Identifying the "Players" in Sports Analytics Research

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Abstract

Despite a sports analytics research history that goes back more than 50 years and despite a dramatic recent rise in the level of scholarly interest, no prior research has attempted to identify the scope, scale, and growth of this sub-discipline in terms of the body of published refereed articles in the literature. Prior research has also not identified the "players" in the field: the journals and institutions that most commonly publish sports analytics research, and are most commonly cited. To answer these questions, I examined 140 journals in operations research, statistics, applied mathematics, and applied economics, and identified 1146 articles addressing the application of analytics in sports. The results provide a picture of the size and nature of sports analytics research and its purveyors and offer some perspective on the parameters of the field.

Identifying the 'Players' in Sports Analytics Research

Introduction

Research interest in the application of analytics in sports has increased dramatically. As described by Wright (2009), operations research (OR) in sports has a 50+ year history, with rising popularity marked by special issues of *European Journal of Operational Research*, *IMA Journal of Management Mathematics*, and *Computers and Operations Research* since 2003. To this list we can add special issues of the *Journal of the American Statistical Association* (1994), *Managerial and Decision Economics* (1994, 2004), the *Journal of the Royal Statistical Society–Series D* (2002), *INFORMS Transactions on Education* (2004), *Applied Economics* (2009), the *International Journal of Forecasting* (2010), and *Interfaces* (currently). The introductions of the *Journal of Quantitative Analysis in Sports* (*JQAS*) in 2005, the *Journal of Sports Economics* (*JSE*) in 2000, and the *International Journal of Sports Science and Engineering* (*IJSSE*) in 2007, further highlight the trend of increasing popularity of analytics in sports (Wright, 2009; Norman and Scarf, 2005). The same can be said of the advent of INFORMS' SpORts section in 2004, the Northern California Symposium on Statistics and OR in Sports in 2008 and 2010, the annual MIT Sloan Sports Analytics Conference since 2007, the biennial IMA International Conference on Mathematics in Sport since 2007, and the Symposium on Statistics and OR in Baseball since 2006.

The sports industry is estimated at $414 billion in the U.S. alone (Plunkett Research, Ltd., 2010). This size, combined with rising use of analytics by sports organizations (Cochran, 2010) and the gains in academic stature illustrated above, creates a constructive environment for sports analytics (SA) as a discipline. However, the SA field remains fragmented. Much of the research represents rare forays into sports by authors who don't further pursue it (Wright, 2009). In addition, Wright remarks that the field is likely still too "incoherent" to support academic programs devoted to it. Moreover, due

to the competitive and secretive nature of professional sports a large number of SA results and methods are internal by nature and not published. This also creates a challenge for academics interested in partnering with teams for projects.

Other than the new journals noted above, there is also no natural target for SA. Thus, authors may be unsure of the most appropriate or receptive place to send a paper, and notwithstanding sports' expansive footprint, whether traditionally high-quality journals are interested in – or yet respect – what is likely considered by many as a somewhat eccentric or less generalizable application area.

There have been efforts to apply structure to the literature (Mottley, 1954; Machol and Ladany, 1976; Ladany and Machol, 1977; Norman and Scarf, 1995; Bennett, 1998; Mondello and Pederson, 2003; Ribeiro and Urrutia, 2004; Albert, Bennett, and Cochran, 2005; Albert and Koning, 2007; Cochran, 2008; Rasmussen and Trick, 2008; Wright, 2009; Kendall et al., 2010). However, no prior work has depicted the field's composite size and growth in terms of the number of published refereed journal articles. In addition, no previous authors have identified the degree to which analytics-oriented journals actually publish SA research, or the journals that contain the most (or most-cited) SA research. There are a substantial number of articles in related disciplines that rank institutions that contribute to the field's journals, such as the eight editions of the Rothkopf rankings in applied OR (Fricker, 2009). However, no such ranking exists for SA.

Filling these voids is the objective of this article. In sum, the goal is to identify the "players" in SA research: the journals, institutions, and the set of articles that constitute SA's current body of peer-reviewed academic literature. Such knowledge will help SA authors identify the best potential publishing options, the extent to which high-quality outlets have been receptive, the journals in which SA research has had the largest impact, and the journals in which they can find prior work. The latter

addresses Norman and Scarf's (2005) concern that "relevant papers are often missed and sometimes papers are published which do not take sufficient account of previously published work."

Identifying research-generating institutions provides insight into whether the field is indeed internationally diverse with "ubiquitous" interest (Koning et al., 2003), and whether certain institutions, countries, or regions appear more supportive. Institutional rankings also help distinguish SA as a sub-discipline. Faculty in well-established areas can usually identify their field's leading institutions. No such perception has necessarily existed in SA. Since very small pockets of prolific authors may comprise the entire SA research group at a given school, such rankings by extension might provide internal or external recognition for these individuals.

Finally, measuring the field using the primary currency of academic research – refereed journal articles – lends further credibility to SA as a maturing, important sub-discipline, and not necessarily just a "fun" application area "that touches most people but carries little risk" (Watkins and Wolstenholme, 2002).

