Feature Article

Best Practices and Lessons Learned in Grant Writing for Ag/Applied Economists to Engage in Interdisciplinary Studies

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Abstract

Learning to write successful grant applications takes significant time and effort. This paper presents knowledge, expertise, and strategies from experienced grant applicants and grant officers across several disciplines to support early career scholars and first-time grant writers, with particular guidance for interdisciplinary collaboration. Many Agricultural and Applied Economists are invited to participate in interdisciplinary grant applications. It is important to fully understand the types of projects, nature of collaboration, co-investigators' characteristics, expected contributions, anticipated benefits, and valuation of collaborative research by one's peers before initiating new opportunities. Leading and participating in interdisciplinary teams also requires mentorship, patience, professionalism, and excellent communication beyond the scientific merits. This paper shares practical insights to guide scholars through the grant-writing processes beginning with nurturing a mindset, preparing for a consistent work ethic, actively seeking advice, identifying targeted programs, matching a programs' priorities, a step-by-step framework for team creation and management, effectively managing time and pressure, and transforming failure into success.

1 Introduction

Seeking funding is a common expectation for employees in academia, nonprofit, and private enterprises focused on research, teaching, and outreach activities. Successful grant applications often lead to favorable evaluations for productivity, tenure, promotion, and other career advancements. Quantitative evaluation of historical trends and success rates of different individuals from a range of Ag disciplines that apply for various grants is limited. Some scholars have discussed grant-writing mistakes and suggested remedies (e.g., Mikal and Rumore 2018; Sohn 2020), and some institutions offer grant-writing workshops, with particular focus on early-career researchers. In general, scholars working in academia are most likely to participate in grant writing to advance scientific knowledge and application that will continuously stimulate rigorous research, innovative teaching, and dynamic outreach (Keogh 2013; Lovitts 2008). There is emerging interest to build multidisciplinary and interdisciplinary teams that include social science researchers, to solve complex societal challenges (Palmer et al. 2016), based on the guidelines from a range of proposal calls by the National Science Foundation (NSF), U.S. Department of Agriculture (USDA), and other funding sources.[1] Agricultural and Applied Economists are likely to be recruited into these teams to perform economic forecasting, simulations, experiments, benefit-cost analysis, or a combination of social-economic-environmental impact assessments (Mooney et al. 2013;

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[1] The National Socio-Environmental Synthesis Center (SESYNC) has hosted several workshops on this topic and has additional useful information that you may wish to access. For example, the SESYNC Networks of Networks Workshop: https://www.sesync.org/project/propose-a-workshop/sesync-networks-of-networks-workshop.

Hertel 2020), or that may lead these teams. There are many evolving new and exciting opportunities for Agricultural and Applied Economists to contribute to broader scientific discoveries and transform knowledge into practice.

Interestingly, the knowledge and skills to successfully pursue grant funding has not been incorporated into a formal curriculum for post-bachelor's degrees across the social sciences, including Applied and Agricultural Economics. The exposure to training or mentoring in grant writing during early career development may depend on whether your PhD supervisor involved you in grant writing or your institution offers you a grant-writing workshop. The ability to conduct research within the bench sciences and engineering is heavily dependent on access to external funds, and graduate and postdoctoral experiences and training to pursue external funds are much more readily available in these areas, than in many social science programs (Kahn et al. 2016). Such opportunities can increase confidence and familiarity with individual and team-based proposals (Wallen et al. 2019). Early career scholars and assistant professors in agricultural and applied economics often face challenges because of a lack of training and mentoring. They regularly express uncertainty in dealing with confronting elements of writing grant proposals. These may include where to find relevant grant programs, what are elements of a successful grant proposal, how to establish validity for your research capabilities, insights into creating and managing research teams, and effective ways to learn from rejection, being able to transform near-term failure into long-term success. Few new and emerging scholars appreciate key differences between multidisciplinary, interdisciplinary, and transdisciplinary proposals. Many social science scholars are also uncertain how to join a grant-writing team at the ideation/inception stage and/or join teams later that have not involved them in the inception of the research idea and planning process of a proposal.

This article provides user-inspired insights into grant writing, including strategies and step-by-step guidance for early career scholars and grant seekers to prepare, plan, and complete an effective grant proposal. Much of the information is generally applicable to single investigator and small team proposals even though the focus is on proposals created with interdisciplinary teams. This article's authors have broad experiences serving as Principal Investigator (PI), Co-Principal Investigator (co-PI), or Program Officer (P.O.) for several grant funding programs. Whether a grant proposal is successful or not depends on many factors, including the quality of the ideas, responsiveness to the funders' needs, ability to clearly and compellingly articulate complex ideas, the composition of grant review panels and funding agencies' priorities and assessments, among many other factors. Given the strong demand for grant-writing supports, the purposes of this article are (1) to articulate and demystify the process of grant writing and (2) to share a list of practical recommendations based on varied and beneficial experiences and skills of scholars who have broad experience in writing, selecting, and administering grant applications.

2 Preparing for a Grant-Writing Mindset

What, Why, Who, How, and So What? Each scholar seeking grants needs to begin with an in-depth self-assessment to identify career interests, capabilities, and goals. One useful approach is to conduct a SWOT (strength, weakness, opportunity, threat) analysis to establish your overarching grant-seeking strategy, and then to implement your strategy using a SMART (specific, measurable, actionable, realistic, time-based) approach (Liang et al. 2019; Liang 2019; Liang 2020). Applying for grants may occur at any stage of the career for individuals working in academia and private/public organizations. For example, a junior researcher is likely to be more interested initially in establishing recognition and credentials through successful grant applications that result in peer-reviewed articles to achieve tenure and promotion. In contrast, a senior researcher is often more motivated to seek grant support that can generate deep disciplinary advances or broader disciplinary-crossing impacts through innovation and novel ideas by taking higher risks.

