How Big Data Can Transform Outcomes and Opportunities

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Abstract

The increasing use of "big data" -- large, multi-dimensional and quickly-changing datasets -- prompted this research, depth interviews that explore how big data affect organizations or even society at large. Examples include one firm now selling data on oil well flow to the well owners, but considering giving it away instead and selling analytics that flag danger signs using 18 years of archival data. The authors conclude that even small firms will find opportunities in big data, likely using consultants rather than employing specialists, and that business as usual will – and should – shift to more creative data usage.

"We close loans more quickly now," says a data analysis manager at a major U. S. bank.

"Our Internet of Things (IoT) solutions help us track the records of all supplier parts that are assembled together, so that we can take a deeper look at the supply chain for safety issues," says a global business line manager for a European-based industrial tool making organization.

From a U.S. consultant: "Our work allows residents to know about dangerous releases of chemicals in their neighborhood."

From an online sales and e-commerce specialist at an African based airline: "We can now target microsegments of customers with targeted offers and deliver an end-to-end customer experience owing to all the data we have and can analyze."

The study described here investigates specifically how organizations are using big data and what changes occur when they do so. Its focus is how usage transforms "business as usual" in a range of organizations located on three continents, to help any manager assess the value of big data in his or her own organization.

Examining the "big data" concept

Commonly, the term "big data" is associated with volume (scale and quantity of data), velocity (complexity in data structure) and variety (different format of unstructured and structured data).[1] In addition, characteristics such as value (extracting knowledge of data), veracity (data assurance, accuracy of data), variability (constantly changing meaning of data) and visualization (presenting the data in a readable manner) are commonly associated with the term.[2,3,4]

However, from a management perspective, what matters is *how* big data are used. Big data analytics refers to extracting unapparent insights from data[5] to create valuable business knowledge: enhanced information and understanding about business processes and the business environment.[6] In other words, big data alone do not represent a solution to a problem faced by an organization [or by society], but rather can be considered fuel, while analytics represents the engine for business insights.[7]

The significance of big data for managers varies, of course. Some managers work in an organization where the term is just a concept; some work with such data routinely; most may be in between. All, however, might reasonably ask how its use can be transformative. Such insights can provide clues to what competitors are or will be doing, also suppliers, also customers – and also non-governmental organizations and governmental bodies.

In addition, insights concerning how big data can lead to change can provide justification for pushing one's own organization forward in this realm. Eighty-two percent of executives say their organizations are increasingly using data to drive critical and automated decision-making.[8] Also, recent research suggests that big data utilization can lead to an increased profitability and productivity.[9,10] Quoting Davenport, whose focus is artificial intelligence: "It is dangerous to do nothing in this area, or to move too slowly."[11]

Nevertheless, Merendino et al. see business decision-makers as deficient in knowing how to deal with big data.[12] Furthermore, because big data extend

into so many facets of organizational life, it is easy for an organization with some utilization to overlook other utilization opportunities. Such an organization may find big data analytics effective in marketing, as suggested by several authors [13, 14] and/or in supply chain management[15] and/or customer relationship management.[16] Yet because the data come from and are utilized by different areas within an organization,[17] opportunities may be overlooked in other areas of operations or in human resources, for example. The chance to bring such opportunities to light justifies this study, which used depth interviews with managers in Europe, the U.S. and in one case Africa to probe how big data are used and with what payoff.

Big data usage: spanning categories of users and functional areas
Our qualitative study was undertaken to gain deeper insights into the results of a quantitative survey of 551 Finnish CEOs and other high-level decision makers that we conducted. Based on categorizations derived from Schmarzo,[18] that study measured big data use in 10 different company functions:

Procurement. In procurement, big data analytics can provide information about supplier performance and assist in predicting and managing supply chain risks. Such analytics can assist in supplier selection and strategic sourcing, but may be helpful also in tracking material availability and detecting quality problems.[19, 20]

Product development. Big data can accelerate the launch of new products and help to determine product weaknesses earlier in the development cycle. Additionally, big data analytics can provide information about which functionalities and product features customers are willing to pay a premium for and which they are not.[21]

Manufacturing. Big data analytics enable a company to forecast product demand and thereby predict optimal levels of labor force and personnel allocation.[22] Also management can collect real-time performance attributes and parameters.

Distribution and supply chain management. In these areas, benefits come from supply chain efficiencies[23]; also data from such sources as RFID tags, EDI transactions and mobile applications[24] can be utilized to optimize logistic arrangements.

