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Data Analytics in Sports

How Playing with Data Transforms the Game

Janine Barlow

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Table of Contents

Data Analytics in Sports

Sports and statistics go hand in hand. As any child with a baseball card intuitively grasps, any sport is a numbers game, converting physical prowess into the scores we see on the board. Meanwhile, as any statistician knows, the more numbers we have, the more questions we can ask and answer: more specific questions, like how quickly an outfielder's reflexes must react to catch a ball; more businesslike questions, like how well an NCAA team must perform to make March Madness (and how much money each round will earn their school); and more meaningful questions, like how much strain a joint can handle—and how we can improve performance to decrease the chance of injury.

"More so than in most other human endeavors, sports have objective, direct, highly measurable, and timely outcomes—winners and losers, margin of victory—as well as easily measured inputs or parameters—teams or players involved, site of game," pointed out Jay Coleman, Associate Provost and Kip Professor of Operations Management & Quantitative Methods at the University of North Florida, one of the data experts with whom we will go in depth in the next section of this report. All of the factors Coleman described make sports ideal grounds upon which to hone analytic software and processes.

Considering how naturally sports and data analytics fit together, it is jarring to watch the general media narrative of the topic remain one of combat: the geeks are invading, and the jocks want them out. Sports are pure, and analytic tools are not, as an opinion piece in the *New York Times* argued earlier this year.

Meanwhile, in an industry valued at $1.5 trillion globally and $485 billion in the United States alone, with revenues making more than billion-dollar jumps every year, and technology surging ahead faster than it ever has, leaders in the field have less time for philosophical arguments about purity and more for seeking the purest data. In this report, through conversations with experts at the intersection of data and sports, we will explore advances in the sports industry, from predictive analytics that work from the outside-in, to the kinds of technology in which organizations like Major League Baseball and the National Basketball Association themselves have invested.

Predictive Analytics and the Secrets of the Dance Card

The most basic questions among sports fans will always be who will win (a game, a set, a championship) and how a team can make it happen, but it takes a great deal of knowledge to build up to predictions. Before the predictive formula comes the data set. Without the historical patterns needed to build a model, there would be no predicted patterns. So, when Jay Coleman discovered a treasure trove of online data revolving around the college basketball teams that made (and many that did not make) the NCAA Men's Division I tournament from 1994 to 1999, he did what any good data scientist would do: he used it.

Coleman, along with colleagues Mike DuMond of Economists Incorporated, and Allen Lynch of Mercer University, is the creator of the "Dance Card," a formula that predicts which men's teams will end up in the "Big Dance"—a common term for the tournament that spawns March Madness every year.

When March Madness rolls around, friends and coworkers across America gamely fill out their brackets the way so many fair-weather basketball fans do: with little knowledge of how the bracket arrived at its current state. This cohort may delve into the world of statistics to improve their bracket predictions, or to substantiate their hope in their chosen teams, but they largely ignore or remain unaware of the extent of the guiding hand of the NCAA Selection Committee.

March Madness draws its teams from 32 conferences, all with extraordinarily different ranges of size and skill, so naturally the NCAA will not just award tournament placement to the top two teams from

each conference. Instead, the winner of each conference receives an automatic bid, and the NCAA Selection Committee fills out the rest of the 64-team bracket with at-large bids. In a simpler world, these at-large bids could conceivably rest on one factor alone: the RPI, or Ratings Percentage Index. RPI calculates a score for teams based on a host of statistics including their win percentage, their "strength of schedule" (the difficulty of playing their opposing teams), and more, with the goal of unifying these statistics across diverse conferences.

The Selection Committee, however, builds the final bracket off of more than RPI alone, and they famously keep their exact criteria secret. This creates a unique territory for predictive analytics to exploit at the intersection of team performance and the psychology of the selection committee.

"[The Dance Card] simply identifies the patterns in the past Selection Committee decisions, and assumes those patterns will repeat in the near future," said Coleman in a recent interview. "The Dance Card's success at predicting indicates that they obviously do."