Data

Consistent with *Analytics*' tagline "math, operations research, statistics driving business," I searched an amalgamation of 140 journals largely from OR, statistics, and applied mathematics, focusing on those constructed by or for an English-speaking audience or source. Noting Wright's (2009) comment about economics being related to OR, I also included a select set of four applied-economics journals that frequently publish SA research. All journals are listed in Table 1 using *Web of Science* (2010) title abbreviations, or for journals not included in the *Web of Science*, abbreviations derived using similar title word shorthand. Table 1 also shows the ranking of each journal within the set of 140, according to its respective *h*-index reported by *Harzing's Publish or Perish* (Tarma Software Research Pty Ltd, 2009). The *h*-index is "defined as the number of papers

4

[*h*] with citation number ≥*h*" (Hirsch, 2005); for example, an *h*-index of 25 would indicate that a journal has 25 articles that have at least 25 citations.

Online searches of each journal were conducted in late 2009 and early 2010 using electronic data bases and/or Google Scholar. I collected refereed articles and notes (and comments, as these are commonly refereed) featuring a sports focus in the title, keyword list, or abstract. I did not include research in which sports examples were used only as convenient illustrations, research that has *potential* or even *common* application to sports but which was not necessarily *presented* as a sports application, or gambling, casino / parlor games, health, physiology, fitness, or engineering-focused research. I included articles posted as forthcoming but already available on the Web site of *JSE*.

Because of various interpretational issues, combined with expediency needs in reviewing thousands of articles, there may be articles that were (were not) SA, but were inadvertently omitted (included). Use of electronic sources was another study limitation, as these cover only the last 20-25 years for some journals, and precluded journals that weren't readily available electronically. I also didn't capture contributions from less analytics-focused outlets, and including only four economics journals didn't capture all contributions of that discipline. However, for researchers whose expertise is in analytics, the journals examined cover the vast majority of the outlets they would favor.

Methodology

For each article, I collected the publication year, primary institutional affiliation (if reported) of each author, and citations received according to Google Scholar as of late January 2010.

I computed the total number of SA articles published in each year, in each journal, and from each institution. Like similar prior research (e.g., Young et al., 1996), two approaches were used to compute institutional figures. In one, each institution received a credit of one for each *unique* time it appeared in an article's authorship. Summing these values over all articles resulted in a simple count

(*a*) of the articles on which an institution appeared. (This is the way institutions were scored in the first seven editions of the Rothkopf rankings of the INFORMS practice literature (Fricker, 2009).) However, this approach did not accurately portray contributions on multi-institution work. Thus, I also computed proportionally-adjusted values, where an institution's credit on an article was the proportion of the authorship from that institution. Summing these values over all articles yielded a proportionally-adjusted article count (a_p) for each institution, equivalent to Fricker's (2009) "yield" metric in the 2009 Rothkopf rankings.

I also counted the total citations generated by each journal and each institution. A similar approach to that described above was used to count each institution's citations. The first (*c*) assigned full credit for all citations to an article to each institution in its authorship. The second was a proportional citation count (c_p) in which an institution was assigned the number of citations to each article multiplied by the proportion of the article's authorship attributable to that institution.

The above resulted in a quantity (article) count and quality (citation) count for each journal, and two quantity and two quality counts for each institution. I ranked the journals and the institutions based on each respective metric, and present a top-40 ranking according to each metric.

To derive a summary (quantity plus quality) ranking for journals and institutions, I computed the corresponding SA *h*-index for each entity. For institutions, I present an *h*-index (or *h*) in which I attributed all citations to an article to each institution in the authorship, and a proportional *h*-index (or h_p) in which I assigned each institution only its proportionally-adjusted citations.

Results: Scale and Growth

The search identified 1146 SA articles. As some perspective, the 2009 Rothkopf rankings (Fricker, 2009) identified the number of articles published in the INFORMS practice literature from 2002 to 2008 as 287 articles. Thus, the number of SA articles in the data is four times the total number

of applied-OR articles published in *Interfaces* and *Operations Research* over a seven-year time frame. These results emphasize that the field is not necessarily a small one, as it equates to nearly 28 years of OR practice literature. Even if all articles in *JSE*, *JQAS*, and *IJSSE* were ignored, the remaining list would still equal nearly 18 years worth. Given that Fricker's (2009) time span (seven years) and number of journals examined (two) are each much smaller than what's covered here, this is not meant as a direct or fair comparison of SA to applied OR. The intent is simply to give some perception of the SA literature size vis-à-vis the number of articles published in those two leading journals.

Figure 1 illustrates the recent growth in the number of SA articles, and mirrors the time-line of 162 sports scheduling papers included in Kendall et al. (2010). The earliest two articles captured were published in *Journal of the Royal Statistical Society* in 1945; the next were in 1956. During much of the ensuing time, the number of articles per year only slightly increased. Over roughly the last decade, annual article counts have skyrocketed, reaching 176 in 2009. This is somewhat attributable to the search methodology, as older articles are less likely to appear in electronic data bases. However, the last 20 years – a window much less affected by the methodology – still demonstrates rapid growth. Growth in the last decade is due in part to the introduction of *JSE*, *JQAS*, and *IJSSE*. However, even if those journals were omitted, the growth is still upward-sloping, as also shown in Figure 1.

To check whether the recent rise in appearances in non-sports journals is simply due to more papers being published in those journals in general, I compared the number of SA articles to the total articles published in all the non-sports journals reported in Table 2 (discussed below), since 1990. The annual percentage of SA articles in these non-sports journals is presented in Figure 1. One-tailed Cochran-Armitage trend tests of the annual proportions (Liu, 2007) were significant at the 0.0001 level since 1990, and at the 0.05 level over the last decade, indicating a positive (upward-sloping) trend in the annual proportions during each of those time frames.

