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# The Dominance of Teams in the Production of Legal Knowledge

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## *The Dominance of Teams in the Production of Legal Knowledge*

*Christopher A. Cotropia & Lee Petherbridge*

*Using a database that contains over 19,000 law review articles published in top 100 law reviews between 1990 and 2010, we observe that team authors dominate solo authors in the production of legal knowledge. Team research is on average more frequently cited than individual research, and teams are more likely than individuals to produce exceptionally high-impact research. These results suggest that a legal research culture that encourages cooperation and collaboration could foster an intellectual connectedness helpful to improving the quality of knowledge production by legal academics.*

### **INTRODUCTION**

A common narrative in the history of science emphasizes the importance of the contributions of solitary authors, such as Galileo, Darwin, or Newton. Studies focusing on the production of scientific knowledge in more contemporary times, however, reveal that the emphasis on the importance of the contributions of solo authors is grounded more in myth than in reality. Knowledge production in the sciences has increasingly become dominated by teams of researchers whose work appears in articles and books with multiple authors.<sup>1</sup>

The shift toward teams in the production of scientific knowledge raises a number of questions. How broad is the shift? Is it limited to fields characterized by capital-intensive research, such as the life sciences, engineering, and physics, or does it extend to the social sciences, arts and humanities, and law where the cost of research may be less? In addition, what is the significance of the shift? Do teams produce better research and make a greater contribution to knowledge production than individuals, or is it the other way round? Has the

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1. See Stefan Wuchty et al., *The Increasing Dominance of Teams in Production of Knowledge*, 316 *SCIENCE* 1036, 1037 (2007) (“Our results show that teams now dominate the top of the citation distribution in all four research domains.”).

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collaborative and cooperative approach that seems to characterize the modern production of knowledge promoted costly and low-impact research at the expense of less costly, higher-impact ideas that remain the province of solitary workers?

Recently, Wuchty et al., using a dataset of research articles from the Institute for Scientific Information (ISI), showed that teams have come to dominate knowledge production not only in the sciences and engineering, but also in the social sciences, arts and humanities, and patents.<sup>2</sup> This work showed, moreover, that not only has team research become a preferred model of knowledge production across nearly all disciplines (arts and humanities being the exception), but also that teams produce higher-quality research on average and are more likely to produce exceptionally high-impact material.

Whether the production of legal knowledge has followed a similar path is an open question. While collaboration is familiar to some legal researchers,<sup>3</sup> the field, for the most part, does not seem to implicate the large-scale complexity and cost that has become associated with big science. These logistical differences, combined with a very strong cultural preference in legal academic circles for solitary work,<sup>4</sup> could potentially keep team research from dominating the production of legal knowledge to the same extent that it has come to dominate the production of knowledge in other areas. On the other hand, the dominance of team research outputs and a shift towards team research has been observed in social sciences and arts and humanities research. To the extent that the production of legal knowledge is analogous to the production of knowledge in the social sciences and arts and humanities, one might anticipate that teams would enjoy advantages in the production of legal knowledge as well.

### I. METHODS AND RESULTS

In an attempt to explore the role of team research in the production of legal knowledge, we examined 19,257 law review articles from the HeinOnline Law Journal Library. The HeinOnline Law Journal Library “includes the vast majority of the entire United States law review literature from the nineteenth and

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2. *Id.* (“Lastly, in arts and humanities and in patents, individuals were never more likely than teams to produce more-influential work.”).
  3. See Tracy E. George & Chris C. Guthrie, *Joining Forces: The Role of Collaboration in the Development of Legal Thought*, 52 J. LEGAL EDUC. 559, 560 (2002) (concluding, however, “that collaboration has *not* played a very significant role in the development of legal thought, particularly when compared to collaborative work in related social science disciplines”).
  4. See Duncan E. Alford, *Symposium Introduction – The Law Librarian’s Role in the Scholarly Enterprise*, 39 J.L. & EDUC. 351, 352-53 (2010) (noting that the “solitary scholar” is “a long standing tradition of the legal academe”).

twentieth centuries.”<sup>5</sup> The articles we examined comprise a randomly selected half of all law review articles published by top 100 law reviews between 1990 and 2010. Team research is defined as any article that has more than one listed author.