To submit a competitive grant proposal within the typically short window between a call for proposals and submission deadline, a scholar must have a mindset of preparedness and readiness. One

good practice is to develop and maintain a list of potential grant ideas, including corresponding references based on personal knowledge, skills, and interests that could be transformed into grant proposals building on historical trends, current affairs, and futuristic predictions. Scholars who plan to write grant proposals need to develop ideas that meet the need and program priorities of grant opportunities. Seasoned grant writers often maintain a broad and comprehensive literature review based on their interests, knowledge, skills, and goals. Frequently updating, accessing, and reading contemporary reports, news releases, and peer-reviewed publications from professional and reliable sources is always a good exercise for us to become familiar with existing knowledge and practices.

Attending conference sessions or accessible conferences beyond a researcher's immediate capabilities and knowledge base can stimulate new perspectives that evolve existing approaches or encourage use of novel tools and approaches to tackle emerging challenges. These exercises encourage a grant writer to become exposed to unconventional and innovative concepts while creating a good list of references ready to use when a suitable grant opportunity becomes available. This practice is also useful for supporting efforts to write and publish journal articles. The synergy between publishing and grant-writing activities is an essential consideration in time management and career development. Participating in professional meetings and workshops is also an effective way to learn from other scholars who have been successful in interdisciplinary grant applications.

Beyond learning from the contexts and contents in professional meetings, it is beneficial to pay attention to presenters who are agricultural and applied economists contributing to interdisciplinary studies. Good questions to consider are (1) what types of interdisciplinary studies are likely to involve agricultural and applied economists; and (2) what objectives and activities agricultural and applied economists contribute to an interdisciplinary project? Many people think that economists must deal with "numbers." Agricultural and applied economists are a very diverse cohort covering many subjects concerning data, experimentation, modeling, analytics, logic, training, demonstration, and evaluation. Common requests made to agricultural and applied economists are to conduct some cost-benefit analysis, survey, financial analysis, or trend analysis. This reflects a small subset of our skill set and a gap in the knowledge available to other disciplines between what we are perceived as doing versus what we can do. A useful strategy to increase engagement and understanding of our skill sets is to do a better job of promoting our talents, knowledge, and skills by widely publishing and presenting in interdisciplinary professional settings. A growing number of professional associations welcome scholars to present interdisciplinary papers or conduct workshops to promote collaborations. The U.S. Association for Small Business and Entrepreneurship (USASBE), National Small Business Institute (SBI), Food Distribution Research Society (FDRS), Institute of Bioengineering (IBE), Soil and Water Conservation Society (SWCS), American Public Health Association (APHA), Community Development Society (CDS), American Geophysical Union (AGU), and American Water Resources Association (AWRA) are a few good examples.

A common complaint about grant writing relates to time management and trade-off associated with writing peer-reviewed articles: "this takes time away from writing papers." While writing papers and writing grants have their differences, there is also a complementarity in these activities. A scholar needs to treat grant writing as a continuum, because successful grant applications lead to peer-reviewed publications. The critical thinking and topical research required to develop a competitive proposal frequently leads to more effective conceptualization and articulation of in-process or recently completed research that can improve preparation of manuscripts for submission. A strong grant portfolio is critical in committee's consideration of a candidate for tenure and promotion. Many external letter writers will comment if there are no attempts to pursue external grant funding and tend to make favorable comments about candidates' efforts to secure funding (even if unsuccessful to date) and the candidate's ability to support their research.

Writing a grant proposal is different from writing a journal article (Porter 2007). Writing a journal article usually demonstrates personal interests in the subject, narrates completed research process and outcomes (e.g., data collection and results of data analysis), and explains research information to an

audience who might share a similar passion in specific topics. However, a grant proposal serves the sponsor's interests and priorities, depicts the research process needed to be done, illustrates necessary data yet to be gathered and analyzed, and markets the idea directly to reviewers and sponsors to fulfill future purposes and missions. In many ways, a grant proposal is like a sales pitch. We all care about our research agenda. To succeed in grant writing, we need to convince the sponsors that we care about their agenda and have the ability and capacity to meet their needs and funding priorities successfully. A bonus point to share—many successful grant writers can convert the critical components in a grant proposal into journal articles to share novel theoretical frameworks, data discovery, integrated analytics, and creative partnerships.

What Is Interdisciplinary? Grant topics could focus on research, teaching, and/or outreach and service. Some grants involve a combination, or an integration, of multiple areas. The number of requests for proposals that involve multidisciplinary, interdisciplinary, transdisciplinary, and convergent approaches has increased recently. These terms are often used interchangeably without a clear differentiation between them. Growing interest in research that crosses disciplinary boundaries has provided clarification about each of these terms (Choi and Pak 2006; Harvard Transdisciplinary Research in Energetics and Cancer Center; Integration and Application Network 2017; Vagios 2017):

- A multidisciplinary grant proposal has the nature of combining or involving several academic disciplines or professional specializations in approaching a topic or problem. Everyone in a team brings in training, experiences, and skills that could add value to a joint effort of problem solving. For example, a team is working with farmers to deal with marketing issues by transitioning from face-to-face sales to eCommerce. This team may consist of scholars specializing in website design, product categorization, visual communication, pricing and cost assessment, payment scheme, and data security.
- Interdisciplinary studies involve combining and integrating two or more academic disciplines into one grant proposal to create a process or strategy across problem-solving boundaries. Individuals contribute specific skills, knowledge, and experiences to integrate with and build on others' abilities and capacity while achieving common goals and objectives. For example, a team is committed to improving food accessibility and affordability for residents of food desert communities. The scholars involved in this project would include economists (for market location assessment), geographers (for transportation assessment), and engineers (for data analytics and alternative food supply chain design).
- Transdisciplinary efforts describe research, teaching, and/or outreach and service initiatives proposed by "investigators from different disciplines working jointly to create new conceptual, theoretical, methodological, and translational innovations that integrate and move beyond discipline-specific approaches" for problem solving (Harvard Transdisciplinary Research in Energetics and Cancer Center; Integration and Application Network 2017). For example, a team is working on designing, developing, and implementing a novel framework to create a Smart Community where residents would enjoy an upgraded infrastructure of data exchange supported by futuristic tools, devices, and applications.
- A convergent research defined by the National Science Foundation (NSF 2021) represents "a means for solving vexing research problems, in particular, complex problems focusing on societal needs. It entails integrating knowledge, methods, and expertise from different disciplines and forming novel frameworks to catalyze scientific discovery and innovation." One of the current NSF Call for Proposals identifies convergence research involving two primary characteristics as described by NSF on the website (NSF, 2021):
  - *Convergence Research is generally inspired by the need to address a specific challenge or opportunity, whether it arises from deep scientific questions or pressing societal needs.*
  - *As experts from different disciplines pursue common research challenges, their knowledge, theories, methods, data, research communities, and languages become increasingly*