Results: Journals

Table 2 contains the results for the top-40 journals according to each metric. Although Table 2 is ordered based on article count, any journal ranking in the top 40 on any metric is included. (In the interest of space, I've omitted journals with $h=1$ that didn't rank in the top 40 in a or c.)

The journals in Table 2 accounted for 97% of all SA articles and 99% of all citations received. Reaching the top 20 only required 13 articles; reaching the top 30 only required six. Despite covering a broad swath of journals in numbers, topics, target audiences, and impact, these results suggest that there is a relatively short list of journals within which a very large majority of SA can be found. This is valuable information for future authors and for those searching and referencing previous research.

As two of the sports-focused journals in the data, it was not surprising to see *JSE* and *JQAS* lead in number of articles published; despite relatively short runs they contributed about 28% and about eight percent of the articles, respectively. Four of the top-seven journals were the applied-economics journals included in the search, which collectively contributed about 42% of the articles. This finding suggests that these journals represent strong publishing options for SA authors.

Other than the four applied-economics journals and *JQAS*, *American Statistician* (at #4) was the leading journal for SA research, and was easily the leading statistics journal, nearly tripling the contributions from the 11th-ranked *Journal of the American Statistical Association* (*JASA*). From OR, the *Journal of the Operational Research Society* (*JORS*) at #5 and *Interfaces* at #8 were the leading publishers of SA. *European Journal of Operational Research* (*EJOR*) and *Computers and Operations Research* (*COR*) also ranked in the top 10, and *Operations Research*, *IMA Journal of Management Mathematics* (*IJMM*), and *Management Science* ranked t13th, t13th, and 24th, respectively. No other OR-research journal published at least 10 articles. *Operations Research Letters*, *International*

Transactions in Operational Research, and *OR Insight* were the only additional OR entries in the top 30.

The teaching-focused journals did have good representation, with *Teaching Statistics* at #11, *Journal of Statistics Education* at #18, and *INFORMS Transactions on Education* (*ITE*) at #20. That teaching journals finished this highly is a compliment to sports as teaching examples, as previously noted by Ribiero and Urrutia (2004), Kendall et al. (2010), and Cochran (2010).

It is worth reiterating here that several of the journals that appear high in the article count rankings have had special issues on SA during the time frame studied. These include *Applied Economics* (*AE*), *Managerial and Decision Economics* (*MDE*), *EJOR*, *COR*, *JASA*, *IJMM*, the *Journal of the Royal Statistical Society–Series D*, and *ITE*. Therefore, their article counts have been influenced accordingly.

Among the leading analytics journals in general, only *EJOR* ranked in the top 10 both in overall (i.e., non-sports-analytics) *h*-index (at #7) and in SA articles published (at #9). *JASA* and *Operations Research* were the only other journals that ranked in the top 20 in both overall *h*-index and in the number of SA articles. The two most frequent publishers of SA from OR – *JORS* and *Interfaces* – ranked 22nd and 44th, respectively, in overall *h*-index.

Although the applied-economics journals ranked at or near the top in terms of their proclivity to publish SA research, only *AE* (at #41) and *MDE* (at #68) placed in the upper half in terms of their overall *h*-index.

Each journal's collective SA impact is best reflected in its SA *h*-index. *JSE* leads with 25 articles with at least 25 citations. While *JQAS* ranks second in number of articles (93), only six have yet garnered at least six citations in the journal's short life, placing *JQAS* 18th in impact. Other than

JQAS, *IJSSE*, *Teaching Statistics*, *IJMM*, and *ITE* demonstrated the largest drops in *h* ranking (19, 16, 9, and 7 spots, respectively) from what was a top-20 ranking based on article counts.

Journals that rose notably in ranking when citation frequency was considered with article count included *JASA*, *Operations Research*, *International Journal of Forecasting* (*IJF*), *Review of Economics and Statistics*, and *Journal of the Royal Statistical Society–Series C* (*JRSC*), which each rose to the top 10 in *h*-index. *Journal of the Royal Statistical Society–Series A* (*JRSA*), *Management Science*, and *American Mathematical Monthly* entered the top 20 when impact was considered. These rises were not necessarily surprising, as only *JRSA*, *IJF*, and *JRSC* ranked worse than 24th in overall *h*-index.

For contributors from OR, *JORS*, *EJOR*, *Operations Research*, and *Interfaces* represent the top four OR journals in terms of impact in SA: only these have published at least nine articles with at least nine citations, and only these rank among the top-10 journals in the sub-discipline.

Results: Institutions

Table 3 contains the top-40 institutions according to each metric. Although ordered based on article count, the table includes any institution that ranked in the top 40 in any of the six metrics.

A total of 648 separate institutions contributed articles, with only 183 of those contributing more than two. Only 22 schools contributed at least 10 articles, and only 78 contributed at least five. Thirteen countries and five continents are represented, lending support to Koning et al.'s (2003) conjecture about the international diversity and ubiquitous nature of the field's research interest.

The leading institutions were British: Lancaster University and the University of Salford. Washington State (WSU) led U.S. schools, followed by Florida, DePaul, Stanford, and Michigan. Australia's Swinburne University of Technology (SUT), the Royal Military College of Canada (RMCC), and Simon Fraser also were in the top 10. Ten of the top-22 institutions were non-U.S.

