Twin-Win Model: A human-centered approach to research success

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A 70-year-old simmering debate has erupted into vigorous battles over the most effective ways to conduct research. Well-established beliefs are being forcefully challenged by advocates of new research models. While there can be no final resolution to this battle, this paper offers the Twin-Win Model to guide teams of researchers, academic leaders, business managers, and government funding policymakers. The Twin-Win Model favors a problem-oriented approach to research, which encourages formation of teams to pursue the dual goals of breakthrough theories in published papers and validated solutions that are ready for widespread dissemination. The raised expectations of simultaneously pursuing foundational discoveries and powerful innovations are a step beyond traditional approaches that advocate basic research first. Evidence from citation analysis and researcher interviews suggests that simultaneous pursuit of both goals raises the chance of twin-win success.

research model | basic research | applied research | Twin-Win Model | human-centered research

The usually quiet world of academic research is being awakened by explosive battles over how to do research (1–4). The traditional linear model of research argued for curiosity-driven basic research in laboratories to acquire new knowledge. This may have been productive in the knowledge-poor early days of discovery, but now, in our knowledge-rich, information-overloaded world, new models are needed. Since collecting new knowledge has become so easy, researchers need to consider which forms of new knowledge would be most beneficial. Collecting the length of every rat's tail or the number of characters in every tweet would add to the store of knowledge. However, it seems clear that collecting the location of every rat to understand the spread of disease or the time stamp of every tweet to understand sleep patterns in different cities would be more helpful in raising further questions and useful in recommending constructive actions.

In short, some knowledge is likely to be more useful than others, because the knowledge relates to meaningful problems and may suggest constructive actions. Knowledge is tied to meaningful problems by way of a causal theory that permits intervention so as to contribute to improvements in human life or environmental preservation. Therefore, my claim is that research can become more productive if the pursuit of new knowledge is tied to actionable insights that can lead to societal benefits and sustainable conservation.

Leading organizations have identified key challenges, such as the 17 Sustainable Development Goals of the United Nations or the 14 Grand Challenges of the US National Academy of Engineering. Common challenges include healthcare delivery, clean air and water, smart cities, improved education, and energy availability.

While most academics support the idea of responding to these challenges by collecting new knowledge that is tied to actionable insights, too often researchers fail to structure their research plans in ways that are likely to lead to the dual successes of new knowledge and societal benefits. The Twin-Win Model (Fig. 1) favors a problem-oriented approach to research, which encourages formation of teams between academics and professionals to pursue the dual goals of breakthrough theories in published papers and validated solutions that are ready for widespread dissemination.

Background

The idea of bringing academic researchers in closer contact with professionals who face authentic problems has long been discussed as a way to achieve higher societal benefits. The famed American poet and philosopher Ralph Waldo Emerson spoke in 1837 about academics working more closely with farmers, business people, and government. Emerson called for academics to engage in the real world: "Action ... is essential ... Without it, thought can never ripen into truth." That encouragement remains valid today.

More than a century later, Vannevar Bush's (5) 1945 manifesto *Science: The Endless Frontier, a Report to the President on a Program for Postwar Scientific Research* sought to separate academic work from practical problems. He argued for a linear model, suggesting that basic research came first, which led to applied research and then commercial development. The linear model was vigorously opposed by Tom Allen (6) in the 1970s, Deborah Shapley and Rustum Roy (7) in the 1980s, and many others. An important contribution was Donald Stokes' (8) 1997 book *Pasteur's Quadrant: Basic Science and Technological Innovation*, which proposed a fresh strategy: "use-inspired basic research." His reference to Pasteur reminded readers about Pasteur's work on the problems of vintners and dairy farmers, which produced the twin-win of solutions to their problems and the germ theory of disease. Lewis Branscomb's (9) 2007 essay supported the idea that creativity and utility (basic and applied) research were happy partners. Steven Chu, Nobel Prize winner in physics and US Secretary of Energy, reinforced the need for a shift in research: "We seek solutions. We don't seek—dare I say this—just scientific papers anymore."

