurement and the ability to make improved decisions is critically important in understanding the potential for Big Data to affect agricultural management.

One of the co-authors of this article grew up on a small farm in Iowa and, throughout his career, has learned extensively from farmers in the United States and globally. Growing up on a farm, the linkage between what could be measured and our ability to improve performance was straightforward. In those days, we had to carry the, hopefully, full milking machine from the cow to the milk tank and it was fairly easy to know which cows were producing more. And because there were less than 20 cows in the herd, it also was possible to make sure that those higher producing cows got an extra portion of grain.

On this same farm, about 120 egg producing chickens were housed in a building, with ample room to roam outdoors as well. Eggs were collected twice a day. Performance of the entire of group was observable. Knowledge that could lead to improved performance of individual birds, however, was not.

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Technically, it might have been possible to establish a production system where measurement of individual bird performance would have been available. However, the economics of egg production at that time didn't justify the costs of such a system.

The important point here is that the desire to link measurement of outcomes and management actions in farming is not new. However, the economics of measurement (the cost of measurement versus the benefits of doing so), given the available technology, has inhibited farmers from capturing and exploiting more data. Without low cost measurement in agriculture, Big Data can't happen. Thankfully, dramatic improvements in sensing technologies are allowing low cost data capture to become a reality.

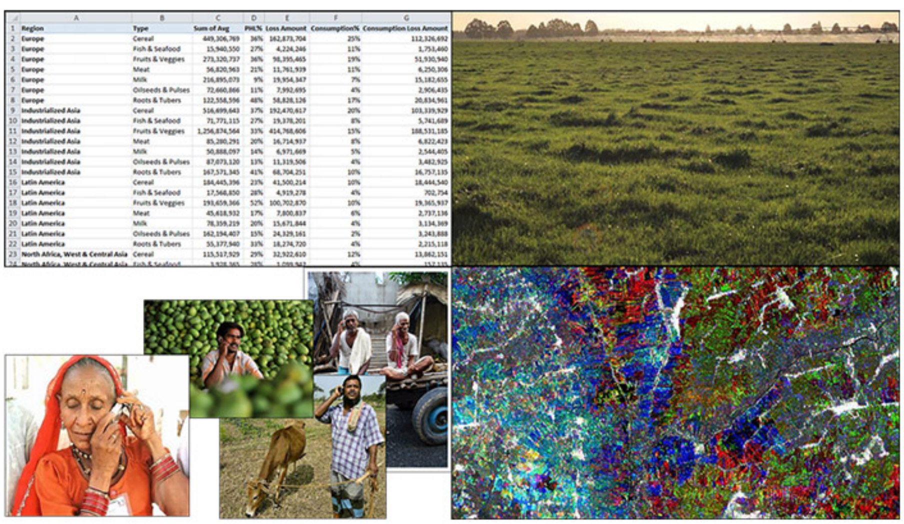
Data Variety Now Possible

Suddenly (at least in agricultural measurement terms), the "what is data" question – the variety dimension of Big Data – has new answers. Figure 1 provides a visual illustration of the change. In its upper left hand corner, we see data as we are used to it – rows and columns of nicely organized numbers.

The picture in the upper right hand corner of Figure 1 is of a pasture in New Zealand, which today also is data. Pasture is the primary source of nutrition for dairy cows there and supplemental fertilization during the growing season is necessary. The uneven pattern of forage growth is measured by a sensor on the fertilizer spreader to regulate how much fertilizer is applied – as the spreader goes across the field. In this situation, uneven forage growth is now data.

The lower left hand corner of Figure 1 shows the most versatile sensor in the world – individuals using their cell phone. Particularly for agriculture in developing nations, the cell phone is a phenomenal source of potential change – because of both information sent to those individuals and information they now can provide. In addition, as illustrated in the lower right hand quadrant of Figure 1, satellite imagery can measure temporal changes in reflectivity of plants to provide estimates of growth (RIICE 2015), in this case, of rice production in Asia.