Indeed, the Dance Card achieved a 92% success rate in 2015 by correctly predicting 33 of the tournament's 36 at-large bids. Over the last four years, since the most recent update in 2012, its predictions number 141 correct out of 146, for an overall 97% success rate.

Coleman, DuMond, and Lynch used SAS analytics to design the Dance Card, which is a stepwise probit model. Probit models predict one of two dependent variables, like the Dance Card's binary variable: whether or not a team will make the bracket. (A probit model would not be appropriate if, for example, the Dance Card sought to determine the Selection Committee's likely seeding choices, which are much more complex outcomes than a binary variable). Stepwise regression, meanwhile, suits the Dance Card's need to sort through a great number of variables, like those that compose the RPI, and others of unknown and differing importance.

The development of such a formula means that the creators can update their predictions for the NCAA tournament after each and every college basketball game, if they choose. It also means that they can continually update the formula itself—and analyze what that means for the evolution of the Selection Committee. The 2012 update, for example, disposes of the variable concerning the committee's bias toward teams within certain conferences. This is a sharp turnaround from Coleman, DuMond, and Lynch's 2010 study

titled "Evidence of Bias in NCAA Tournament Selection and Seeding," which suggested that there was substantial bias toward teams playing in six 'major' and six 'mid-major' conferences, over teams playing in nineteen 'minor' conferences through two models, based around the committee's team selection and their seed placement. These results, derived from ten years' worth of Division I game play from 1999 to 2008, made waves in the media, but within two years such historical bias was nullified enough to necessitate a change in the Dance Card formula. This suggests that the Selection Committee members themselves were aware of the bias towards major conferences and the need to correct it. Perhaps even the NCAA knows when data analytics are about to catch up with them.

By pulling aside the curtain on the opaque practices of the NCAA Selection Committee, the Dance Card reveals the power of predictive analytics in areas that don't get as much attention as, say, how to win your office betting pool. Achieving a place on the March Madness bracket can mean big gains in money and exposure for the players—and, on the flip side, losing a place can mean big losses, especially for those unpaid players hoping to propel themselves into the NBA. With stakes like these, expect more eyes on the Dance Card in years to come.

Nostalgia, Statistics, and the Challenges of Motion Sensors

With the Dance Card, we took a look at one algorithm and its impact on one of the most lucrative sports events in history, the NCAA Division I Men's Basketball Tournament. Let's zoom out now for a full perspective on a professional sports club's technology needs.

"As you know, baseball has a tremendous amount of nostalgia—and almost limitless data," said Brian Shield, Vice President of Information Technology for the Boston Red Sox, "but that data is changing too."

Baseball, "America's pastime," and the nostalgia of its fans, have produced a great wealth of data stretching back through the history of the country's professional leagues. As Benjamin Morris of FiveThirtyEight, an *ESPN* blog founded by statistician Nate Silver after his rise to prominence predicting the results of the 2008 American pres-

idential election, recently commented, many young fans' appreciation begins with baseball cards and the numbers and details they provide; *because* of statistics, their interest in the sport deepened to a unique level. On the other side of the same coin, there exists a distrust in deviation from the traditional ways of analyzing and collecting these statistics. This is why *Moneyball* and the rise of sabermetrics, a term for the objective analysis of baseball statistics, caused a stir among baseball fans and commentators in a way no other sport's adoption of data analytics could. This is why, even in 2015, the *New York Times* ran the aforementioned opinion piece titled "Don't Let Statistics Ruin Baseball," by baseball expert Steve Kettman, implying that fans cannot truly experience or appreciate a game if they focus too much on the numbers behind it.

Brian Shield acknowledges that the world of baseball has so far been warier than other sports to embrace analytics. "In many ways, it hasn't, like football perhaps, tried to be the leader in adopting the latest technology," he said. "That's changing. That's what baseball is now doing."

Unlike the haphazard adoption of sabermetrics that initially gave the Oakland Athletics their advantage in the seasons documented by *Moneyball*, the rollout of baseball's latest statistical innovation occurred jointly for the teams of Major League Baseball. Statcast, a player-tracking system developed by the MLB Advanced Media (MLBAM) group with Amazon Web Services, began operating officially in each of the 30 major league ballparks as of Opening Day 2015. Using a network of cameras and radar, Statcast tracks the entire field to collect data on each player and each movement of the ball. The technology won MLBAM the MIT Sloan Sports Analytics Conference's prestigious Alpha Award for Best Analytics Innovation/Technology earlier this year.