> *intermingled or integrated. New frameworks, paradigms, or even disciplines can form sustained interactions across multiple communities.*

The following sections will discuss different strategies to explore and nurture the grant-writing mindset, grant-seeking approaches, and effective team-building dynamics and situate these suggestions within the four phases of Decision Emergence Theory (DET). Each section below includes knowledge, experiences, and recommended perspectives from the authors, with a specific emphasis on team-based grants. The information should not be generalized to provide a "one-size-fits-all" solution to all the grant applications. Rather, we intend to present a broad view and offer insights that will help grant applicants in the agricultural and applied economics fields to overcome some challenges and barriers.

3 Seeking Grant Funding Programs

If you work for a higher education institution, the best place to look for grant opportunities begins with your institutional office of sponsored programs or other university unit in charge of supporting faculty applying for external grants. Most higher education institutions maintain an updated list of grant opportunities, offer grant-writing training and assistance to clarify grant opportunities, identify grant program priorities, and construct grant proposals and related documents such as budget development, mentorship plan, and data management. Grants can take a long time to write, especially if a large team needs to be assembled. As mentioned earlier, due dates for many programs tend to follow similar patterns each year. It can help start tracking due dates each year and maintain a calendar that contains your best estimate of each due date, so you are already thinking of the opportunity and starting to plan time in your day/week/month to create your proposal. Many researchers use an option to sign up for notifications of recently released grants using a database such as COS[2] Pivot, developed by ProQuest. Many university libraries or offices of sponsored research subscribe to this database. It includes federal grants, state grants, and many opportunities from philanthropic organizations, all of which could be opportunities suitable for your work. Individuals can set up keyword searches to seek funding opportunities with characteristics that match or overlap with your research area. Once a profile has been established, weekly (or daily) emails are sent directly to you that contain funding opportunities with your selected keywords. This is an excellent resource to become aware of new Requests for Funding Proposals (RFPs) that you had not previously seen and a reminder about upcoming opportunities you were thinking to target. Another source of information at the early stages of familiarizing yourself with grant opportunities is to talk to colleagues with similar interests about their experience with funding agencies and programs that they might consider suitable for your work.

3.1 Government Agencies

The most popular and comprehensive website about federal grants is www.grants.gov. There is a Grants.Gov mobile app for searching and submitting grants on the go. This website or app contains information to assist applicants searching for grants and tips and suggestions for individuals or teams to write proposals. It incorporates several services to guide applicants through the grant-writing process and get familiar with the grant-making agencies and policies. Clicking on the option "Search Grants," the applicants can choose different options to review relevant grant opportunities offered by different federal agencies based on various eligibilities and categories, and/or closing dates.

For research relevant to agriculture and the environment, state agencies are a fruitful source of potential funding opportunities. Pursuing funding from state agencies is an important avenue to consider as competition increases for a fluctuating (and often decreasing in real dollars) pot of available federal funds. State agencies are tasked to solve emerging and ongoing regional problems using cost-effective approaches to satisfy regional stakeholders that may include the agency, the voting public, and often related state agencies. Agency officials are eager to identify researchers from in-state universities with

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[2] Community of Science.

relevant expertise and a passion for addressing problems that impact their communities and state. Useful solutions are often nuanced by regional differences best understood and accommodated by a researcher from a local institution. Relationships developed with officials at state agencies can develop over the years to become long-lasting mutual benefit sources for the agency and faculty members in collaborative research opportunities. Such interactions may also offer future employment opportunities in the region for participating undergraduate and graduate students. Alumni so placed become vocal advocates for continued interactions with faculty researchers at the home institution.

Besides, many institutions offer (often smaller) internal grant opportunities. These are excellent opportunities to obtain small amounts of funding to develop data sets or ideas that can build toward submitting a more comprehensive, external grant proposal. It is common for there to be opportunities for early-career investigators. The probability of success with these programs is generally higher than with federal funding agencies. Some offer a chance for feedback on your proposal, which can help increase your skills in this area.

3.2 Industry Grants

It is advisable to consider funding opportunities from different sources as government grants are not always available. University research has been increasingly supported by industry as funding has generated technology-based economic activity at the state level (Atkinson 2018). Atkinson's report reveals that the industry funding share varies considerably between states, from a high of 12.1 percent in North Carolina to 1.7 percent in Nevada, with North Carolina, Georgia, Kansas, Ohio, and Missouri as five leading states for industry funding.

Collaboration with industry is a unique opportunity to see that your research has real-world impact and meets your institution and students' demands, with the latter specifically interested in research experience that leads to jobs right after graduation. However, before seeking this funding type, it should be noted that industry-sponsored research is often applied or Research and Development (R&D) and may not be as intellectually stimulating or scholarly as federally supported, long-term fundamental research. Also, industry contracts impose different pressures on timelines and specifications and may have a different set of interests and criteria than federal and state grants. Industry funding should be treated as a business activity vs. a federal grant. One additional caveat associated with industry grants is about potential restrictions for the publication of research in academic journals. Depending on the funder and solicitation specifics, an academic researcher might need to forfeit their "bragging rights" about the results of industry-sponsored research as all or part of the work completed on such a grant becomes the intellectual property of the funder. The inability to publish the results in academic journals could be detrimental to the promotion and tenure processes as many applied and agricultural economics academic departments place a higher value on peer-reviewed publications than on grant-writing success (Todd 2013; Schroeter and Anders 2017).