Marketing. Big data consumer analytics can extract hidden insights about consumer behavior.[25] Fan, Lau & Zhao[26] recommend applying insights from data to such decisions as customer segmentation and customer profiling, product reputation management, promotional marketing analysis and competitor analysis, while Sprigg[27] offers an example from a hotel chain of using big data to test the relative success of promotions.

Pricing and yield management. Big data allow firms to compare quoted prices with those actually paid under varying conditions. For example, in the semiconductor industry, analysis of data for meaningful patterns can influence pricing to increase the likelihood of matching supply to future demand. [28]

Merchandising prompts such ideas as an example of a retailer who monitors customers' abandoned online shopping carts.[29] The retailer then targets these customers with a special promotion at the location closest to them, thus combining location data with the store's inventory levels.

Sales. Sales operations utilize orders, customer data, inventory data and supplier data. Additionally, the sales function benefits from information about customers' preferences, locations and other information to improve product design, production, logistics and sales processes.[30]

Store operations. Fisher and Raman[31] report on optimizing store assortments using sales data from existing products to estimate the demand for relevant attributes, and estimating the demand for a potential new product from the demand for its constituent attributes. Retailers can also use novel technologies such as eye-tracking technology and RFID chips to monitor customers' in-store behavior,[32] while mobile apps add additional opportunities.[33]

Human resource management. With big data analytics, HR departments can predict personnel allocation requirements more accurately, reduce labor costs[34] and better understand employees' attitudes and behavior toward the company.[35]

These ten areas, probed in on online survey, led to finding broad usage of big data across firm sizes and across functional areas, although usage in general was only about half of what respondents deemed to be the maximum. The 551 Finnish managers surveyed were asked to scale on a 1 to 5 range their organization's usage of big data in each area. The results of the survey, shown in Table 1, show no significant differences between the b-to-b and b-to-c marketing organizations in usage. The table does show big data usage spanning all 10 functional areas probed, even though to a lesser extent among small firms.

Table 1. Usage of big data among Finnish managers by function and firm size*

Company size	All (n=551)	Small (n=378)	Medium (n=132)	Large (n=41)
Overall	2.36	2.26	2.52	2.88
Procurement	2.04	1.93	2.20	2.44
Product Development	2.15	2.02	2.36	2.73
Manufacturing	2.22	2.04	2.51	2.95
Distribution	2.13	2.04	2.23	2.63
Marketing	2.41	2.30	2.58	2.93
Pricing and Yield Management	1.90	1.83	1.98	2.27
Merchandising	1.89	1.85	1.89	2.24
Sales	2.14	1.96	2.49	2.61
Store Operations	1.80	1.79	1.65	2.41
Human Resources	2.14	2.05	2.20	2.83

* Average scores shown in the table. The range was from 1 for no usage to 5 for maximum usage.

Interviews to gain more specific insights

Based on these insights concerning potential transformations possible with big data analytics, we conducted a qualitative study to highlight actual applications. Our study consisted of in-depth interviews with managers and consultants in Africa, Europe, and the U.S., seeking anecdotal or illustrative descriptions of how 18 organizations use big data.

Our goal was to identify disruptive or transformative uses of big data in a range of industries. We employed a convenience sample, principally recruited from LinkedIn requests for participation, including managers from the public sector and consulting. We asked what data their organization use, what they get out of analyzing what they would consider big data, and how employing such analysis has disrupted or transformed "business as usual" in their organization.

Transforming "business as usual" in marketing-related contexts

The first set of responses concerned use in marketing-related contexts. These ranged from the retail shopping experience in a U.S. furniture store chain to fare-setting by an African airline. Key to the disruptive outcomes in each case was the ability to know more about customers and as a consequence, to make decisions more astutely.

One manager we interviewed discussed usage of big data at one of the largest home furnishing store chains in the U.S. A primary focus is ensuring the availability of the merchandise the customer is looking for, an analysis undertaken by relating the past buying patterns for a particular product to indicators of current interest. Also, the chain uses a customer's past

purchasing data as well as their online search patterns to direct that customer's path inside the store, to help drive purchases.

Another set of marketing applications came from the e-commerce and online-sales manager of an airline company in Africa. Like any airline, their major marketing concern was ensuring high load factors on their flights. To do so, the firm uses big data from its revenue management system to understand the booking patterns of passengers for every flight/route -- at different times of the day, week, season, etc. They also collect data about what fare/types get the most bookings on each time dimension and compare those insights to market data they purchase from a third party with information from other airlines operating on the same routes. The African airline then uses both these sources of information to come up with dynamic pricing promotions to help target specific customers, in specific markets, flying on specific routes, at specific times of the year.