The MLB has previously teamed with Sportvision to develop programs like PITCHf/x and HITf/x, which track and record data on the trajectories of pitched balls and hit balls respectively, but HITf/x data remained proprietary to each team. Statcast's promised availability to public-sphere statisticians, commentators, and fans will create an unprecedented level of batted ball data.

The radar technology responsible for ball tracking, by TrackMan, will work in conjunction with cameras by ChyronHego that will

track player movement, going above and beyond PITCHf/x and HITf/x to collect vital data on base running and fielding.

"We all consider this the next significant jump in baseball analytics that was never there before," said Shield. "A lot of things that were qualitative information will be quantitative. Did that player get a good jump on the ball? Well, now you can see how many tenths of a second it took for the person to react to that ball."

Claudio Silva, Professor of Computer Science and Engineering and the NYU Polytechnic School of Engineering and a member of the team building Statcast, also spoke with us regarding progress and challenges of the technology. Silva works primarily in creating algorithms that translate radar data into game metrics, and although he grew up watching soccer, he sees baseball as a unique opportunity to make inroads into sports technology.

"Baseball looks more like chess, where there are pieces that each have certain properties," said Silva. "[In baseball,] you know that someone is going to throw the ball in a particular way, hit it so many times." This creates openings for the gathering of more specific data, and thereby the construction of better algorithms.

Still, Silva explained, creating high-fidelity models has been tough. Statcast represents "the next generation" in terms of modeling what the game actually looks like, he said, largely because of the raw data sources: the advanced radar and cameras. As a data scientist, he has found himself in the position of determining not only what improvements he and his team need from software, but also what kind they need from hardware.

"The rate at which you can sample anything on the field determines whatever you have on that particular derived metric," Silva said. "If I can track the players at 30 Hertz, there are certain implications to what I can measure. Then if I only have the *ball* at 30 Hertz, that would limit my knowledge of the ball, because the ball moves much faster than the players."

The ultimate challenge with optical technology lies not with the limits of what it can do when it's functioning properly, but with how it functions in the real world. The simple matter of placing sensors and cameras where they will be least affected by factors as elemental as the weather can become a significant burden on any system.

Plus, as Silva pointed out, there is no way to adjust to such sensors on the fly. Comparing the system to something with smaller stakes, he suggested thinking of the Microsoft Kinect, a set of motion-sensing equipment primarily for Xbox gaming. "Imagine, in your home, trying to play with the Kinect," he explained. "You're probably going to notice if you get too far, and the Kinect will actually tell you: you're out of bounds! You have to get closer to the sensor." During a baseball game, needless to say, there will be none of that. It can only be an ongoing process of adjustments.

Brian Shield can corroborate the obstacles associated with placing any new physical systems in a baseball park. The MLB's initiative to ensure public-facing WiFi in all stadiums within the 2015 season has spurred the Red Sox to install over 500 wireless access points around Fenway Park, but, as a site of historical significance to the community, the site cannot display too much visible change.

"Fenway Park is like a living museum in many ways. Any kind of revision to the ball park is scrutinized," said Shield. "We work quite a bit with our Historical Society to make sure that we can both meet our needs as far as delivering a quality WiFi experience *and* [maintaining] what we like so much about Fenway." The same goes for all types of technological equipment.

Despite the importance of keeping up a traditional low-tech appearance on the (literal) surface, teams like the Red Sox are quickly becoming their own technology creation centers. This year, Shield mentioned, the Red Sox launched their first customer data warehouse. Public-facing WiFi naturally extends a great service to game attendees, but it also has the power to feed important data back to the teams.

"We want to know how fans operate within the park so we can create better fan amenities—create a better fan experience overall," said Shield.