Thus, it is crucial to consider the university's policies and guidelines to work with industry partners to identify and agree upon proper research agenda and dissemination of research results that might not be allowed to publish in academic journals due to confidentiality rules. For this, one should find companies working in his/her field of interest, asking them what they need and would like to work on to meet their criteria, and consider their interests. Several benefits are possible in working with industry, particularly those local to the university. Some of these benefits may not be readily apparent at first glance but tend to emerge over time as trust develops between industry research champions and the university researcher. For example, an industry may be motivated to attract or retain an exceptional new hire or employee by offering graduate education support. Depending on each institution, it may be possible for graduate tuition and fees to be paid by the industry sponsor and time provided (sometimes during regular work hours) for the employee to complete graduate courses and conduct research. Such a situation can support a productive, motivated graduate researcher without requiring a graduate stipend on a mutual interest project to the company, graduate student, and faculty member.

4 Matching Your Proposal Idea to a Program and Funding Agency

Federal funding agencies differ in their review process, the type of work they are looking for, and their expectations about pitching your ideas. For example, proposals to the NSF compared to those to the USDA differ considerably. As examples, NSF places significant emphasis on the transformative aspects of fundamental or basic research in unsolicited proposals. USDA often prioritizes research funding for proposals that have potential for broad impact in constituent communities, particularly through existing research networks and extension mechanisms.

The requirement to demonstrate broader impacts in each NSF proposal may go beyond expectations for research-based recommendations to other federal agencies in areas of, for example, professional development and dissemination. Similarly, proposals to a philanthropic foundation or industry can also be written in a very different style. When first starting to write grant proposals, we suggest that you focus on one or two outlets and spend time learning about the characteristics of what makes a good proposal for that funder. Good advice for proposal writing to a particular program at any stage of one's career is to contact the program officer, provide a short description of your research capabilities and interests, and participate in a review panel for proposals in that program. A good time to do that is shortly after you see the RFP released. Soon after release, the program officers will be devoting time to securing reviewers and organizing the panel dates. Participation as a panel reviewer will familiarize one with the "norms" for that program. Other panelists are likely to share your interest in the area and may be open to collaborating on a topic of mutual interest in which each brings complementary capabilities. Once you have regular success, it is easier to write for a wider variety of funders. Or, possibly, if you have no success, you might have chosen the wrong funder and should move on.

Funding amounts also differ considerably (see Table 1) as do success rates. It is essential to "right-size" your initial grant submissions. In general, multi-million dollar large and complex team grants (such as Engineering Research Centers or Science and Technology Centers) are not led by junior faculty or investigators with little grant writing and team management experience. However, these efforts might be an excellent way to become part of a larger team or seek smaller awards that do not require a larger team's management. A good strategy is to map out possible programs for your work and think of these as a continuum over time as you build smaller to larger awards. This is not required for all research, though, and you may spend your entire career working in smaller teams that are well funded by smaller awards.

Table 1 illustrates a range of awards in terms of duration (years) and size (typical annual budget) available from different NSF programs. Also noted is the funding cycle or frequency for offering the awards. Additional detailed information can be obtained through the NSF Budget Division web site (https://www.nsf.gov/bfa/bud/) and accessing the Budget Internet Information System (https://dellweb.bfa.nsf.gov/) designed to be an information resource for award summaries and NSF funding history.

Expectations for the content of the proposal vary, depending on the program and size of the award. For example, at the level of a research center, the proposer should be prepared to address questions in the proposal, such as:

- What is the innovative idea, and what important societal need does it address?
- How will the proposed project enhance the foundational sciences across disciplines?
- What is the compelling working hypothesis for the proposed approach that addresses this need?
- What is the value (benefits vs. costs) for society from this approach?
- Why is the new value significantly better than the competition and alternatives?

As you and your team members tackle these questions, be sure to reach out and talk to the Program Leader or P.O. of the program that has issued the RFPs to which you are responding. Prepare a one-page concept note describing the proposed team effort as it responds to the RFP in the context of the

Table 1. Types of National Science Foundation Awards Available Across a Range of Programs in 2020

NSF Program	Award Budget ($)	Duration (Years)	Funding Cycle (Years)
Engineering Research Center	10,000,000	5	2
NSF Research Traineeships	600,000	5	2
Emerging Frontiers in Research and Engineering	500,000	3	1
Industry/University Cooperative Research Center	150,000	5	1
Standard Grant	300,000	3	1

Data Source: NSF publishes and announces funding allocations each year by programs. The information is available on the NSF website for those who are interested in finding funding allocations.

above questions. Ask the P.O. if this proposed concept would be a good fit for the program. The P.O. and their colleagues, with assistance from their program staff, craft the RFPs and assemble panelists for the review panel. In doing so, they may ask people who have applied for grants in the past and consider people who ask to be a reviewer among other sources. Before submitting a proposal to a new program, it may help to participate as a panelist on a panel review for the program to familiarize yourself with program norms—expectations that the P.O. and panel have for proposals seen as responsive to the RFP. It is suggested that you contact the P.O. as early in the proposal development stage as possible, at least 60–70 days before proposals are due, to indicate that you would like to be considered as a reviewer. Include your resume, web site address, and a brief list of your expertise areas to help the P.O. understand if your expertise is a good fit. Do not be discouraged if you are not immediately accepted; keep trying to get this experience both in future submission dates and similar programs.