A third approach to big data usage came from a global manufacturer of semi-finished products. He saw big data helping his firm understand the underlying mechanisms that connect macro/microeconomic factors to the price volatility of the raw materials they require, which in turn affects pricing their products. For example, while the firm was well equipped to deal with news about an escalating trade war between China and the U.S., they failed to notice issues arising with the devaluation of the currency in a major European country, leading customers in that country to default on payments or cancel orders that they could no longer afford. In the past, the firm had only focused its limited personnel resources on big strategic problems, but now with the higher processing speeds, big data let their management track market fluctuations that might affect the demand for their products.

An unusual example of using big data in marketing came from a manager in a worldwide leader in equipment used in maritime vessels. These vessels frequently change hands, making it difficult for the firm to keep track of the owners. All of this changed with the installation of sensors in the vessels, recording data constantly. These data, combined with information about how frequently the equipment in the vessels required routine maintenance, let the firm segment its customers based on how well they maintained their equipment and thereby offer appropriate service contracts. Also, potential new buyers of these ships now can see the condition of the vessel and the equipment that they are buying.

A final marketing related example concerns an opportunity for expanded service offerings. A manager whose company operates in the healthcare management space initially had only one product, a platform focused on helping ACO's (accountable care organizations) deliver a seamless patient experience by having access to every patient's health records

over their lifetime. Now, however, with the cost of storing data going down and with processing speeds going up, this organization can analyze patient information not just at an individual patient level, but at the level of an entire population segment. They provide this analysis as predictive information to ACO's to help them not only provide preemptive care for their patients, but also reduce the cost to serve them.

Transformations in operations, including purchasing
The perspective that big data can be transformative in operations came from a manager from a European-based global manufacturer. He observed: "Two key developments over the past few years have contributed to how our industry (including our competitors, suppliers, and sometimes even customers) has been forced to disrupt its "business as usual" approach. Those developments are the (1) cost of sensors used to connect machines in a manufacturing facility going down, so that we now can capture infinite amounts of data at almost no cost, and (2) the processing powers of servers becoming so fast that data analysis has become much faster and accurate."

Another perspective applauding the transformations made possible by big data came from a manager in a procurement department. He noted that his firm uses big data to better forecast their manufacturing needs, resulting in an increase in their manufacturing efficiency, owing to raw material availability plus better utilization of machines and personnel.

Similarly, a manager for an industrial tool manufacturer supplying the automotive sector offered an insight into how big data help his organization reduce technician errors. Sensors on the tools and the manufacturing line can help determine if the right work has gone into completing the job before it is passed on to the next step in the production line. Additionally, the ability to store and access information at any time has meant that at any stage in the production line the operator can look at the history of the job and in case of any errors, can go back to the exact point in the production line where any defects could have arisen. This manager expects that such information will help in increasing the safety aspects of the next generation of automobiles.

Another manager we interviewed, a procurement specialist for a $5 billion semi-finished products company operating globally, pointed out that his firm's purchases usually fell into two main categories: 1) items non-critical to the business and 2) items strategically important items to the business. To help with the non-critical items, the organization invested in big data analytics that would help them monitor negotiated price agreements with their suppliers, look at order patterns and be able to more accurately predict internal business demands leading to better forecasting, which turn led to better negotiations with their suppliers. Big data also helped them work on

reducing transaction costs at a strategic level by analyzing past agreements with strategic partners for insights into how to better negotiate with their key suppliers. The manager said that the use of big data led his top management to view procurement as a strength rather than a cost center.

Using big data in U.S. oil and gas exploration and production was described by one interviewee whose organization offers technical support for off-shore drilling. As he explained: "We have archived everything we ever did – how we approached particular formations, what we did, what results the customer got from our work. And our ability to use that huge dataset to plan how we would handle a current challenge means that we have survived whereas small competitors have not. Customers expect that your plan will be based on archival data, and that expectation has shrunk the industry to about 20 companies– the ones big enough to have that historical data."

A project manager in the same industry used the term" disruptive" without prompting, explaining that big data may transform the service her company provides. The company has for 18 years taken data from sensors on producing wells and recorded each well's production in barrels, its pressure readings, and similar data, selling those data to the owner of the well. Thus, the company had all the historical data archived but unused, until they realized that they could analyze current data coming in with remarkably useful insights based on the archived data; they could, for example, predict that a well would soon have production interrupted. As the manager explained: Selling data is a commodity business. We are considering giving it away instead of fighting price wars with our competitors; then we would instead sell the analytics -- moving, in other words, from descriptive to predictive use of big data.