The same 12 schools – the above ten plus Bowling Green and Northeastern – comprised the top 12 in both total and proportional article counts. Lancaster and Salford again led in proportionally-adjusted articles, with 22.5 and 14.7 respectively, with RMCC third. As a comparison, in the 2009 Rothkopf rankings (Fricker, 2009) the top institution contributed 9.06 proportionally-adjusted OR-practice articles in just two journals during just seven years. A total of 9.06 SA publications would have ranked 13th over the entire sample of journals and years covered by the current search. This implies that the contributions of even the leading institutions in SA are not that large by comparison to a much more well-established related discipline (applied OR).

Lancaster and Salford also ranked first in citations, and WSU was fourth, regardless of whether c or c_p was used. Carnegie Mellon, IBM, Georgia Tech, Imperial College London (ICL), Universidade Federal Flumenense, SUT, and the University of Maryland Baltimore County (UMBC) also ranked in the top 10 in citations received. In terms of proportional citations, Lancaster, Salford, IBM, WSU, and UMBC were the top five, with Ecole Polytechnique Fédérale De Lausanne, the University of Victoria, the University of Twente, SUT, and the University of Antwerp rounding out the top 10. Thus, seven of the top-10 most-cited institutions (proportionally-adjusted) were non-U.S.

In terms of h-index, the top contributors to SA have been Lancaster, WSU, Salford, SUT, ICL, and Victoria, meaning that five of the top six are non-U.S. The composition of the first four is the same when citations are proportionally-adjusted, with Victoria, Cal State–Long Beach and Harvard tied for fifth. Lancaster's leading h and h_p values are only 14 and nine, respectively, which are fairly small values. Only 55 institutions have at least four articles with at least four citations. When compared to the size of the data, these findings emphasize the sub-discipline's fragmented nature, as well as Wright's (2009) observation regarding the infrequency with which many SA authors publish such research.

A closer look at articles from the leading institutions reveals that a school's contributions often come from one (or a very few) authors. For example, Michael B. Wright and Robert Simmons have contributed 18.3 of Lancaster University's institutional-leading 22.5 total. Rodney Fort, William J. Hurley, Stephen R. Clarke, and James Albert account for the vast majority of the contributions from WSU, RMCC, SUT, and Bowling Green respectively, with the remaining proportional authorships often largely (if not fully) accounted for by co-authors on the same paper. Raymond T. Stefani of Cal State–Long Beach accounts for all of his institution's articles, and John S. Croucher from Macquarie University (Australia) nearly does so for his school. These observations emphasize that SA has been and/or still is the bastion of a small and widely distributed group of individuals.

Summary and Conclusion

An expansive search of 140 analytics journals reveals a sizable and growing SA literature. This research appears concentrated in a list of approximately 30 journals, led largely by those from economics. The four OR journals with the most substantial impact in SA are *EJOR*, *JORS*, *Operations Research*, and *Interfaces*, with *Interfaces* being the U.S.-based OR outlet most frequently publishing such research.

Examination of leading institutional contributors indicates strong international diversity and non-U.S. presence in the sub-discipline, led by the universities of Lancaster and Salford in the UK. The prevalence of non-U.S. schools points to possibly more ready acceptance of SA research outside the U.S. Investigating whether there are international differences in how publishing in SA is viewed – by editors, current and prospective authors, promotion and tenure reviewers, institutions, or even the analytics or sports communities in general – is a potential avenue for future research. A look at the

contributions from leading institutions suggests a field in which research is being performed by a few contributors at each school, supporting Wright's (2009) comments regarding its fragmented nature.

This work represents an effort to better define a field with growing research interest. While contributions to research include books, editorships, conference presentations, etc., this study concentrates on the most recognized medium for academic research: refereed journal articles. The findings provide some guidance for those researching in SA and those considering doing so. They also hopefully provide a measure of definition and advancement for the field.

References

Albert, J., Bennett, J., and J.J. Cochran (Eds.). 2005. *Anthology of Statistics in Sports*. Philadelphia: Society for Industrial and Applied Mathematics.

Albert, J. and R. H. Koning (Eds.). 2007. *Statistical Thinking in Sports*. Boca Raton, Florida: Taylor and Francis Group.

Bennett, J. 1998. *Statistics in Sports*. London: Arnold.

Cochran, J. J. 2008. Operations Research and Sports: A Brief Overview. *StatOR 8(2)*, available at http://www.vvs-or.nl/stator/Stator2008-2CochranSports.pdf.

Cochran, J. J. 2010. The emergence of sports analytics. *Analytics* (January/February) 36-39, available at viewer.zmags.com/publication/ed2f8ceb#/ed2f8ceb/37.

Fricker, Jr., R. D. 2009. Editorial: the eighth Rothkopf rankings of universities' contributions to the INFORMS practice literature. *Interfaces*, 39(6) 533-539.

Hirsch, J. E. 2005. An Index to Quantify an Individual's Scientific Research Output. *Proceedings of the National Academy of Sciences of the U.S.A.*, 102(46) 16569-16572, available at www.pnas.org/content/102/46/16569.full.pdf+html.

Kendall, G., Knust, S., Ribeiro, C. C., and S. Urrutia. 2010. Scheduling sports: An annotated bibliography. *Computers and Operations Research*, 37 1-19.