5 Strategies for Team Creation and Communication

Writing a team-based grant proposal is a complicated communication process (Bordage and Dawson 2003; Dopke and Crawley 2013; Velarde 2018). Developing the proposal may take a few months to a few years, beginning with initiating the ideas, gathering supportive evidence from preliminary studies, designing innovative approaches for problem solving, and convening stakeholders' inputs to strengthen the broader impacts. Some grant writers act as single PIs, while most of the funding agencies request team applications. A single applicant's advantages are: (1) acting as a free entity without negotiation and compromising with other's opinions, and (2) fully controlling the proposal and budget development. The team collaboration, however, provides benefits to (1) stimulate intellectual activities to potentially uncover new knowledge and practices that might impact multiple disciplines, (2) reduce stress and pressure to complete a grant proposal when properly sharing tasks and responsibilities, and (3) elevate the scope of research, teaching, and outreach programs with broader connectivity.

The timeline between the RFP release to submission deadlines is usually between 60 and 90 days. Adequate planning and preparation are essential for grant-writing success, particularly for team collaboration submissions. Many RFPs are released on relatively predictable cycles, allowing an

individual or team to plan and work on drafts of their ideas for more extended periods. It is important to cultivate interdisciplinary collaborations well in advance of the release of an RFP. There are many methods to do this, but in general, it involves making the effort to make a connection, explore if there are shared interests, appropriate time availability, and a fit in styles and personality. Common ways to "get to know each other" are through Zoom or other meetings, as well as an informal meeting such as over coffee or a meal. An invitation to guest lecture to your class and co-advising students are among many other opportunities for connection.

Fisher (1970) introduced a Decision Emergence Theory (DET) that involves four phases of group decision making. The DET could serve as a useful guide for early career scholars as they plan, prepare, and draft a grant proposal effectively with a team (Dopke and Crawley 2013). A summarized interpretation of a team grant-writing approach using the four phases of DET is as follows:

▶ Phase 1—Orientation
This phase represents the initial team organization and connectivity. This phase emphasizes team members' general agreement to a high-level of understanding and agreement to the proposed ideas, research questions, plan of work, collective and individual responsibilities, and timelines and deliverables. Team members will get acquainted with each other and learn from each other about knowledge and skills corresponding to the proposal's needs. Individuals will reveal some personalities and express polite opinions during the team meetings in this phase. Team members must get a sense of potential tension or ego across the individuals while moving forward to write the grant proposals.

This is also an excellent time to engage with your university-sponsored research office and let them know you are beginning to engage in proposal preparation discussions. The research office could assist by identifying prior submissions from colleagues to the program (or similar programs) and securing copies. These can provide useful guidance for how to present content and degree of detail. In some instances (often depending on resource availability at the institution), they may be able to connect you with a staff grant writer, or a list of writers that the university has commonly used that you could contract with if you had professional funds available.

▶ Phase 2—Conflict
This phase represents a dynamic between team members after everyone has a chance to share voices and perspectives. There might be some arguments, disagreements, and persuasions exchanged among individuals. Most of the conflicts arise from struggling to achieve mutual understanding or buying-in about the overall goals, objectives, and specific project-related activities. Some contests would also link to budget distribution and credit allocations among individuals and partnering institutions. The leader(s) of the proposal would surface naturally or by team members' choices in this phase. The leader(s) may or may not serve as the lead PI(s) for the team. The leader(s) often leads in the technical design and development of the proposal or takes charge of the team management by delineating tasks, deadlines, and deliverables diplomatically.

▶ Phase 3—Emergence
Team members should achieve a sense of collegiality and refrain from attacking and rejecting others' ideas without due consideration. Some debate and spirited discussion are expected, and respectful disagreements may occur. It is important to hear out reasoned arguments and work to create a common understanding of the problem, vocabulary, and overarching aims. The leader(s) would facilitate discussion among groups to weigh the pros and cons of various options while negotiating for goals, methods, and budgets. There will be some ambiguity regarding the proposal development in this phase, and team members should feel comfortable seeking alternatives if necessary. Given the proposal submission deadline's pressure, team members will be more likely to

set aside personal issues and abide by a cohesive decision. According to Fisher (1970), teams collaborating on grant writing might spend most of the time in this phase, until issues are resolved, and everyone is willing to move on by reaching consensus or agreement on the choices made that all members respect.

Recently, the National Research Council (2015) identified a useful set of best practices that can guide multi-, inter-, and transdisciplinary research teams. They identify three common areas that benefit from early clarification and help to reduce conflict and support team emergence (DET phases 2 and 3) in addition to suggestions that support team formation and identification.

a) *Standardize vocabulary:* A common vocabulary is necessary to smoothly integrate data, tools, knowledge, and theories across disciplines. This will significantly improve understanding in areas that are not been commonly shared across fields and will help to avoid confusion. A shared vocabulary referred to as a trading or pidgin language facilitates interrelation of subsystems that cross traditional disciplinary boundaries in a broad conceptual diagram of a transdisciplinary system (Alberti et al. 2011).

b) *Attribution of credit:* Clear guidance for how credit will be attributed across team members and how participation will be assessed and recognized. There are many team-based work tools available that can track participation and contributions to meetings, data collection, analysis, and manuscript preparation. For example, Google Docs is a common tool that tracks individual input as is Track Changes mode in Microsoft Word. Some teams may want to create a team log that updates workload and outputs. In addition, Google Docs allows working with other team members concurrently when changes made go live instantly, and there is no more wondering who has the latest version of the proposal.

c) *Training in knowledge development:* Communication effectiveness can be increased by engaging the team in facilitated opportunities for dialogue that aim to increase individual knowledge sharing and improve problem identification and solution generation. Facilitated conversations can significantly alleviate tension and improve collegial efforts.

Further areas that benefit from early clarification are the norms and expectations for using project data and resources in other projects; what manuscripts are planned first and who are the likely team members contributing to these manuscripts.