In our study, banks provide a final example of an industry in which big data improve operations. In terms of financial decision making, one banker observed: "We utilize vendors who can better assimilate and package the information for us to use in underwriting or in the field (business development). Traditional sources like credit bureaus and D&B have been around forever. Personal and business credit scores are vital especially when consistency and fairness are a requirement of regulators and the public alike. Data providers like CoStar (commercial real estate information), Coleman Publishing (SBA loan data), and Infogroup/ReferenceGroup (business database) are more recent additions that help the banks get more information from external sources for risk management and sales purposes."

Another manager from the banking sector discussed big data usage in an efficiency context. Her bank looked at data from customer-facing loan officers. One database covered the time spent in each phase of their decision process to approve a loan or fail to approve it, examining how long each phase

took, on average. Another covered which documents each loan officer requested from the potential borrower or other sources. After analyzing those data, management conducted an experiment, asking loan officers to forgo requiring specific documents: "Does it really matter if your client is missing the business plan he prepared two years ago?" They found greater productivity from this experimental group than from a control group given no such instructions, thereby transforming the number of loans processed.

Transformation in influence on government

Four striking examples of using big data to disrupt "business as usual" in the realm of governmental actions – or non-actions – also emerged from our interviews. One was from Washington state and three from Texas. In each case, the message from those analyzing the data was some version of "now that we know this picture, and can make it available to the public, decision-makers in the public sphere will feel more confident taking actions they wanted to take but couldn't justify, or those decision-makers will face pressure to take actions the public wants, because now the public will have the facts to enable them to exert that pressure."

The Washington state usage, in King County (home to Seattle) exemplified the former. County officials responsible for open land in their county, which could be used for parks or trails, wanted to invest wisely in deciding where they should go. Also with the facilities already in place they wanted to know more about usage – heavy usage might indicate the need to expand a parking lot, for example, and low usage might indicate the need to use Facebook ads to promote a park. In addition, they believed that knowledge of what demographic groups use a park might prompt, for example, a need to add signs in Japanese.

Washington does some "trail intercept" interviewing to ask about usage. King County staff put their data together with an analysis of Instagram posts, people telling where they went and posting pictures. They found out the two sets of data match up well, so concluded that they can in the future analyze Instagram and other social media data to learn more about who uses what open space assets. Also, county staff are making these aggregate data available to those planning future parks and trails, but the data have many other potential uses. For example, if they show that an affluent school district offers their students a high number of field trips to parks and trails, but less affluent districts do not, county funding can be shifted to correct those disparities – and parents will have the facts to urge decision-makers to do just that.

Three Texas examples also show how disruptive to "business as usual" big data can be, in both commercial and governmental contexts. One involves

investing in affordable housing, one involves criminal justice, and the third involves environmental dangers.

The use of big data to increase affordable housing was to scrape rent information from the Internet in Harris County, home to Houston, and put the data into a map available online. The objective was to increase information to potential investors, whether non-profit organizations trying to increase the stock of affordable housing or private investors. They now can look at this map, click on a property, and thanks to data from the Harris County Appraisal District know who owns it and its rent.

Simply making such information available changes the affordability of housing in the county, according to a consultant who worked on the project. If someone is bidding against another investor, they can see what other properties that individual or company owns, he points out. Also, by seeing the valuations and rents associated with similar properties, investors can avoid overpaying – which allows them to keep rental rates lower than they might otherwise be.

Another example from Texas involves the criminal justice system. The U.S. Department of Justice maintains a database of case outcomes, and those have been juxtaposed with sentencing and bail trends to show the results of, for example, longer vs. shorter sentences for the same crime. The database juxtaposing those sources now also allows – based on records that go back 30 years – members of the public to interact with the data to explore what individuals by demographic category, for what alleged crimes, have been granted what level of bail by a particular judge -- and also that judge's sentencing record. The expectation is that bail policy, and sentencing policies, will be open to public influence as the database is transparent to all, and judges are elected in Harris County.

A third Texas application involves environmental dangers. Emissions of toxic chemicals and gases are mapped, based on data from the Texas Commission for Environmental Quality, an agency which employs air monitors that turn readings of hazardous releases into a database. That database is combined with data from complaints concerning air quality, enabling prospective home buyers or renters to see the actual hazards and also perceived hazards in a neighborhood they are considering, plus giving residents already in those neighborhoods a basis for complaint to polluting companies and the agencies that regulate air quality. Standards for hazardous emissions exist, but the existence of big data on this topic enables the whole community to have facts to demand their enforcement.

Conclusions, and how managers can use these results

Across industries, it appears that the use of big data will accelerate if for no other reason than competitive pressures. These examples suggest that as organizations and consultants familiarize themselves with available data sources, they will see that combining them, then analyzing patterns that would not otherwise show up, have a constituency that will pay for their skills to do both. Small companies, now less likely to be big data users, may simply turn to consultants for what they need.