Koning, R. H., Sierksma, G., and S. van de Velde. 2003. Introduction: Sport and Computers. *European Journal of Operational Research*, 148 231–232.

Ladany, S. P., and R. E. Machol (Eds.). 1977. *Optimal Strategies in Sports*. Amsterdam: North-Holland Publishing Company.

Liu, H. 2007. Cochran-Armitage Trend Test Using SAS. *Proceedings of PharmaSUG* (The Pharmaceutical Industry SAS Users Group), available at www.lexjansen.com/pharmasug/ 2007/sp/sp05.pdf.

Machol, R. E., and S. P. Ladany (Eds.). 1976. *Management Science in Sports*. Amsterdam: North-Holland Publishing Company.

Mondello, M. J., and P. M. Pederson. 2003. A Content Analysis of the *Journal of Sports Economics*. *Journal of Sports Economics* 4(1) 64-73.

Mottley, C. M. 1954. Letters to the Editor: The Applications of Operations-Research Methods to Athletic Games. *Journal of the Operations Research Society of America*, 2(3) 335-338.

Norman, J. M., and P. A. Scarf. 1995. Dynamic Programming in Sport: A Survey of Applications. *IMA Journal of Management Mathematics*, 6(2) 171-176.

Norman, J. M., and P. A. Scarf. 2005. OR in Sport. *IMA Journal of Management Mathematics*, 16 87-88.

Plunkett Research, Ltd. 2010. Sports Industry Overview, available at www.plunkettresearch.com/ Industries/Sports/SportsStatistics/tabid/273/Default.aspx.

Ribeiro, C. C., and S. Urrutia. 2004. OR on the Ball: Applications in Sports Scheduling and Management. *OR/MS Today*, 31(3), available at www.lionhrtpub.com/orms/orms-6-04/ frsports.html.

Rasmussen, R. V., and M. A. Trick. 2008. Round robin scheduling – a survey. *European Journal of Operational Research*, 188 617-636.

Tarma Software Research Pty Ltd. 2009. *Harzing's Publish or Perish*, available at www. harzing.com.

Watkins, A., and L. Wolstenholme, 2002. Editorial. *Journal of the Royal Statistical Society, Series D (The Statistician)*, 51(2) 127-128.

Web of Science. 2010. Journal Title Abbreviations. Available at images.isiknowledge.com/WOK46/help/WOS/0-9_abrvjt.html.

Wright, M. B. 2009. 50 Years of OR in Sport. *Journal of the Operational Research Society*, 60 S161-S168.

Young, S. T., Baird, B. C., and M. E. Pullman. 1996. POM Research Productivity in U.S. Business Schools. *Journal of Operations Management*, 14 41-53.

Table 1. These 140 analytics journals were searched, including selections from OR, statistics, applied mathematics, and applied economics; they ranked within the set of 140 as shown, according to their respective overall *h*-indexes.

#	Journal	#	Journal	#	Journal	#	Journal
1.	J Am Stat Assoc	37.	Data Min Knowl Disc	72.	Can J Stat	107.	T Soc Comput Simul
2.	Manage Sci	37.	J Roy Stat Soc A Sta	73.	Constraints	109.	Decis Sci J Innov Educ
3.	Biometrika	39.	Discrete Math	73.	J Roy Stat Soc C-App	110.	4OR-Q J Oper Res
4.	J Econometrics	40.	INFORMS J Comput /	75.	Commun Stat B-Simul	110.	Stat Method Appl
5.	Ann Math Stat		ORSA J Comput	75.	Statistics	110.	Stoch Stoch Rep
6.	Oper Res	41.	Ann Appl Probab	77.	J R Stat Soc	113.	Stoch Dynam
7.	Eur J Oper Res	41.	Appl Econ	77.	Stoch Models	114.	J Decis Syst
8.	J Roy Stat Soc B	43.	J Comb Theory A	79.	Group Decis Negot	115.	Operational Res
9.	IEEE T Neural Networ	44.	Interfaces	80.	J Stat Comput Sim	116.	Stat Educ Res J
10.	Math Program	45.	IEEE Intell Syst	81.	INFOR	116.	Stat Methodol
10.	Technometrics	46.	Appl Math Comput	81.	J Appl Stat	118.	Int J Oper Quant Manag
12.	SIAM Rev	46.	J Multivariate Anal	83.	J Sched	118.	J Data Sci
13.	IEEE T Syst Man Cyb	48.	Oper Res Lett	84.	Appl Econ Lett	118.	J Mod Appl Stat Method
14.	Rev Econ Stat	49.	J Time Ser Anal	84.	Probab Eng Inform Sc	121.	Ann Appl Stat
15.	J Bus Econ Stat	50.	Stoch Proc Appl	86.	Lect Notes Artif Int	121.	INFORMS T Educ
16.	Ann Probab	51.	Int J Forecasting	87.	Int T Oper Res	121.	J Appl Stat Sci
17.	IEEE T Fuzzy Syst	52.	Expert Syst Appl	88.	J Comb Optim	124.	Int J Oper Research
18.	Math Oper Res	53.	J Global Optim	88.	J Roy Stat Soc D-Sta	124.	J Appl Math Decis Sci
19.	Decision Sci	54.	Comput Ind Eng	90.	Stoch Anal Appl	124.	Pac J Optim
19.	J Appl Econom	55.	Comput Stat Data An	91.	IEEE T Syst Sci Cyb	124.	Teach Stat
21.	SIAM J Sci Stat Comp	55.	Queueing Syst	91.	J Stat Educ	128.	J Quant Anal Sport
22.	J Oper Res Soc	55.	Theor Probab Appl+	93.	J Sport Econ	128.	Math Program Stud
23.	Ann Oper Res	58.	Commun Stat A-Theor	94.	Probab Math Stat	128.	Theor Probab Math Stat
24.	Am Math Mon	58.	Int J Intell Syst	95.	Computation Stat	131.	Comb Design Appl
24.	Networks	58.	Int Stat Rev	96.	Und Stat	131.	Theor Stoch Proc
26.	J Appl Probab	58.	J Forecasting	97.	Appl Stoch Model D A	133.	Adv Appl Stat
27.	Am Stat	62.	Ann I Stat Math	97.	Stat Model	134.	J Probab Stat Sci
27.	Discrete Appl Math	62.	Math Comput Model	99.	IMA J Manage Math	134.	J Stat Theory Appl
29.	Comput Oper Res	64.	Nav Res Log	99.	Stat Pap	134.	J Stat Theory Pract
29.	J Comb Theory B	64.	Stat Comput	101.	Am J Math-S	134.	Model Assist Stat Appl
31.	Decis Support Syst	66.	J Stat Plan Infer	101.	J Comb Math Comput	134.	OR Insight
31.	IIE Trans	67.	ACM T Model Comput S	101.	Stat Decis	139.	Int J Sport Sci Eng
31.	Omega-Int J Manage S	68.	Manage Decis Econ	104.	Stat Infer Stoch Proc	139.	Stoch Model Appl
34.	Adv Appl Probab	69.	J Heuristics	105.	Appl Stoch Model Bus		
34.	Ann Stat	69.	Simulation	105.	Discrete Optim		
34.	Oxford B Econ Stat	71.	Stud Appl Math	107.	Stud Manage Sci		