Figure 1. A Few Sources of Data



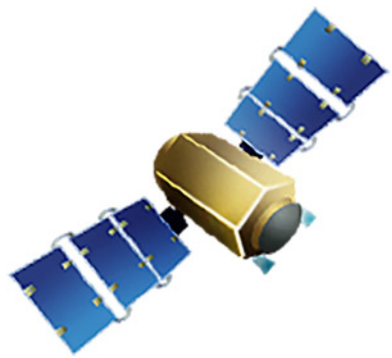
Graphics courtesy of: agrioptics.co.nz; T. Abdelzaher, Champaign, IL.; International Rice Research Institute.

While satellite imagery is one source of remotely sensed data, recent years also have seen a pronounced increase in the capabilities and interest in Unmanned Aerial Systems (UAS) as a source of data for agriculture (Figure 2). Numerous efforts are transforming UAS technology first focused on military purposes to applications supporting farming. Here are just a few examples (King 2013):

- Monitoring of potato production (Oregon State University)
- Targeting pesticide spraying on hillside vineyards (University of California, Davis)

- Mapping areas of nitrogen deficiency (Kansas State University)
- Detecting airborne microbes (Virginia Polytechnic Institute and State University)

Figure 2. Unmanned Aerial Systems Offer Low-Cost Data Acquisition



Graphic courtesy of: Microsoft Corporation

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Analytics

Access to lots of data, generated from diverse sources with minimal lag times, sounds attractive. Managers, however, quickly will ask, what do I do with all this stuff? Without similar advances in analytic capabilities, just acquiring more data is unlikely to have significant impact within agriculture. Tools based on analytics are being developed for implementation in the sector, although these efforts are at their very early stages. These tools will enable farmers and managers to gain insights that foster improved decision-making.

An example of such a tool, from outside of agriculture, was recently unveiled by the giant retailer, Amazon (Bensinger 2014). This patented tool will enable Amazon managers to undertake what it calls “anticipatory shipping”, a method to start delivering packages even before customers click “buy”. Amazon intends to box and ship products it expects customers in a specific area will want but haven’t yet ordered. In deciding what to ship, Amazon’s analytical process considers previous orders, product searches, wish lists, shopping-cart contents, returns, and even how long an Internet user’s cursor hovers over an item.

Production agriculture is complex, where biology, weather, and human actions interact. As noted in a prior article of this series, science-based methods have been employed to discern why crop and livestock production occurs in the manner in which they do. In agriculture, therefore, knowledge from science will need to be effectively integrated within Big Data efforts. Even with this additional complication, the potential for Big Data based tools offers significant promise to create value within the agriculture.

Public Pressures to Better Monitor Agriculture

Beyond its direct economic impact, society has intense interest in the social and environmental effects of farming. Food safety and security are of public interest in every society. Interest in reducing the environmental impacts of agricultural operations is increasing. In addition, some consumers express concern regarding the practices employed to produce food. Therefore, in addition to regulation, documentation of farming practices is increasingly being required by food manufacturers and retailers. Technological innovations associated with Big Data have the potential to provide much better evidence as to these societal and environmental effects.

At first blush, managers tend not to welcome additional constraints, whether from public or private sources. However, there can be an interesting “unintended consequence” effect when information is captured digitally. Digital information, which might not have been captured otherwise, now becomes available to be used to improve performance. As we saw during the knowledge economy of the 1990s, valuable insights can be developed from digital data captured for other purposes (Sampler 1997).

Big Data and Value Creation

Three interrelated forces have been identified as likely change agents driving value creation if Big Data capabilities are applied successfully in agriculture:

- Extensive implementation of low-cost sensor capabilities will allow managers to more effectively respond both in "real-time" and in planning future operations.
- The application of advanced analytics will provide insights that support improved decision-making.
- Societal and business motivations will increasingly require more extensive monitoring in response to requirements imposed by the public or by customers.

A final note; while recent advances in sensing capabilities are promising, technology applications today tend to be more experimental rather than proven. As noted earlier, low cost measurement is necessary to provide the data streams that are needed for Big Data to have significant economic impact in agriculture.

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