The data suggest that in the study of law, there has not as yet been a substantial shift toward collective research similar to that seen in the social sciences. Instead, solitary authors still produce nearly 90% of the papers in law, as seen in Table 1 below.

# Authors	Frequency	Percent
1	16,643	86.43
2	2,168	11.26
3	332	1.72
4	114	.59

**Table 1.** The frequency of team authorship in top 100 law reviews between 1990 and 2010.

This is consistent with what others have observed in the arts and humanities;<sup>6</sup> it suggests the presence of a strong cultural preference for insular, solitary work among law faculties, and is consistent with a theory that much of the present production of legal knowledge is relatively small-scale, of limited complexity, and low-cost.

Previous work has nonetheless shown a significant positive trend favoring teams in arts and humanities research,<sup>7</sup> and our data suggest a similarly directed trend in the production of legal knowledge.<sup>8</sup>

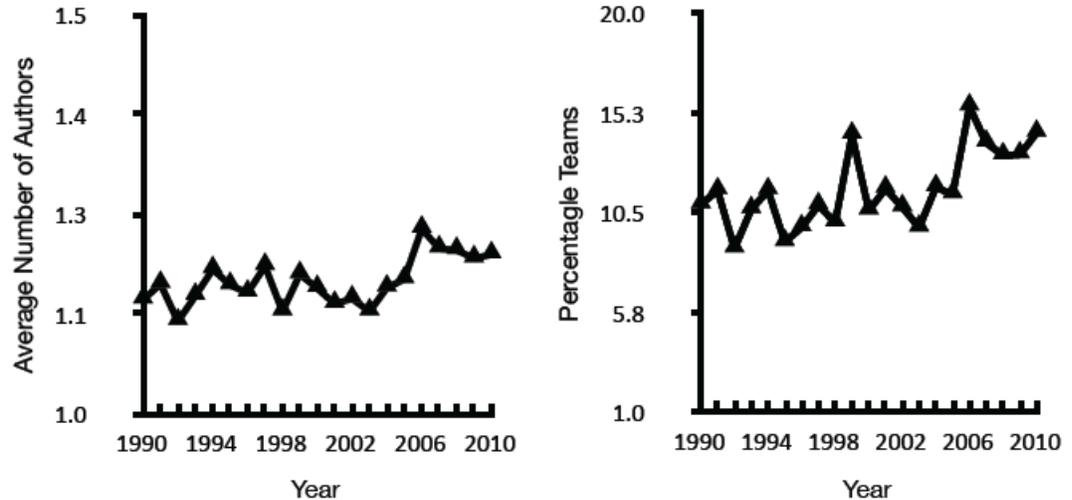
5. See Fred R. Shapiro & Michelle Pearse, *The Most-Cited Law Review Articles of All Time*, 110 MICH. L. REV. 1483, 1486 (2012).

6. See Wuchty et al., *supra* note 1, at 1037-38.

7. *Id.*

8. There is significant correlation between average number of authors and publication year ( $r = 0.584$ ,  $p = 0.005$ ), and percentage of team authorship and publication year ( $r = 0.642$ ,  $p = 0.002$ ).

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**Figure 1.** The growth of team authorship 1990-2010. There has been at best a modest increase in the average number of authors per article and the percentage of papers authored by teams in top 100 law reviews.

Over the last twenty or so years, the average number of authors per paper has ranged between a low of 1.11 in 1992 and a high of 1.23 in 2006. The average number of papers authored by teams has averaged 11.59%, and ranged from a low of 8.78% in 1992 to a high of 15.54% in 2006. Taken together, these data reveal a significant, although perhaps modest-appearing trend favoring the use of teams in the production of legal knowledge, with more recent years evidencing greater levels of collaborative authorship.