Table 2. These were the top-40 journals in sports analytics articles (*a*), citations (*c*), or *h*-index.

Journal	*a* (rank)		*c* (rank)		*h* (rank)	
Journal of Sports Economics	317	(1)	2747	(1)	25	(1)
Journal of Quantitative Analysis in Sports	93	(2)	117	(21)	6	(18)
Applied Economics	73	(3)	1195	(2)	21	(2)
American Statistician	64	(4)	574	(4)	14	(4)
Journal of the Operational Research Society	53	(5)	568	(5)	13	(6)
Managerial and Decision Economics	44	(6)	665	(3)	15	(3)
Applied Economics Letters	43	(7)	447	(8)	14	(4)
Interfaces	41	(8)	249	(14)	9	(10)
European Journal of Operational Research	32	(9)	514	(6)	13	(6)
Computers and Operations Research	24	(10)	200	(15)	7	(16)
Journal of the American Statistical Association	23	(11)	440	(9)	13	(6)
Teaching Statistics	23	(11)	36	(37)	3	(27)
Operations Research	20	(13)	496	(7)	10	(9)
IMA Journal of Management Mathematics	20	(13)	49	(32)	4	(22)
J. of the Royal Statistical Soc., series D (The Statistician)	18	(15)	314	(12)	9	(10)
International Journal of Forecasting	17	(16)	189	(16)	9	(10)
Journal of Applied Statistics	15	(17)	130	(20)	6	(18)
Discrete Applied Mathematics	14	(18)	254	(13)	7	(16)
Journal of Statistics Education	14	(18)	67	(27)	4	(22)
INFORMS Transactions on Education	13	(20)	22	(42)	3	(27)
International Journal of Sports Science & Engineering	13	(20)	2	(59)	1	(39)
Review of Economics and Statistics	12	(22)	402	(10)	9	(10)
J. of the Royal Statistical Soc., series A (Stat. in Society)	12	(22)	158	(18)	8	(15)
J. of the Royal Statistical Soc., series C (Applied Stat.)	11	(24)	322	(11)	9	(10)
Management Science	11	(24)	162	(17)	6	(18)
American Mathematical Monthly	9	(26)	103	(23)	6	(18)
SIAM Review	8	(27)	137	(19)	3	(27)
Operations Research Letters	8	(27)	63	(29)	3	(27)
Journal of Forecasting	6	(29)	52	(30)	4	(22)
International Transactions in Operational Research	6	(29)	43	(35)	3	(27)
OR Insight	6	(29)	1	(61)	1	(39)
INFOR	4	(32)	113	(22)	2	(33)
J. of the Royal Statistical Soc., series B (Stat. Method.)	4	(32)	89	(24)	2	(33)
Journal of Applied Probability	4	(32)	47	(33)	2	(33)
Omega	4	(32)	44	(34)	4	(22)
Annals of Operations Research	4	(32)	32	(38)	2	(33)
Discrete Optimization	4	(32)	26	(41)	4	(22)
Mathematical and Computer Modelling	4	(32)	7	(51)	2	(33)
Expert Systems with Applications	4	(32)	4	(55)	1	(39)
International Journal of Operational Research	4	(32)	1	(61)	1	(39)
IEEE Transactions on Systems, Man, and Cybernetics	3	(41)	66	(28)	3	(27)
Naval Research Logistics	3	(41)	22	(42)	2	(33)
Journal of Scheduling	2	(44)	71	(26)	1	(39)
Data Mining and Knowledge Discovery	1	(55)	76	(25)	1	(39)
Constraints	1	(55)	51	(31)	1	(39)
Mathematical Programming Studies	1	(55)	38	(36)	1	(39)
Networks	1	(55)	32	(38)	1	(39)
Journal of Applied Econometrics	1	(55)	29	(40)	1	(39)

Table 3. Among the top-40 institutions, Lancaster University produced the most sports analytics articles (a), proportionally-adjusted articles (a_p), citations (c), and proportionally-adjusted citations (c_p), and had the highest h-index and proportionally-adjusted h-index (h_p).