▶ Phase 4—Reinforcement
This is the last phase in teamwork and occurs close to the proposal submission deadline. A team engaged in effective collaboration should by this point have reached an agreement about all aspects described in the proposal, checked, and validated supplemental documents required by the funding agency, and completed subaward packages as required by the lead institution and the funding agencies. Each institution involved in the proposal usually requests between 7 to 10 days for internal review and to process the subawards. It is critical to keep in touch with the office of sponsored programs at the lead institution and receive detailed instructions about a subaward institution's required paperwork. It is always a good idea to complete the subaward package as soon as possible to avoid delays in submissions. The PI usually shares the confirmation of submitting a grant package with team members and should follow up with future communications with the funding agency program leaders. A post-submission follow-up with proposal team members to reflect on the teamwork, planning, and application process is strongly recommended. This activity presents an opportunity to get ideas for improving the experience of early career investigators and inclusiveness, and to receive other suggestions for future process improvement. As there is a range of power dynamics with teams, the leads may wish to consider setting up a system for deidentifying comments.

DET theory provides one path for collaborative grant writing. It is not necessarily true that every team goes through the same phases each time. Each phase is an interactive process within the team, and each team may go through each phase multiple times throughout the grant-writing process. There is no guarantee that each team member will be completely satisfied with the proposal development just because the team reaches a consensus. Each member often needs to weigh the pros and cons in this process and make educated and informed decisions to stay with the team or depart.

The National Research Council (2015) suggests using research networking systems to facilitate the assembly of partners well-suited to tackle a particular research concept, as well as applying task analytic methods to identify knowledge, skills, and attitudes required for effective team performance.

6 Establishing or Joining an Interdisciplinary Team

The good news (for applied economists) is that many federal granting agencies such as NSF and USDA encourage and sometimes require social scientists' participation and leadership of interdisciplinary projects. Federal agencies are tackling grand challenges and so-called wicked societal problems that can benefit from consideration of bio-physical systems and processes within a larger policy or societal context. Over the last several years, new programs have been developed that broaden the opportunities for economists to lead and participate in teams seeking federal funding. Some recent examples from NSF are: Dynamics of Integrated Socio-Environmental Systems (DISES),[3] Innovations at the Nexus of Food, Energy and Water Systems (INFEWS),[4] Human Networks and Data Science (HNDS),[5] Accelerating Research through International Network-to-Network Collaborations (AccelNet),[6] and several opportunities within the Established Program to Stimulate Competitive Research (EPSCoR),[7] among many others. The USDA also offers many programs, for example under the Agricultural and Food Research Initiative (AFRI).[8] Many other agencies, for example, Department of Energy, NOAA, and NASA also provide opportunities to include social science within some of their proposals. So how do we, applied and agricultural economists, make ourselves known and start joining or establishing potential interdisciplinary teams?

Accessing the institutional database about research interests and funded projects and reaching out to the deans for research and university research office lets one tap into the resources available at your institution. Attending seminars at the home institution in other departments helps identify potential collaborators and learn about contexts and their studies/methods. A route that worked for this paper's authors is to attend and present at multidisciplinary conferences related to the faculty's research interests. For example, applied economists working on environmental problems might present at the meetings focused on water or soil conservation topics such as those organized by SWCS, AWRA, or AGU.

Initial conversations with the scientists from other disciplines (DET phase 1) may require becoming (temporarily) an economics instructor, as more often than not, researchers outside of economics are not thinking about the broad concept of opportunity costs and might have limited understanding of what economic analyses could bring to the table. When approaching potential colleagues from other disciplines, a useful strategy is to set your mind to be ready "to teach" Economics 101 and "be taught" non-Economics disciplines 101. Different sciences speak different languages and have different norms. Phases 2 and 3 of DET focus on strategies for and the importance of creating a shared understanding. For example, disciplines have a differing understanding of what constitutes a good model: an R^2 of 0.7 might be intolerable in some controlled agronomic experiments, but could be considered an excellent statistical fit for an econometric model estimated using cross-sectional data. Such

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[3] https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf20579
[4] https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf18545
[5] https://www.nsf.gov/publications/pub_summ.jsp?WT.z_pims_id=505702&ods_key=nsf21514
[6] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505584
[7] https://www.nsf.gov/od/oia/programs/epscor/
[8] https://nifa.usda.gov/program/agriculture-and-food-research-initiative-afri

disciplinary differences are generally not common knowledge and putting yourself in a learner and educator mode helps start productive communication, which in turn helps establish a grant-writing team. Another potential strategy is to seek co-advising graduate students working on research that is of interest to two or more collaborators from different disciplines. Such advising collaborations provide an additional benefit that is likely to help with future grant applications by developing joint, co-authored publications and what could be considered as preliminary data for the research to be proposed.

An important consideration for early-career academic researchers is to weigh perspectives from mentors, colleagues, and leaders in their academic unit (department, college) and institution about valuation of multi-, inter-, or transdisciplinary collaboration in the advancement and tenure process. Valuation of an early-career investigator's contribution to discipline-crossing collaborations relative to primary-authored proposals and publications can vary substantially between institutions and among peers within an institution (Alberti et al. 2011). Whether potential interdisciplinary benefits of building a broad collaborative network that generates synergistic advances and contributes to outcomes whose impact is recognized across several fields are justifiable from a career advancement perspective depends on the academic institution. Given the typically lengthened development phases and lessened individual credit in multidisciplinary projects, the finite timeline for early-career advancement should be discussed with an early investigator's supervisor(s) and advancement committee before initiating such collaboration. The grant-related choices such as determination of authorship credit, proposing to write a sole or first-authored article that leverage group efforts, or sharing of proposed or received budgets, influence the time to the outcomes that are evaluated for promotion and tenure. The proverb, "If you want to go fast, go alone. If you want to go far, go together" has relevance here.

Once the team starts forming around a research theme or topic, continuing identification of mutual interests and open and honest communication cannot be overstated. As mentioned earlier, not all applied economics departments value grant writing as much as peer-reviewed publications. The opposite might be right for many science and technology departments. Clarifying early on which grants (amounts, funders) are valued most and which ones are sufficient for a start will help understand the motivation of individual interdisciplinary team members. Not every proposal needs a big team. The members' career advancement considerations could influence the grant for which the team decides to apply, the number of collaborators, and budget size.