For those watching from afar, any conversation about the impact of data analytics on sports expectedly homes in on player statistics and how teams can use predictive analytics to judge their players (and, of course, any *potential* players). For a team's IT executive and his department, however, like Shield, the in-house experience dominates the workload. The impact of team performance on hooking and maintaining fans is only one aspect of the business of data in sports.

The NBA: "A League Driven by Data"

The National Basketball Association, like Major League Baseball, has recently set its optical tracking system in place, and based on the sheer nature of the game, the league stands to gain even more. As discussed with Claudio Silva, traditional analytics suit baseball easily: the game breaks down into discrete plays, hinging on the one-on-one confrontation between the pitcher and the batter each time. Until now, the seamless flow of basketball has rendered a similar breakdown beyond the capacity of technology, but the era of big data means working with huge amounts of micro data. Suddenly, that seamless flow looks like an analyst's vision of wave after wave of data.

These data come in the form of coordinates sent from the six-camera system now in each of the NBA's thirty arenas, using technology called SportVU (pronounced *SportView*). This technology's long journey to universal adoption by the NBA began in Israel, where missile defense specialist Miky Tamir began adapting military-style optical recognition to the soccer field in 2005. Once American company STATS LLC acquired SportVU in 2008, they saw an opportunity in the world of basketball.

Eight teams signed for and installed SportVU by the end of the 2011-2012 season, paying out-of-pocket, and seven more did so by the 2012-2013 season—not yet enough to generate conclusive, league-wide figures, but enough for two game-changing paper presentations at the MIT Sloan Sports Analytics Conference 2013. Kirk Goldsberry and Eric Weiss's "The Dwight Effect: A New Ensemble of Interior Defense Analytics for the NBA" and Philip Maymin's "Acceleration in the NBA: Towards an Algorithmic Taxonomy of Basketball Plays" put SportVU on display for an audience of true influencers. Goldsberry and Weiss's sweeping look at how spatial analysis can measure defensive success and Maymin's deep dive into the technology's ability to track a previously unquantifiable skill won over fellow researchers *and* executives at Sloan. It's no wonder that the NBA moved to partner with STATS LLC to use SportVU across the entire league.

In the NBA's official press release following the decision, a statement from Steve Hellmuth, Executive Vice President of Operations and Technology included the boldly-put phrase, "We are a league driven by data."

Philip Maymin, Assistant Professor of Finance and Risk Engineering and the NYU Polytechnic School of Engineering, has a long history of analytics consultancy for NBA teams, and has recently joined forces with Vantage Sports, a new leader in sports analytics and a finalist for Sloan's 2015 Alpha Award for Best Analytics Innovation/Technology, as their Chief Data Scientist. He spoke with us about the value of new analytics technology for sports organizations and his upcoming work with Vantage Sports.

"There's a lot of new data tech that's come out. You still have to have a human element to make sure it's reasonable," said Maymin. As good as new wearable devices and optical tracking have become, he explained, sometimes there are errors a human needs to spot. "You don't have a heart rate that jumps up to a billion, then goes back down to zero. You don't have a guy who's on one side of the court and he magically materializes on the other. You have to look for these kinds of mistakes in the data and fix them. They're not common, they're rare—all the data providers do a wonderful job—but things happen and you have to keep an eye on it, because any one of those outliers could have a very large effect on what you're trying to do."

Using Data Analytics to Course-Correct

High-profile media coverage of advancements in sports analytics frequently feature division between supporters of data analytics and those more leery of the shift towards new technologies, but within any sports organization the true goal is harmony among all. As Maymin says, "You don't want to lose somebody who doesn't understand data as well as you do, because they contribute in many other ways."

Proper use of analytics should serve to bring departments together. As in any industry, using the data to show an associate how to correct his or her course should come long before the statement that the data show this person is performing poorly—so goodbye. To illustrate this, Maymin uses an example of "the scout who is always wrong."

"Every guy he thinks is great ends up being a bust. Every guy he thinks will be a bust ends up a superstar," Maymin described. "In any regular organization, that guy would have been fired ten times over." With an approach involving data analytics, using input from scouts and the ensuing player outcomes, this scout may have course-

corrected much earlier, and many patterns of missteps that do arise will be much simpler to identify and improve. In the same way, coaches can better hone their players' skills based on the results of emerging technologies, so can departments within an organization better train their workers.