Such consultants are likely to point out the value of combining databases and using new sources as well. As an illustration, the manager we interviewed from an airline company noted how advances in technology have made it easier for his company to capture data from their customers not just from their interactions with the company, but also from their social media activity, then process this information to come up with targeted offers. To the extent that such offers can now be matched to customer habits and plans, this capability illustrates how an organization willing to change can seize new opportunities.

For any manager, the overall message appears to be to seek, not fear, the disruptions in "business as usual" that big data can provide. Specifically, we offer seven recommendations:

#1. Because big data make strategic transformations possible, organizations should consider its use beyond a few functional areas. The airline company, the healthcare platform provider, and the monitor of oil wells basically reported that use of big data enables them to rethink their business.

#2. However, it pays to consider change management approaches, both in the selling firm as well as for customers. For example, one manager we interviewed pointed out that in his firm the salespeople were not convinced of the value proposition of the company's new service and the customers were not ready to "be the guinea pigs" for a new service deployment. This firm realized that they needed to test the concepts with a few early adopters in their own sales force and their customer base, then gradually go for a broader rollout. Another manager said his firm is beta-testing a new concept with some of their key customers in certain markets before rolling it out across the world.

#3. In whatever way big data are used, understand the need for new capabilities and skills to use them effectively. Most managers mentioned how their firms had to either upskill their existing employees to be more comfortable with data and data analytics or work on building new capabilities in their firms. One manager said his company has invested in 40 data scientists over the past three years to help the firm deal with the huge

amounts of data they were confronted with and from which they had to make business sense. The airline company we talked to mentioned how their data scientists also needed to have skills to work with algorithms, given the emergence of Artificial Intelligence systems. The same theme was echoed by a global manufacturer of industrial solutions that was slowly transitioning into the world of Internet of Things (IoT) and machine learning.

#4. Top management must support the disruptions associated with big data usage. For example, one company decided to work with Amazon web services (AWS) despite having no prior experience with the platform and despite its considerable cost. But the willingness of top management to take this risk, with the explicit goal of this investment's helping them meet their strategic goals, made a transformation possible. Another manager reported that at his firm top management support was enlisted with relative ease -- creating new functions of business analysts and staffing them with new recruits -- with the aim of being one step ahead of the competition.

#5. A sensible place to start for any organization is the customer's total experience with the goods or services provided. For example, the company that sells equipment in maritime vessels focused on the concept of "cradle-to-grave," which involved keeping track of when the maritime vessel is commissioned, sold, put into use, undergoes equipment maintenance, is re-sold, and finally when it is decommissioned and then stripped for parts. By keeping track of information, operating conditions, and maintenance schedules, the firm gains two opportunities: to sell the data to customers interested in buying the vessel, or to propose new service contracts to its current operators.

#6. Use cross-functional teams to ease internal disruptions as well as improve the benefits for customers. At the furniture firm, data scientists identified customers' purchasing behavior (recency, frequency, monetary value) along with their credit scores to capture customer lifetime value along with each customer's risk profile. This information was then shared with the marketing department, helping them wisely run promotions or extend credit limits for specific customers (and in some cases, refuse credit requests from risky customers). Similarly, the firm kept track of inventory levels for all products in the store and compared the inventory levels across different time periods to track historical trends, to help their supply chain management forecast demand better and decrease inventory costs.

#7. Pay attention early and often to privacy issues. One concern shared by managers and consultants we interviewed involved both data security and, in Europe particularly, data privacy laws. Use of social media data is a particular red flag, suggesting the value of considering customer reactions. Market research on this topic can provide insights, from how a business

buyer will react to having a supplier capture data about when its firm buys what products at what prices to how someone walking a trail will react to having systems capture his or her social media postings. One person we interviewed asserted that cybersecurity is key to the success of all big data initiatives.

Overall, however, we conclude that knowing more -- whether about processes or customers or both – has the potential to bring an organization new competitive advantages, whether they come from efficiencies, targeted product or service development, or any other area. Therefore, a wise manager will look at his or her organization broadly, and consider what that organization might achieve IF data were available that are not now utilized. Then assess how those data might be brought to bear on problems previously assumed to be beyond solution and/or opportunities previously assumed to be beyond the possible. Also, we suggest consideration of using big data beyond the organization, for example, to influence public policy or its enforcement. Joining forces with others in one's industry may make such usage not only possible but successful in achieving the intended outcome.

Finally, we recommend taking to heart the admonition quoted earlier from Davenport: "It is dangerous to do nothing in this area, or to move too slowly."

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