In addition to the open discussion about the importance of specific grants, publishing priorities are not always self-evident in teams. Two aspects of team publishing worth noting: one concerning any team publishing, and the other—specific to interdisciplinary teams. For any team, misunderstandings about roles, responsibilities, and credit attributions are common contributors to the dissolution of promising research collaborations. Early on in your collaboration and partnership, initiate a discussion about these aspects of proposal and publication development. Several valuable resources are available from, for example, writers (Albert and Wager 2003; Herz et al. 2020; Oliver et al. 2018) and publishers (Elsevier 2019), highlighting essential considerations in collaborative publication and providing a framework for discussion and rubric for establishing expectations about attribution and other aspects of copublication.

Publishing by interdisciplinary teams endures additional challenges. Publishing in economics journals could be taxing, especially when the economists have the ownership of data and research process because economics journal impact factors are generally lower than those in other disciplines. Open communication about how the paper authorship is related to grant and identifying target journals early on help avoid conflicts and disappointments when researching for publication opportunities. Again, different disciplines have different conventions and values assigned to single- versus multiple-authored publications, the authors' order on a paper, peer- reviewed conference proceedings, papers published in interdisciplinary outlets, tand other publication issues. An open discussion and clarification of these differences are needed.

A second factor to consider are the incentive and reward structure in your own department. It is

important to understand if work published in interdisciplinary journals or journals outside of your discipline is valued and rewarded by your unit (Haider et al. 2018; Mooney et al. 2013). If it is not, we encourage you to be clear about the elements of the project that will enable you to create the types of scholarship that is rewarded by your unit, or consider transferring to a school that is open to you pursuing the scholarship that interests you.

Finally, when it comes to writing the proposal, project leaders must be effective managers and establish and maintain personal contacts and continue to reinforce excellent communication and management practices (DET phase 4). Strong leaders bring people together for planning meetings, make sure people understand what is happening, keep up with the deadlines, encourage interactions and venues to exchange information and share progress, and give intellectual buy-in early on to motivate collaboration and productive relationships. At the stage of proposal development, starting with broad concepts, leaders must identify potential individuals to complete specific tasks and activities, and to acquire a consensus with colleagues before confirming assignments. As with research itself, we all have our up and down times. In terms of effort, consistently maintaining progress with the proposal is no different from consistently maintaining a research project.

7 Understanding Proposal Development and Review Process

Most federal grants are solicited through an RFP.[9] The RFP outlines what the program is looking for (types of science, topic areas, etc.), the amount of funding available, any limitations about individuals or institutions that can apply, and the review criteria. If you are not sure that your idea fits with the program, look for opportunities to attend webinars or other information events, where program officers talk about the needs of the programs and may answer general questions about the intent and what they are expecting as well as any significant considerations that would make your proposal more responsive to the RFP. Program officers at some programs are willing to talk with you about your ideas and suggest appropriate programs that might be a good fit. This is particularly the case for early-career faculty. The RFP may also contain specific information to be included in the proposal as well as font size, requirements for a bio, conflict of interest, current/pending funding and commitments, headings of each section, page limit, attachments, and so on. Proposals can be (and are) rejected by the funding agency, without review, if they are not compliant with formatting and page limits. Many early investigators might underestimate the strict adherence to the formatting guidelines, particularly by federal funding agencies. We encourage you to take this very seriously. We can assure you they do! It is disappointing to spend several months on a grant proposal to have it rejected without review because it is too long, the font size is off, a required section is missing, or some other formatting reason.

Some institutions have resources available to help investigators collate, format, and check compliance of their grants. If these services are not available, we suggest that you carefully read the formatting and other requirements and then check your own work or enlist the help of colleagues and collaborators. This activity takes time, is not that complicated, and can be successfully accomplished without professional help if the grant does not involve many institutions and lots of personnel.

As the requested amount increases so does the complexity of the proposal (in general), as larger grants might require services of a professional manager or sharing other support personnel (e.g., communication professionals) with other externally funded projects. If the grant size is significantly large (e.g., over $1 million), consider working with a professional proposal development consulting team or hiring a proposal manager through the institutional Division of Research's assistance if these services are available to you. These services increase the ease of creating the proposal, but many investigators complete their submissions without such support.

Writing a strong and well-crafted proposal will take significant attention, thought, and time. Like

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[9] Sometimes referred to as a "solicitation" or request for applications (RFA).

writing successful journal articles, proposal writing is a learned skill that improves with practice. We encourage early career investigators to focus on one project and create a highly competitive proposal rather than spend time superficially working on several proposals that may lack focus or polish. It is also important to assess the skills of the team you are joining in this regard. If joining a large team, look for one where the PI has strong organizational skills and a good track record of prior funding. Contributing a smaller part to a large and well-run proposal is a great way to learn more about the process and good practices for organization, timing, team management, and writing. Earlier we noted that there are many agencies that offer opportunities for social scientists to propose and receive funding for their work. One important consideration is that each agency has slightly different expectations regarding presentation of material and the focus of the work that they fund. These differences are significant enough that early career investigators will benefit from pursuing funding from a single or possibly two agencies initially until they are familiar with their expectations before seeking broader funding support.