In the past few years, *The New ABCs of Research: Achieving Breakthrough Collaborations* (10), which advocated for "applied and basic combined (ABC)," was joined by Narayanamurti and Odumosu's (2) book on *Cycles of Invention and Discovery: Rethinking the Endless Frontier*. Dan Sarewitz (3) wrote a powerful essay on "Saving science," pushing for reform of science to increase its impact, while reducing the prevalence of results that could not be replicated. Sarewitz (3) stressed that "scientists must come out of the lab and into the real world." A similar call for emphasizing applications as the path to discoveries came

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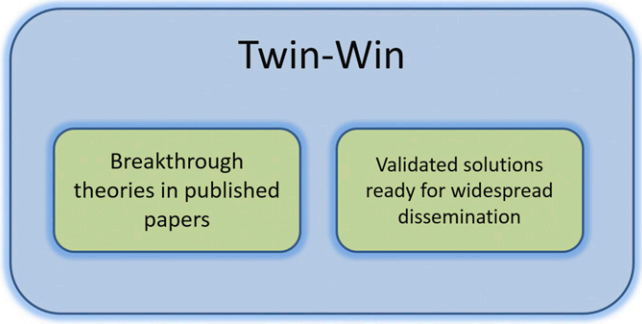

Fig. 1. Twin-Win Model of research goals.

from a group of information visualization researchers who called on their colleagues to "apply or die" (4).

Leading organizations have also called for reforms to academic practice in major reports. They have invoked many terms to describe their variations on the theme of blending applied and basic research through interdisciplinary, cross-disciplinary, multidisciplinary, and transdisciplinary approaches (11). The National Research Council called for convergence (12), and later, the National Academy of Engineering (13) offered a variation on convergence as part of their engineering research centers program to "ensure that the teams work in concert to maximize the value created for society." A word of caution: I do not think that interdisciplinary or convergent ideas are sufficient to achieve the goal of high research impact. Such approaches may be helpful, but a vital component is that researchers need to work with professionals who have authentic problems, which allows for validation of proposed theories and solutions.

The importance of developing the strategies for team formation and management was presented very effectively in a thoughtful, well-documented, and highly readable report on *Enhancing the Effectiveness of Team Science* (14). Another valuable source was Google's report on its hybrid model of research, which described the benefits of working on authentic problems as a path to better theories and deeper understanding (15, 16). Academics working with business have a strong history of successes (17), but there clearly have been problems in working with business, which have led many academics to be cautious about such partnerships or funding sources (18). A study of academic medical centers found that patented inventions by clinical researchers were more likely to be licensed to firms than inventions by laboratory researchers pursuing basic science (19).

Prominent academic leaders, such as Michel M. Crow, President of Arizona State University, have implemented these ideas. He has worked for more than a decade to steer his campus to transform society by conducting "use-inspired research" that is "socially embedded" in local, regional, and national projects (1). Shirley Ann Jackson (20), President of Rensselaer Polytechnic Institute, called for her faculty to "collaborate more effectively with businesses and governments . . . educating our students in multidisciplinary and collaborative thinking . . . guided by social concerns and ethics." Similarly, the Irish Research Council (21), which uses the term "engaged research" to describe collaborations "with community partners, rather than for them," calls for academic research to address societal challenges.

All of these reports are helpful in understanding the broad push to change academic research culture, but there are those who resist and seek to preserve current practices (22). A group of academic leaders have been meeting to develop strategies that can work across many campuses and disciplines. The Highly Integrative Basic and Responsive (HIBAR) Research Alliance is partnering with established organizations, like the National Academies of Science, Engineering, and Medicine and the Association for Public and Land-grant Universities (www.aplu.org/projects-and-initiatives/research-science-and-technology/hibar/index.html).

Modeling the Research Ecosystem

Having a visual model of the research ecosystem could help researchers understand how they can improve their chances of attaining twin-win successes. The simplified model in this paper (Fig. 2) is a refined version of the model in *The New ABCs of Research: Achieving Breakthrough Collaborations* (10). This refined model, which describes university components (yellow boxes in Fig. 2) and relationships (black arrows in Fig. 2), focuses on departments, which hire and reward faculty. In turn, the faculty teach students and form research teams, which produce and promote their papers. The students join the research teams, and eventually, they may become faculty members. Outside the universities (gray boxes in Fig. 2), the papers get submitted to journals and conferences, and they are published by professional societies and commercial publishers. Some papers that are described by journalists can reach wider audiences.

The two large boxes on the bottom show the powerful role of governments (federal, state, and local), businesses, and philanthropies in funding research and the powerful benefits of collaborations between research teams and businesses, government laboratories, and nongovernmental organizations. These latter organizations also hire the students as interns and full-time employees.

This simplified model fails to include many other important actors and actions, such as state legislatures, university boards of directors, and key university officials, such as presidents and provosts. However, it could guide thinking about interventions that improve the efficacy of university research, such as hiring stronger faculty, forming more effective teams, or publishing in journals and conferences that might attract more interest from colleagues and journalists. Richer models of universities as complex enterprises could lead to further insights about how to reform research (23, 24).