We used the number of citations to assess the quality and impact of each paper in the study.<sup>9</sup> Number of citations has been shown to correlate with research quality,<sup>10</sup> and is commonly used by law faculties to make determinations

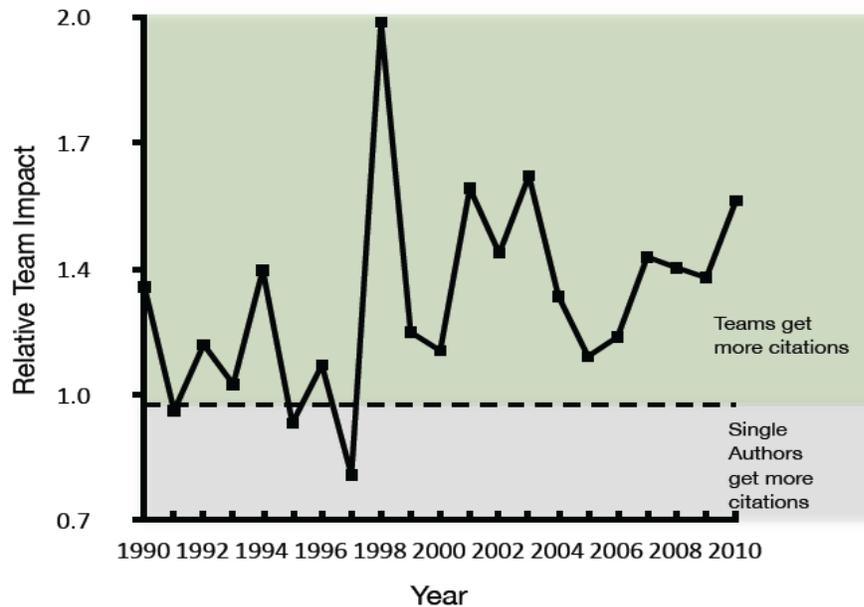
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9. See William M. Landes & Richard A. Posner, *Heavily Cited Articles in Law*, 71 CHI.-KENT L. REV. 825, 827-28 (1996) (noting the use of citations to measure an article's quality); see also Shapiro & Pearce, *supra* note 5, at 1484-85; Ian Ayres & Frederick E. Vars, *Determinants of Citations to Articles in Elite Law Reviews*, 29 J. LEGAL STUD. 427, 428-29 (2000) (calling "sophisticated," but critiquing, the Posner and Landes method).
  10. See Stephen M. Lawani & Alan E. Bayer, *Validity of Citation Criteria for Assessing the Influence of Scientific Publications: New Evidence with Peer Assessment*, 34 J. AM. SOC'Y FOR INFO. SCI. 59, 66 (1983) ("Our results do clearly show, however, that peer assessments and citation rates are, in general, highly correlated."); Brownlynn H. Hall, *et. al.*, *Market Value and Patent Citations*, 36 RAND J. ECON. 16 (2005); Manual Trajtenberg, *A Penny for Your Quotes: Patent Citations and Values of Innovations*, 21 RAND J. ECON. 172 (1990).

concerning tenure and promotion and by administrators and other agencies to make determinations about research funding.<sup>11</sup>

We ultimately find that teams produce research of higher quality. Teams are also more likely to produce research of exceptionally high impact, given their prevalence amongst papers at the higher end of the citation distribution.

We measured team impact by calculating a ratio (relative team impact or RTI).<sup>12</sup> RTI is calculated by dividing the mean number of citations received by team-authored work over the mean number of citations received by solo-authored work. Thus, when RTI equals 1 the rate of citation to team and solo authored papers is the same. When teams produce more highly cited papers than solo authors RTI is greater than 1. When solo authors produce more highly cited papers than team authors RTI is less than 1.

The average RTI was 1.19 and exceeded 1 in all but three of the years studied:



**Figure 2.** The impact of teams. Relative Team impact was calculated similar to Wuchty et al. It is a ratio of the mean number of citations received by team authored work divided by the mean number of citations for solo authored work. A ratio of 1 indicates that team and solo authored work had on average the same impact. Ratios greater than 1 indicate that on average team authored work had greater impact, while ratios less than one indicate that on average solo authored work had greater impact.