Institution	a(rank)		a_p (rank)		c (rank)		c_p (rank)		h (rank)		h_p (rank)	
Lancaster University	32	(1)	22.5	(1)	579	(1)	459.0	(1)	14	(1)	9	(1)
University Of Salford	21	(2)	14.7	(2)	304	(2)	228.0	(2)	9	(3)	7	(3)
Swinburne University Of Technology	16	(3)	12.4	(4)	171	(9)	142.0	(9)	8	(4)	8	(2)
Washington State University	16	(3)	11.9	(5)	239	(4)	169.4	(4)	10	(2)	7	(3)
Royal Military College Of Canada	14	(5)	13.2	(3)	24	(184)	20.5	(154)	4	(34)	3	(44)
University Of Florida	14	(5)	11.7	(6)	65	(74)	57.0	(55)	4	(34)	3	(44)
DePaul University	14	(5)	10.2	(7)	84	(53)	59.2	(53)	6	(7)	4	(20)
Simon Fraser University	14	(5)	9.3	(12)	82	(56)	60.9	(50)	5	(15)	3	(44)
Stanford University	13	(9)	9.9	(10)	150	(15)	131.6	(12)	6	(7)	4	(20)
University Of Michigan	12	(10)	9.4	(11)	36	(132)	20.8	(151)	3	(56)	3	(44)
Northeastern University	11	(11)	10.2	(7)	41	(117)	36.7	(89)	4	(34)	4	(20)
Bowling Green State University	11	(11)	10.0	(9)	97	(41)	89.5	(28)	6	(7)	5	(8)
University Of Sheffield	11	(11)	8.5	(14)	87	(50)	74.0	(37)	6	(7)	5	(8)
Harvard University	10	(14)	8.8	(13)	118	(29)	116.7	(19)	6	(7)	6	(5)
Temple University	10	(14)	7.8	(16)	127	(26)	94.8	(24)	5	(15)	5	(8)
University Of Kiel	10	(14)	7.8	(17)	87	(50)	49.5	(64)	5	(15)	5	(8)
Georgia Institute Of Technology	10	(14)	7.8	(19)	216	(6)	120.0	(16)	5	(15)	5	(8)
Auburn University	10	(14)	7.2	(22)	83	(55)	79.0	(33)	4	(34)	4	(20)
Carnegie Mellon University	10	(14)	6.0	(29)	283	(3)	138.7	(11)	5	(15)	5	(8)
Technical University Of Lisbon	10	(14)	5.5	(34)	55	(93)	32.5	(99)	4	(34)	4	(20)
Imperial College London	10	(14)	4.9	(39)	194	(7)	125.4	(15)	8	(4)	4	(20)
University Of Wales Aberystwyth	10	(14)	4.3	(52)	157	(13)	65.3	(45)	5	(15)	5	(8)
American University	9	(23)	7.8	(17)	38	(126)	13.5	(197)	2	(103)	2	(87)
Iowa State University	9	(23)	5.5	(34)	128	(24)	81.5	(31)	5	(15)	4	(20)
Macquarie University, Australia	8	(25)	8.0	(15)	23	(187)	23.0	(138)	3	(56)	3	(44)
University Of Groningen	8	(25)	7.5	(20)	129	(23)	129.0	(13)	5	(15)	5	(8)
University Of Antwerp	8	(25)	7.3	(21)	140	(19)	140.0	(10)	3	(56)	3	(44)
California State University - Long Beach	8	(25)	7.0	(23)	135	(20)	117.5	(17)	6	(7)	6	(5)
Cornell University	8	(25)	6.8	(24)	122	(28)	101.7	(23)	4	(34)	4	(20)
University Of North Carolina - Charlotte	8	(25)	6.8	(25)	36	(132)	28.3	(119)	3	(56)	3	(44)
University Of Dayton	8	(25)	5.2	(37)	73	(64)	55.5	(59)	5	(15)	3	(44)
University Of Nottingham	8	(25)	4.7	(43)	61	(85)	43.5	(71)	5	(15)	4	(20)
Universidade Federal Fluminense	8	(25)	4.2	(54)	172	(8)	73.3	(38)	5	(15)	5	(8)
Ecole Polytechnique Fédérale De Lausanne	7	(34)	6.3	(26)	159	(12)	159.0	(6)	4	(34)	4	(20)
University Of Chicago	7	(34)	6.2	(27)	142	(18)	102.2	(22)	4	(34)	4	(20)
University Of Victoria	7	(34)	6.2	(28)	160	(11)	148.7	(7)	7	(6)	6	(5)
University Of Illinois At Chicago	7	(34)	6.0	(29)	51	(103)	48.5	(67)	3	(56)	2	(87)
Universität Osnabrück	7	(34)	5.5	(31)	40	(120)	28.5	(117)	3	(56)	3	(44)
University Of Colorado - Denver	7	(34)	5.3	(36)	63	(81)	49.2	(66)	5	(15)	4	(20)
Columbia University	7	(34)	5.2	(38)	101	(39)	61.5	(48)	3	(56)	3	(44)

Table 3 (continued).