Moving from Raw Data to Analytics

Vantage Sports, the company Maymin joined earlier this year, offers teams this capability to hone their training and improve their players with a combination of optical data and the "human element" that Maymin considers still vital in a world of imperfect machine learning.

When it comes to optical data, Maymin questioned, "how do you get from the x/y data, the raw data, to interesting basketball questions, like was there a pick and roll?" Since optical systems alone are currently not capable of honing their data to this level, the program is a mixture. Using an organizational system breaking down move after move that can happen on offense or defense, the program tags over 16,000 "events" per game.

"For example, one thing we tag, that no one else on Earth has, is whether a defender had his arm raised when defending a shot," said Maymin. "It turns out to be very important! Who knew? Of course, every coach and fan knows it is important, but it is literally impossible to derive from the raw x/y data, which measures a person's center of mass, whether or not their hand was raised."

Vantage Sports CEO Brett McDonald gave a presentation to the Sloan Sports Conference of 2014 on taking sports data from proprietary "walled gardens" to "open access," a shift for which all of those at the intersection of sports and data should be on the lookout. The company currently provides distinctive NBA commentary on its website, using some of their data, but going forward, said Maymin, they are "aiming to put out a new fantasy analytics product."

Data in Soccer: Crumbling Long-Standing Myths About Performance

We've already established that basketball is a game of flow compared to the discrete play of baseball, but what about the next level of flow?

Basketball games in the NBA's 2014-15 season averaged 37.5 field goals, so over the course of a four-hour game, there could be nine or ten of these natural resets per hour. The shot clock ensures this. A game without even these easily identifiable changes in state, however, exists: soccer (hereafter referenced as football).

Garry Gelade, Director of Business Analytic Ltd., through which he has advised teams like Chelsea Football Club, Paris Saint-Germaine Football Club, and Real Madrid, as well as businesses outside the realm of sports, speaks of this in terms of accurate judgment of performance. Analytics can do this in ways subjective observation cannot.

"Players get feedback from their managers and teammates, but it isn't easy to judge performance in a complex flowing sport like football or rugby," said Gelade. The quantifiable data that analytics bring to the table ease this burden. "Being able to track the important components of performance and having sound benchmarks for comparison can give a player and his manager a clear sense of what they are doing well and where they need to improve."

It takes massive amounts of data, Gelade explained, to weed out the key components of player performance. "In team sports, measuring the ability of individuals uncontaminated by the performance of their teammates is a decidedly non-trivial task," he said. "[It's] something you can only do by analytical modeling."

As is the case with other leagues and teams throughout the sports industry, top-of-the-line recording equipment to gather data for descriptive analytics will come before prescriptive analytics. High-resolution tracking system TRACAB by ChyronHego, the aforementioned company that honed its player-tracking software for the MLB, is now in use by the Barclays Premier League in the United Kingdom, the Swedish premier league Allsvenskan, and the J.League, the top division of the Japan Professional Football League, among others. When it comes to processing stats, competing companies Opta and ProZone use a combination of recording technology and human analysts who tag "events" within the game (much like Vantage Sports). Opta calculates that it tags between 1,600 and 2,000 events per football game—all delivered live.

"These sources will produce vast amounts of data, which will probably drive a move towards machine-learning and data-science approaches," Gelade hypothesized.

Some long-standing myths have already begun to crumble as data-driven approaches thrive and the information from them begins to emerge. Gelade cited distance run as one of the pillars of football that we can now examine more critically. "Blindly assuming that more running equates to a more effective performance was for a long time an article of faith in football, but data modeling shows it isn't true," he said. And this is where the shift from descriptive analytics into prescriptive analytics will occur. "It's all very well to know how far or how fast a football player has run in a match, but the real question is does it make any difference to the result, how much and in what way?"

Gelade sees a slower march towards wide acceptance of sports analytics in Europe than in the United States. The singular champions of analytics who popularized it here do not exist there. Billy Beane, the executive of the Oakland Athletics who drove the events documented in *Moneyball*, is the kind of figure other leagues need.