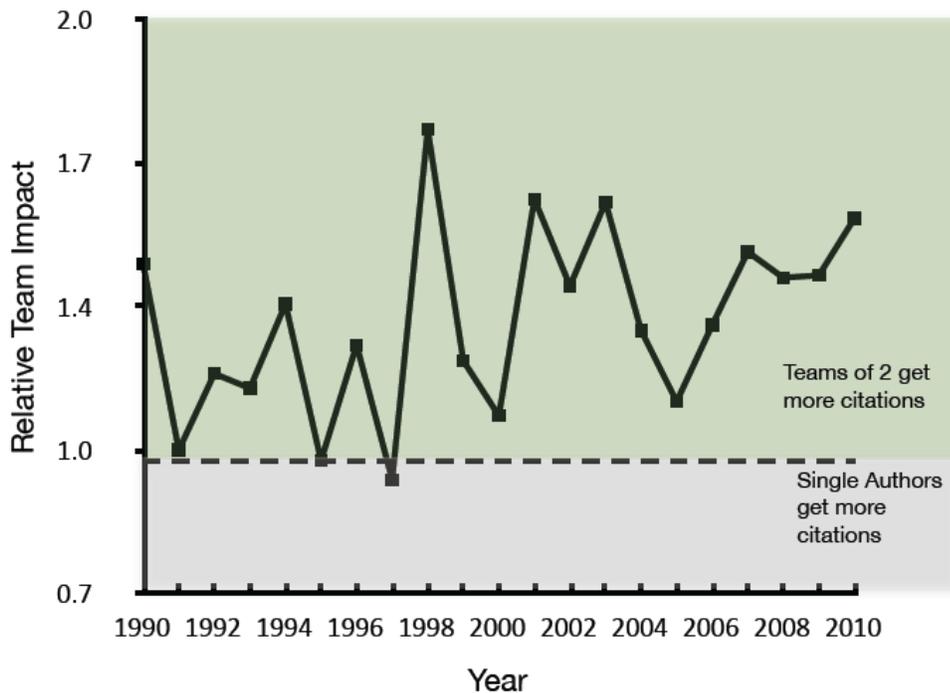
11. See Lawani & Bayer, *supra* note 10, at 66. We recognize that there may be other methods for determining the quality and impact of scholarship beyond citation. But for the purposes of this essay, citation is used, as it has been in other team studies, see Wuchty et al., *supra* note 1, at 1037, as the sole indicator of quality and impact.

12. See Wuchty et al, *supra* note 1, at 1037-38.

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This indicates a general tendency for teams to produce more highly cited work than solo authors.<sup>13</sup> The years that exhibited an RTI less than 1, moreover, were all in the 1990s, and RTIs greater than one were observed from 1998 through 2010. RTI thus appears to be rising with time. During the first 7 to 8 years of the period studied, while RTIs were generally higher than 1, they hewed somewhat closer to 1 and, as noted above, occasionally drifted below 1. Since that time RTI's appear to have trended upwards, suggesting that the quality advantage teams have over solo authors is increasing.<sup>14</sup>

The citation advantage of teams is also evident when teams of fixed size are compared with solo authors, suggesting the impact of teams is not merely a function of teams increasing in size<sup>15</sup>:



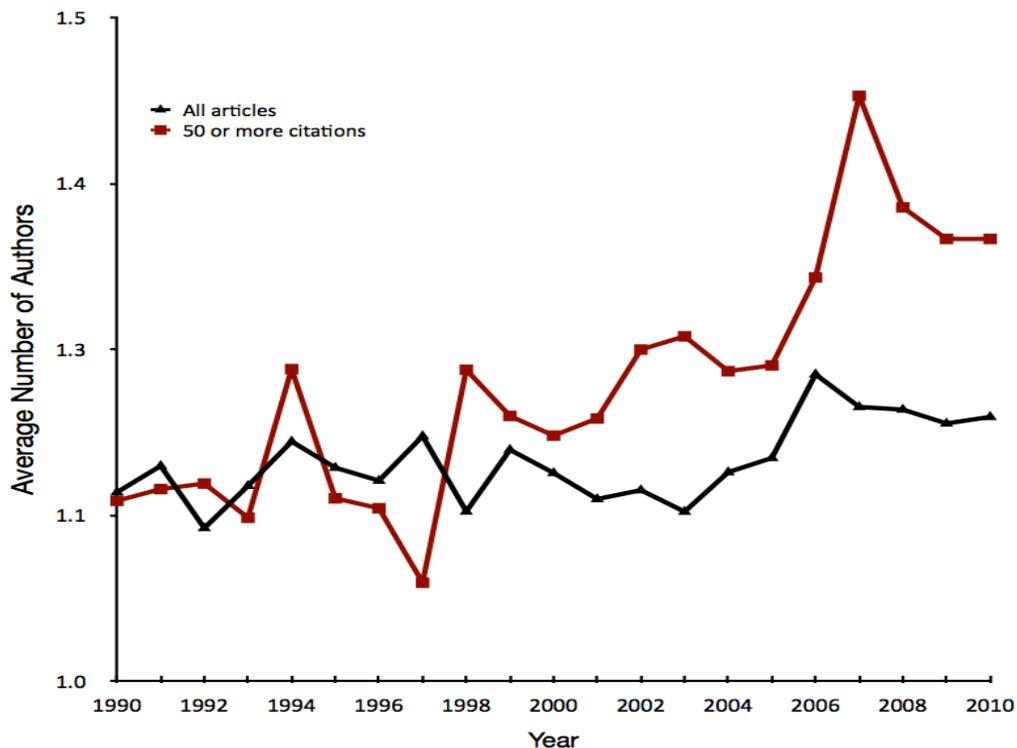
**Figure 3.** The impact of teams of two. Relative team impact was calculated as a ratio of the mean number of citations received by teams of two divided by the mean number of citations received by solo authored work.

13. Papers that are team authored are on average cited more often than solo authored work,  $p < 0.000$ .
14. Correlation of RTI and publication year, while positive, is not statistically significant,  $r = 0.332$ ,  $p = 0.142$ .
15. Papers that are authored by teams of two are on average cited more often than solo authored work,  $p < 0.000$ .

The average RTI when teams of two authors were compared with solo authors was 1.24, and as was the case when teams of any size were compared with solo authors the quality advantage of teams having only two authors appears to be increasing.<sup>16</sup>

It may be that the progress of understanding law is driven by a relatively small number of key insights. It is further possible, even though teams clearly outpace solo authors on average in terms of quality, that the small number of especially important insights tend to come from solo authors.<sup>17</sup>

To examine whether the highest-impact contributions to legal scholarship come from solo authors or teams, we performed two additional analyses. First, we compared the average number of authors for all papers in the study to the average number of authors for papers that received more than fifty or more citations:



**Figure 4.** Average number of authors per article for articles that receive 50 or more citations (red/blocks) has increased, while there has been a much smaller increase in the average number of authors per article overall (black/triangles) in top 100 law reviews.

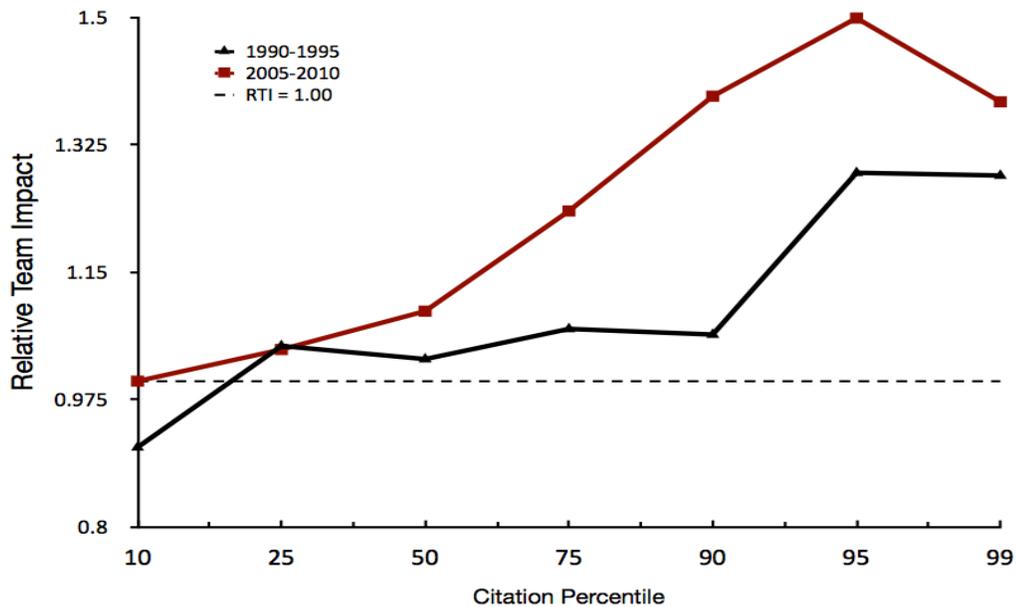
16. Correlation of RTI for teams of two and publication year, while positive, is not statistically significant,  $r = 0.358$ ,  $p = 0.111$ .