Institution	a(rank)		a_p (rank)		c (rank)		c_p (rank)		h (rank)		h_p (rank)	
Yale University	7	(34)	4.8	(42)	50	(108)	40.5	(78)	5	(15)	4	(20)
College Of William And Mary	7	(34)	3.8	(66)	67	(71)	37.5	(86)	6	(7)	3	(44)
Oklahoma State University	7	(34)	3.7	(69)	49	(109)	30.0	(107)	3	(56)	2	(87)
California State University - Bakersfield	7	(34)	3.2	(86)	68	(70)	29.0	(112)	6	(7)	3	(44)
National University Of Singapore	6	(45)	5.5	(31)	128	(24)	128.0	(14)	3	(56)	3	(44)
University Of North Texas	6	(45)	5.5	(31)	89	(45)	65.0	(46)	5	(15)	5	(8)
Royal Melbourne Institute Of Technology	6	(45)	4.9	(39)	38	(126)	30.4	(106)	3	(56)	2	(87)
University Of Twente	6	(45)	4.8	(41)	152	(14)	146.3	(8)	4	(34)	4	(20)
Clemson University	6	(45)	4.5	(44)	105	(35)	91.5	(25)	4	(34)	4	(20)
University Of Surrey	6	(45)	4.3	(49)	144	(17)	90.0	(27)	5	(15)	5	(8)
University Of Otago	6	(45)	4.3	(52)	89	(45)	60.8	(52)	5	(15)	4	(20)
University Of Bath	6	(45)	3.4	(81)	65	(74)	41.1	(77)	4	(34)	3	(44)
University Of Wales Swansea	6	(45)	3.2	(86)	66	(73)	42.0	(73)	4	(34)	3	(44)
University Of Texas - Arlington	5	(58)	4.5	(44)	45	(112)	37.0	(87)	4	(34)	4	(20)
University Of Bradford	5	(58)	4.3	(49)	104	(36)	84.0	(30)	5	(15)	5	(8)
College Of The Holy Cross	5	(58)	3.9	(63)	25	(179)	18.9	(160)	4	(34)	3	(44)
Monash University	5	(58)	3.8	(64)	102	(37)	80.8	(32)	4	(34)	4	(20)
IBM	5	(58)	3.7	(71)	225	(5)	179.3	(3)	5	(15)	4	(20)
SUNY Cortland	5	(58)	3.3	(84)	61	(85)	33.0	(97)	4	(34)	3	(44)
University Of Hull	5	(58)	2.2	(147)	150	(15)	60.8	(51)	5	(15)	4	(20)
University Of Maryland Baltimore County	4	(79)	4.0	(55)	166	(10)	166.0	(5)	4	(34)	4	(20)
Indiana University	4	(79)	4.0	(55)	73	(64)	73.0	(39)	3	(56)	3	(44)
Western Michigan University	4	(79)	4.0	(55)	52	(99)	52.0	(60)	4	(34)	4	(20)
California State University - Hayward	4	(79)	3.5	(73)	130	(22)	107.0	(21)	3	(56)	3	(44)
University Of St. Andrews	4	(79)	3.3	(85)	51	(103)	39.8	(82)	4	(34)	3	(44)
Tilburg University	4	(79)	3.0	(91)	71	(66)	56.5	(57)	4	(34)	4	(20)
Smith College	4	(79)	2.8	(111)	113	(31)	63.8	(47)	3	(56)	3	(44)
University Of Aarhus	4	(79)	2.5	(118)	101	(39)	58.5	(54)	4	(34)	4	(20)
Portland State University	4	(79)	2.3	(136)	132	(21)	77.5	(35)	3	(56)	3	(44)
University Of Wales	4	(79)	1.4	(245)	89	(45)	32.4	(100)	4	(34)	3	(44)
University Of Melbourne	3	(121)	3.0	(91)	78	(59)	78.0	(34)	2	(103)	2	(87)
University Of Texas - Dallas	3	(121)	3.0	(91)	77	(60)	77.0	(36)	3	(56)	3	(44)
University Of Tulsa	3	(121)	2.5	(118)	102	(37)	70.0	(43)	3	(56)	3	(44)
Brown University	3	(121)	2.3	(136)	127	(26)	90.3	(26)	2	(103)	2	(87)
Boston University	3	(121)	2.2	(147)	111	(32)	86.8	(29)	2	(103)	2	(87)
University Of Leeds	3	(121)	1.3	(247)	111	(32)	44.7	(70)	3	(56)	3	(44)
University Of Toronto	2	(184)	2.0	(154)	117	(30)	117.0	(18)	2	(103)	2	(87)
University Of Stirling	2	(184)	2.0	(154)	111	(32)	111.0	(20)	2	(103)	2	(87)
University Of Aberdeen	2	(184)	1.7	(209)	89	(45)	73.0	(39)	2	(103)	2	(87)
University Of Utah	2	(184)	1.5	(215)	74	(63)	73.0	(39)	2	(103)	1	(182)

Figure 1. **The number and proportion of journal articles on sports analytics has risen substantially since 1990, regardless of whether articles in the relatively new journals *JSE*, *JQAS*, and *IJSSE* are considered.**