Collecting Actionable Evidence

The stream of writers mentioned in *Background* gave numerous examples and arguments in support of the Twin-Win Model that academics who collaborate with professionals to work on meaningful problems produce higher levels of impact. This thesis is controversial, as there is a continuing belief among many

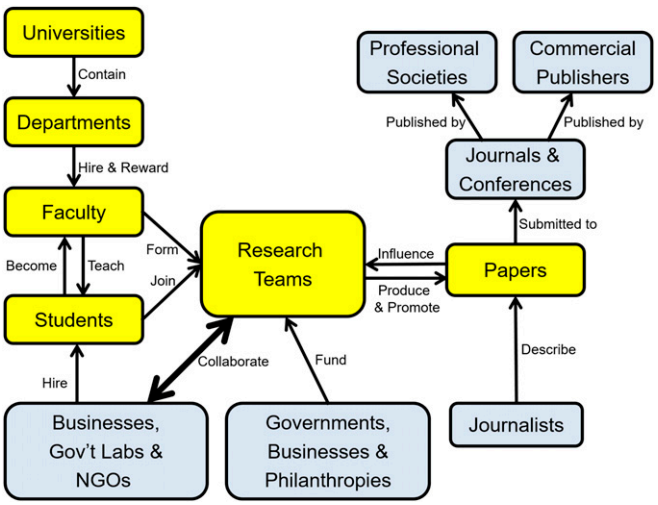

Fig. 2. Simplified model of the research ecosystem emphasizing the role of collaborations with business, government laboratories, and nongovernmental organizations. Yellow indicates campus actors and actions, while gray indicates other actors. Labels on edges are actions. NGO, nongovernmental organization.

researchers that their work should be devoted to laboratory studies and focused on their theories. These researchers do not seek out partners in business, government, or nongovernmental agencies; in fact, they actively reject such collaborations. They fear that working on problems brought by off-campus professionals are not interesting, too applied, or too difficult. They fear, sometimes with good reason, that businesses are not interested in serious research that would lead to respected publications, seek to control the intellectual property, or use academic credibility only to achieve corporate goals. In short, academics do not want to "dirty their hands" by working on real problems, sometimes making explicit statements that applications and policy issues are not appropriate concerns for researchers.

There are certainly dangers, but a growing number of academics have come to understand that there are great opportunities in working with businesses, governments, and nongovernmental organizations to pursue twin-win successes. Many universities have recognized the power of such partnerships and actively seek them out by forming partnerships with individual businesses or creating consortia of businesses to support a laboratory working on a problem or widespread interest. Academic leaders and faculty are discovering that joining in government, industry, and university Centers of Excellence brings together diverse researchers with stable funding to work on substantive problems. Recognizing the efficacy of larger teams, the US National Science Foundation has launched 12 Science and Technology Centers in the past decade to support "integrative partnerships" (https://www.nsf.gov/od/oia/programs/stc/).

While National Science Foundation and American Association for the Advancement of Science (AAAS) reports documented the efficacy of larger centers, I wanted to understand the benefits to individual faculty members of working with professionals. Fresh data up to and including 2016 from the Elsevier SCOPUS database, which holds the metadata on 70 million published papers, provided evidence about the impact of papers written by my University of Maryland colleagues. The results were striking: single authored papers produced, on average, 3.0 citations, while collaborations among University of Maryland faculty averaged 6.1 citations. When my colleagues collaborated with faculty at other US universities, they averaged 9.2 citations, while collaborations with international faculty raised the average to 13.9. However, the remarkable result was that coauthoring with colleagues in businesses or organizations, such as the World Bank, resulted in a dramatically higher citation count of 20.3.

This pattern proved to be common at other universities with strong research programs. Figs. 3 and 4 show the SCOPUS data for the leading private and public universities (as determined by research output). They show similar patterns of substantially higher impact when papers include corporate coauthors.

More extensive analysis is needed to verify this strong benefit of having corporate coauthors. A confounding factor may be that many projects that bring academics in contact with domain experts who have meaningful problems in businesses, government, or nongovernmental organizations do not list the domain experts as a coauthor. These domain experts could be involved in the research, but they may not become coauthors. Another important category of collaborations might be with academics in other disciplines who draw on the skills of their colleagues. This form of interdisciplinary research is driven by the need to solve a clear and meaningful problem.