17. See Landes & Posner, *supra* note 9, at 827.

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The average number of authors on articles that received more than 50 citations is significantly higher ( $p < 0.05$ ) than the average number of authors on articles that received 50 or fewer citations. There has also been a marked increase in the average number of authors on articles that receive more than 50 citations ( $p < 0.000$ ). Figure 4 offers a somewhat more descriptive account and suggests that the number of authors on articles receiving more than 50 citations was relatively close to the average number of authors for all articles throughout much of the 1990s, but that starting in the late 1990s, articles that received 50 or more citations become increasingly dominated by teams. Taken together, these results indicate that teams are indeed responsible for more high-impact research, and that this fact may be a more modern phenomenon. .

To further evaluate whether teams are especially responsible for exceptionally high-impact research, we next calculated relative team impact measures for different percentiles of citation over the first six years of the period studied and the last six years of the period studied, as shown in Figure 5. This approach not only offers insight into whether teams are responsible for exceptionally high impact research, but also shines light on the question of whether there has been some change in the relative contributions of solo and team authors to exceptionally high-impact work.



**Figure 5.** Teams are more likely than individuals to produce high impact and exceptionally high impact research. Relative team impact is calculated for different percentiles of citation, after averaging the citations at the various percentiles for the first (black/triangles) and last (red/blocks) six years of the study period; 1990-1995, and 2005-2010, respectively. The right tails of both lines show that teams are responsible for more high impact and exceptionally high impact legal knowledge creation in both the first *and* last six years of the period studied, although teams have been even more impactful in the most recent five years.

Figure 5 shows that teams dominate the top of the citation distribution. Even more important, perhaps, is that when it comes to exceptionally high-impact research—the right tail of Figure 5—teams have always—at least during the period we studied—dominated the top of the citation distribution, although team dominance appears more pronounced between 2005 and 2010 than it was between 1990 and 1995.

## II. DISCUSSION

Some may raise the concern that our results are driven by self-citations. Because team research involves multiple authors, the argument runs, teams have more opportunities to self-cite their work than do single authors.<sup>18</sup> While a citation to one's own prior work may be as legitimate as a citation to work by another, we nonetheless have empirically founded reasons for believing that the relative citation advantage enjoyed by teams would be substantially unaffected if self-citations were removed from the data.

To begin with, and perhaps most importantly, prior work examining relative team impact in science, engineering, the social sciences, and arts and humanities, has considered the effect of self-citations and has discovered that the relative citation advantage enjoyed by teams remains essentially intact when self-citations are removed from the data.<sup>19</sup> Second, in the data, the citation advantage of teams of a fixed size over solo authors has grown, as seen in Figure 3 above. The fact that the citation advantage of teams has increased even in the absence of an increase in the size of the teams, and thus no increase in team members available to enhance the self-citation of a team's work, suggests that it is a change in the impact of team authorship and not a change in self-citation that explains our observations. In addition, while the observation that the citation advantage of teams of a fixed size over solo authors has grown might be made to fit with an explanation that credits self-citation, the most direct explanation, namely, the one that involves the smallest multiplicity of additional assumptions, appears to be that the impact of team authorship has increased.

Finally, team dominance over solo authors is so pronounced as to make it implausible that the differences can be convincingly explained by co-authors systematically citing their own work. For example, in the data underlying Figure 5, for the period of 1990 to 1995, the average difference in citation between teams and solo authors at the 99th percentile was 64 citations. To put that in perspective, a co-author—and it is likely to be a single co-author given that most team research we observed involved teams of two authors only—would on average have had to author sixty-four additional articles between that peri-

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18. See Wuchty et al., *supra* note 1, at 1037.