"We don't have that kind of charismatic role model," said Gelade. "We can't point to any European managers or teams who overcame their financial disadvantages in such a spectacular way."

Statisticians may brush aside the greater public's lack of enthusiasm for analytics with the assertion that a club or a league does what it needs to do regardless of the layperson's suspicion, but as Maymin pointed out, sports organizations themselves contain multitudes. It will take strong leaders to cause changes in company culture.

"In America [there are] some high-profile and very successful sports team owners who have espoused the analytics approach," Gelade explained. "People like John Henry, owner of the Boston Red Sox, and Darryl Morey, GM of the Houston Rockets, are evangelists for analytics in the USA—and this has given analytics a credibility in America that it still somewhat lacks in Europe."

Football does have its own John Henry now—in John Henry himself, who is now the principal owner of Liverpool Football Club. Gelade praised their "strategic commitment to analytics," including the creation of a sophisticated data repository, and the employment of their own team of coders and data scientists. That way, Gelade said, "They have control over what they do, and can build some invaluable intellectual capital."

The growth of staff data teams is a trend across all sports, as Brian Shield attested earlier, and they are only one way in which analytics are changing the industry *and* the industry is changing how the world sees analytics.

Wearable Devices and the Future of Sports Analytics

What does the future hold for sports and data? Look for an increased focus on injury prevention, especially through a greater range of questions asked of players and, of course, data collected through wearable sensors.

"We tend to think of predictive analytics using statistics about player performance—as a way of evaluating talent," said Brian Shield. "I think you'll find predictive analytics being applied to health science as well."

For now, the practical application of such data still goes a long way toward player evaluation; as research accumulates, organizations don't need to take risky bets on whether that player with a bad knee will be viable long-term—the predictions are much closer to the truth. Plus, as Shield pointed out, historical data like that bad knee will begin to yield to closer scrutiny of whether currently healthy bodies can withstand years of professional play. In terms of baseball, Shield phrased it, "Is their physique the kind of physique that can go through two hundred innings a year?"

Philip Maymin remains wary of anyone's ability to mine data for injury-related predictions just yet. "The database of injuries is very sparse, so it's hard to make this kind of judgment," he said. "Every single injury for every single person seems to be very specific to them and idiosyncratic. It's hard to get a very reliable data set."

Wearable bio-devices and the myriad types of data they can collect promise to make this lack of information a thing of the past, though they still have a long way to go. No major leagues currently allow wearable devices during actual games, in part, Maymin noted, because of the lengthy collective bargaining between the organization and the players' union that would need to take place in a league like the NBA. In 2014, however, the NBA's Development League (D-League) allowed four trial teams to begin wearing devices manufactured by STAT Sport, Zephyr, or Catapult Sports to track movement

and heart rate in-game. For a sport in which practices are notably far slower-paced than games, this is a major step.

American Football and Strides in Technology

These devices are one area in which American football has taken strong strides ahead in technology. Over half of the teams in the NFL use wearables during practice, and the NFL could conceivably be the first league to use them regularly in-game—they have, in fact, already collected some in-game data using technology called "Next Generation Statistics," created in partnership with Zebra Sports Solutions, albeit no data that teams themselves can access. Using Next Gen Stats, chips placed in players' shoulder pads transmit Radio Frequency Identification Signals (RFID) to receivers throughout the stadium. With the NFL allegedly planning to dispense some of this data to teams and create some distillations of it for fan consumption, RFID will soon have a major foothold in sports, and could pave the way for more complex wearable devices.

As Philip Maymin joked, "Ideally, you'd want every player wearing those virtual reality suits that people use for video games," but of course, there are some nods toward purity among the sports and data set.

For now, optical tracking, wearable devices, and the minds and machines that extract meaning from it all will be enough.

About the Author

Janine Barlow is a writer and publishing professional currently working with AMACOM Books, the publishing arm of the American Management Association, where she promotes books on business, marketing, technology, psychology, and more. Outside AMACOM, she brings a sharp editorial eye to content on business intelligence and advanced analytics. In the world of sports, look for her at the NWHL's New York Riveters' games in Fall 2015.