Whatever the source of the collaboration that applies academic skills to a meaningful problem, a deeper understanding of the processes that enable such collaboration would be helpful. The Elsevier SciVal tool permits drilling down to identify the faculty who have the largest number of papers with corporate coauthors. By limiting the search to the computer science field, I identified which colleagues in my University of Maryland Department of Computer Science had the largest number of papers with corporate coauthors in the past 5 y. The top person, who had 22 such papers during 2012–2016, was a complete surprise, because I knew him to be a strong theory researcher working in algorithmic game theory. In an interview, he confirmed that he liked to work with corporate partners, because "they had better problems." He invited corporate collaborators to visit and speak with his students on campus and sent his students to do internships, which often led to full-time job offers. He described long-term durable relationships, which led to coauthorship of papers. The next most prolific producer of papers with corporate coauthors had 12 such papers in computer vision. He reported similar patterns of eagerly working with businesses, sometimes funded by government agencies, because the problems challenged his

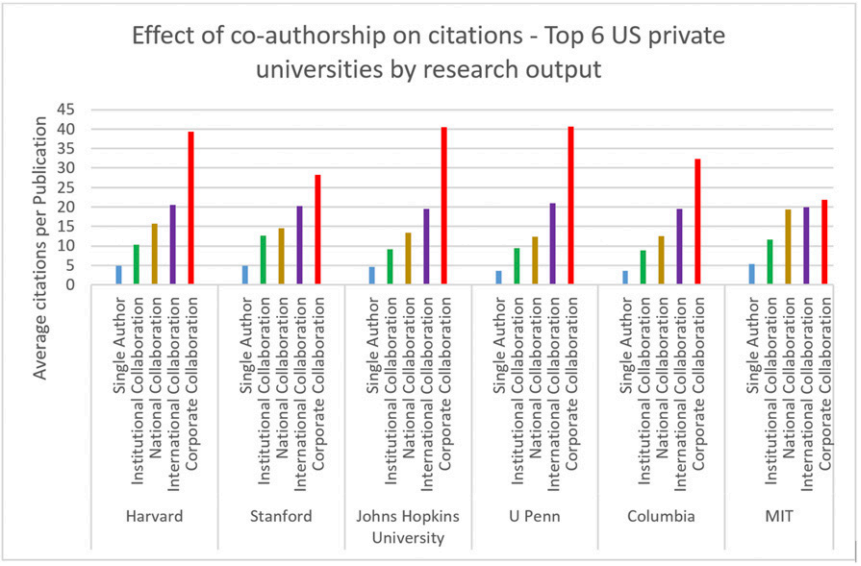

Fig. 3. Top six US private universities show similar patterns of increased citation impact when there are corporate coauthors. Data cover 2012–2016. MIT, Massachusetts Institute of Technology; U Penn, University of Pennsylvania.

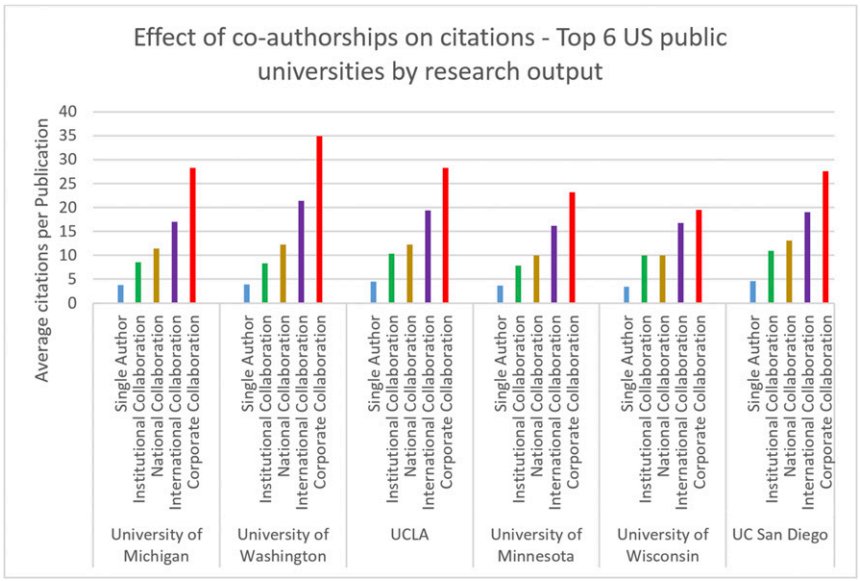

Fig. 4. Top six US public universities show similar patterns of increased citation impact when there are corporate coauthors. Data cover 2012–2016. UCLA, University of California, Los Angeles; UC San Diego, University of California, San Diego.

group and led to strong papers. Four other faculty had fewer collaborations with business partners but spoke of their positive experiences in building and maintaining collaborations with off-campus partners.