19. *Id.*

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od and the present, all of which would need to self-cite the article in our study. If we were to leave room for the possibility that the author might have authored articles that did not self-cite, or for that matter were not placed in top 100 law reviews, the number of articles required for the self-citation explanation would need to be even higher. The average co-author at the 95th percentile would have had to author an additional thirty-one self-citing articles – again assuming no non-self-citing articles and consistent publication in the top 100 law reviews. An examination of the period between 2005 and 2010 – a period in the data for which articles have generally received fewer citations, presumably due at least in part to the fact that they have not been available for citation as long as those published earlier<sup>20</sup> – shows that co-authors would on average, again assuming no non-self-citing articles and consistent placement in top 100 law reviews, need to author an additional 26 (99th percentile) articles and an additional 19 (95th percentile) articles, all of which self-cite the article in our study. The productivity required, as well as the discipline and consistency with which co-authors would have to be self-citing, suggests that self-citation does not offer a compelling explanation for team dominance in exceptionally high-impact research.

## CONCLUSIONS

This study suggests that team authors dominate solo authors in the production of legal knowledge. Team research is more impactful and likely to be of higher quality, and teams are more likely than individuals to produce exceptionally high-impact research. Team dominance, moreover, appears to be following an upward trend, suggesting that teams may come to further dominate the production of legal knowledge in the future.

These findings may come as a surprise in light of the tradition of insular, solitary work in legal scholarship<sup>21</sup> and the fact that the cost of performing typical legal research has if anything gotten cheaper as information technologies have improved. The findings could reflect a broadening, diversification, and specialization of legal knowledge. The study of which may be better suited to cooperative and collaborative approaches. Changes in the complexity and nature of information necessarily used by legal scholars may also be complemented by declines in communication costs that could have made team research more difficult in the past.

The findings might also reflect something of a change in the nature of legal research. It may be the case that some legal academics are moving in the direction of more complex, costly, and capital-intensive research, or that an increas-

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20. See Landes & Posner, *supra* note 9, at 826-27.

21. See *supra* Table 1.

ing number of legal scholars are moving to ground research into and analysis of legal problems in objective empirical science.<sup>22</sup> Similarly, the our observations might be explained by increasing numbers of legal researchers entering the academy with graduate training.<sup>23</sup> Such training tends to both emphasize empirical science and encourage team research. If scholars with backgrounds in other fields are gaining an increasing foothold on law faculties, it is not unreasonable to think that they would bring some of the pro-team norms from these disciplines to the practice of legal research.

The findings could also reflect something much simpler: that two minds are better than one, even when it comes to theoretical work. All authors tend to internalize the benefit (or cost) of a research publication, and so all authors have incentives to produce quality research. Having a diversity of minds addressing a research problem forces a form of rigor in thinking that is impossible to replicate in the context of solo research. Our observations might simply reflect that legal scholars are beginning to appreciate this fact.

Some additional areas for future work stimulated by the findings reported here are (1) the extent to which there are other determinants of scholarly impact besides team research, and (2) whether there are relationships between such other determinants and the effect of teams on scholarly impact.<sup>24</sup>

The developments chronicled in this Essay suggest that a legal research culture that encourages cooperation and collaboration could foster an intellectual connectedness helpful to improving the quality of knowledge production by legal academics. They accordingly offer a challenge the traditional, solitary model of the production of legal knowledge.

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22. See Alford, *supra* note 4, at 351.

23. See Larry E. Ribstein, *Practicing Theory: Legal Education for the Twenty-First Century*, 96 IOWA L. REV. 1649, 1656-57 (2011) (noting that law school faculties are “[l]aw faculties [are] increasingly populated by PhDs in such subjects as economics, sociology, philosophy, psychology, political science, literature, and history”).

24. See Ayres & Vars, *supra* note 9, at 437-42 (providing evidence that other determinants exist, at least for a small set of elite law reviews, and exploring their statistical relationships).