Most grants are reviewed by groups of people either in a panel or several *ad hoc* reviews (or a combination). Reviewers often read several proposals for the same program (sometimes as many as 20), which can be very time-consuming. The reviewer is unlikely to read your proposal several times, and as such, it is important to be clear and concise in your writing and presentation of ideas. Inexperienced grant writers tend to provide too much information in background and rationale and fail to describe detailed scientific merit in limited space. Creating explanatory graphics, color coding elements, and highlighting key proposed activities and impacts are some examples to help guide the reviewers through your ideas. Explanatory graphics that lead the reviewer through the main ideas of the proposal (particularly the complexities of a multidisciplinary proposal) are very helpful to convey complex ideas to a broad array of reviewers who may have expertise in one element of the proposed work but need to understand how those elements tie in with the larger project. Some institutions provide help with graphics to improve the look and readability of proposals. Several freelance graphic creators specialize in research graphics. Each institutional sponsored program likely can help you find a graphics professional; another option if to reach out to colleagues and ask them for suggestions and names. Possibly the best way to learn how to write a compelling proposal is to work with other researchers that are experienced grant writers and/or read other successful and unsuccessful grant proposals. As mentioned earlier, an excellent way to see many proposals at one time is to volunteer to serve on a grant review panel. This experience will quickly provide you with a lot of information about common criticisms and innovative means to propose and explain research ideas. The most benefit can be gained by volunteering to review at agencies and for programs that you intend to submit to in a later year.

8 Turning Failure into Success
What contributes to rejection of a proposal for research funding? Multiple factors can contribute, some of which are similar to the reasons behind papers' rejections in peer-reviewed journals. However, with grants, there are additional, important possibilities:
- The proposed topic and orientations do not match with the program's priorities.
- Not all the specific review criteria identified in the request for proposal were addressed.
- The proposed research lacked one or more factors deemed necessary to achieve the targeted outcomes, e.g., resources, methods, expertise, or contingency plans.
- The overall presentation of the proposal lacks clarity, consistency, and purpose.
- The reviewers had questions about purposes, collaborations, and the novelty of the concepts from both scientific merits and broader impacts.
- The proposal was well written and meritorious but funding available was not sufficient to support many proposals.
- The reviewers have reservations about the risks and proposed activities, and other reasons.
  Reviewers' comments are usually very informative. Communicating with the program officer to

solicit additional feedback when possible can provide useful guidance. Discussing the lessons learned with the proposal team is also important, especially if revising and further developing the rejected proposal resulted in establishing good rapport and understanding.

Multiple strategies are possible to turn the rejection into future success. Using reviewers' comments to improve the proposal's quality for the same or similar solicitations can improve chances for funding, especially if a standing panel evaluates the revised proposal. Like the case for a journal article rejection, another strategy is to rewrite parts of the proposal and target another solicitation or program. Resubmitting the identical proposal is generally not recommended because it is unlikely to be responsive to another program. However, consider opportunities to "repackage" some of the ideas, take a subset of ideas, or possibly redevelop and expand some of the ideas. In some cases, you might consider inviting additional expertise to your team to strengthen expertise in some vital areas.

9 Final Thoughts and Recommendations

Each scholar who designed and developed grant ideas has a unique experience with the process. Some enjoy the ride, while many struggle through the process. This article intends to shed light on grant writing myths using experiences and advice from senior scholars who have worked with interdisciplinary teams. To summarize take-away key messages:

- Set aside the necessary amount of time to contribute to the project. Some helpful strategies for doing this could include scheduling an appointment on your digital calendar to avoid interferences. Schedule advising sessions with individual students on one day. Schedule large meetings during lunch.
- Prioritize your work effort consistent with your personal goals. This could include ranking and ordering what it is you need to do.
- Take into consideration your well-being. Align your work activities according to what is expected to result in the largest return on your investment of time.
- Avoid recurrent email and phone checks, setting aside regular times during less productive times of the day to do this. Some researchers report that it is helpful to set aside time to do research two days each week.
- Consistency pays off—keep working on your ideas each week. Minimize the amount of decision making needed for projects. Follow schedules to meet deadlines, and plan for each day's activities.
- Document your progress or work to keep up with tasks. Ask yourself what you need to do when you are not interrupted. Keep a record of thinking and working progress and organize your work materials into folders.
- Do your work and be efficient to elevate skill levels. Remember, it is ok to say no to requests that do not align with your personal/career priorities. Identify if there is sufficient time in your current workload to contribute in a way that would be satisfactory to you and others involved in the collaboration.
- Be patient while building collaboration. It is rewarding and fun to learn about other disciplines.
- Describe your data to the team—what it is, how it works, what you need, and how the data helps with research questions and hypotheses.
- Create productive relationships.
- Use economics to explain how the theories and application would enhance the foundational sciences in other fields (e.g., how the technology works and the expected benefits). While solving societal challenges are our goals, we need to keep it simple to explain economics concepts, models, frameworks, and applications to the interdisciplinary team and focus on the team's overall success.

Finally, what not to do in grant writing? On the team-building side, lacking communication across co-PIs and collaborators, and making assumptions that each team member will complete tasks on time without following through usually leads to visibly patchy proposals that do not suggest a collaborative project. Some step-by-step guidance for team management and creation was discussed earlier with DET and the following sections. On the process management side, not budgeting sufficient time to review and revise the submission gives the reviewers an impression of an unfinished product. Grant reviewers are quick to notice when proposals do not read well or when changes in tenses, nomenclature, and acronyms are present. On the presentation side, not following required proposal development guidelines presented by the funding agency, by, for example, missing the required documents, page limit, and other specific guidelines could result in disappointing rejections without review. Unclear writing and spelling and grammar errors would not lead to the same outcome. Still, they would project an image of the lack of professionalism, which brings into question the ability of a group to do an excellent job with high-quality research and execution to accomplish the science.

This article aims to provide some assistance for agricultural and applied economists to pursue a positive trajectory in the journey of grant writing. The solutions are not one-size-fits-all. Each scholar has unique sets of skills and reasons to apply for grants. Many of us serve multiple roles in our positions as researchers, educators, and service providers. It is a challenging yet exciting to participate or lead interdisciplinary teams. It is an honor and pleasure to introduce and incorporate novel economic theories, concepts, tools, and applications to support problem-solving in a complex systematic environment while pursuing new knowledge and expanding scientific boundaries. All it takes is determination, discipline, and desire to succeed!

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