The journey of working with businesses takes an open mind and some effort. Sometimes, it begins with a contact (email or phone) from a corporate researcher who is interested in a faculty member's research. This can lead to invitations to speak or consult for the corporation or invitations for the corporate researcher to speak on campus. Other corporate connections come from students who intern or go to work for a corporate research laboratory. These students may still be finishing work that they began on campus, and later, they may build on their campus connections for new lines of work. However, another path to corporate connections is by way of direct corporate funding of academic research through unrestricted gifts or contracts.

Government funding, which requires university–industry collaboration, can also establish collaborations that endure, such as the US National Science Foundation's Industry-University Cooperative Research Centers (https://www.nsf.gov/eng/iip/iucrc/home.jsp) and the US National Network for Manufacturing Innovation (https://www.manufacturing.gov/). Other integrative research centers, such as the Science and Technology Centers (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5502) and Engineering Research Centers (https://www.nsf.gov/od/oia/programs/stc/), provide further opportunities for productive collaborations.

The University-Industry Demonstration Partnerships (https://www.uidp.org) is one of many organizations with the goal to promote collaborations by supporting "mutually beneficial university-industry collaborations by developing and disseminating strategies for addressing common issues between the two sectors." The University-Industry Demonstration Partnerships grew out of an initiative of the National Academies Government-University-Industry Research Roundtable. Another organization is HIBAR Research Alliance (www.aplu.org/projects-and-initiatives/research-science-and-technology/hibar/index.html), which is pursuing strategies for campus culture change to promote closer collaborations with government, business, and nongovernmental organizations. Lorne Whitehead of the University of British Columbia offered this description: "HIBAR specializes in projects that

Seek both deep new knowledge and new practical solutions

Use both academic research methods and practical design thinking

Are led by both respected academics and real-world experts."

Additional evidence of the potency of seeking twin-win successes comes from a recent study of the relationship between research papers and patents (25). This study found that patents often cited academic papers, but more importantly, academic papers that are cited by patents get greater attention in the research community: "papers directly cited by patents were also the highest-impact papers within the scientific domain" (25). The business benefits of close connection with research were also found: "Patented inventions that draw directly on scientific advances were especially impactful compared to other patents" (25).

The focus of this paper has been the benefits to academics of working with business coauthors. Another question is whether there is benefit to business professionals in working with academics. An exploration in the SCOPUS data for the data from 12 large corporations during 2012–2016 found that the average citation count for papers with academic coauthors was 11.7 (SD 4.9), while for papers without academic coauthors, the average citation count was 6.3 (SD 4.0). Of these 12 companies (Agilent Technologies, Bayer, Boeing, Exxon Mobil, General Motors, Google, Huawei, IBM, Medtronic, Oracle, Sony, Waters Corporation), 11 had higher citation counts for the papers with academic coauthors, but 1 company, Google, had higher citation counts in papers without academic coauthors. Their current and previous directors of research conjecture that Google's highly cited system design papers describing implemented systems are largely written by Google employees, while papers coauthored with academics are more theoretical or early research. While this result needs further exploration and confirmation, it adds to the evidence that working on realistic problems and the diversity brought by intersectoral collaborations strengthens researchers who are seeking the twin-win success of published papers and validated solutions (ref. 10, p. 175).

Conclusion

There are many paths to twin-win research success, but working on authentic problems with partners who care about the solutions seems important. This article stresses partnerships between

academics and businesses, but there may be utility for academics with strong research methods, such as software, statistics, or surveys, to work with academic colleagues in other disciplines who have strong research problems. The widely held belief in the benefits of interdisciplinary research may stem from situations where academics with strong research methods work with colleagues with strong research problems.

In summary, there is growing evidence that, when academics work with partners in business, they address authentic problems that challenge the research team to produce more potent solutions. Such partnerships often have access to more resources (money, staff, data, etc.), enabling them to take on more substantive problems, although they may be working with greater time pressures than in academic projects. The authentic setting for these problems means that there is often potent feedback that guides reconsideration of goals and methods. The stakes are higher in authentic settings, since a validated solution can have large payoffs.

While these conclusions need refinement and verification, the takeaway lessons for academic researchers seeking twin-win success include

Build long-term relationships with professionals in business and government research laboratories,

Seek funding to work on problems that businesses and governments find relevant, and

Encourage your students to do internships at business and government research laboratories.

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