MAXIMIZING INNOVATION AND TECHNOLOGY COMMERCIALIZATION OF FEDERAL RESEARCH INVESTMENTS

BEST PRACTICES AT INNOVATION AND ECONOMIC PROSPERITY UNIVERSITIES

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ABOUT ECONOMIC GROWTH INSTITUTE:
The Economic Growth Institute has provided innovative economic development programming and applied research for more than 35 years. Through our work, we build more resilient businesses and communities, connect university innovations with small and medium-sized enterprises, and provide student learning experiences for the next generation of community and business leaders.

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INTRODUCTION

OVERVIEW

Research universities and Federal Research Labs (FRL) are the cornerstone of American innovation. The country's national competitiveness depends on these institutions to increasingly perform, translating research into the innovative products the country needs.

Understanding how to best facilitate translating research into the market is complex. Practitioners understand that research translation is both an art and a science, requiring a careful balancing act among research, its funding mechanisms, government, and industry. Critical to building on the successes of research translation is understanding gaps in the processes, incentives, and support systems, as well as opportunities for growth.

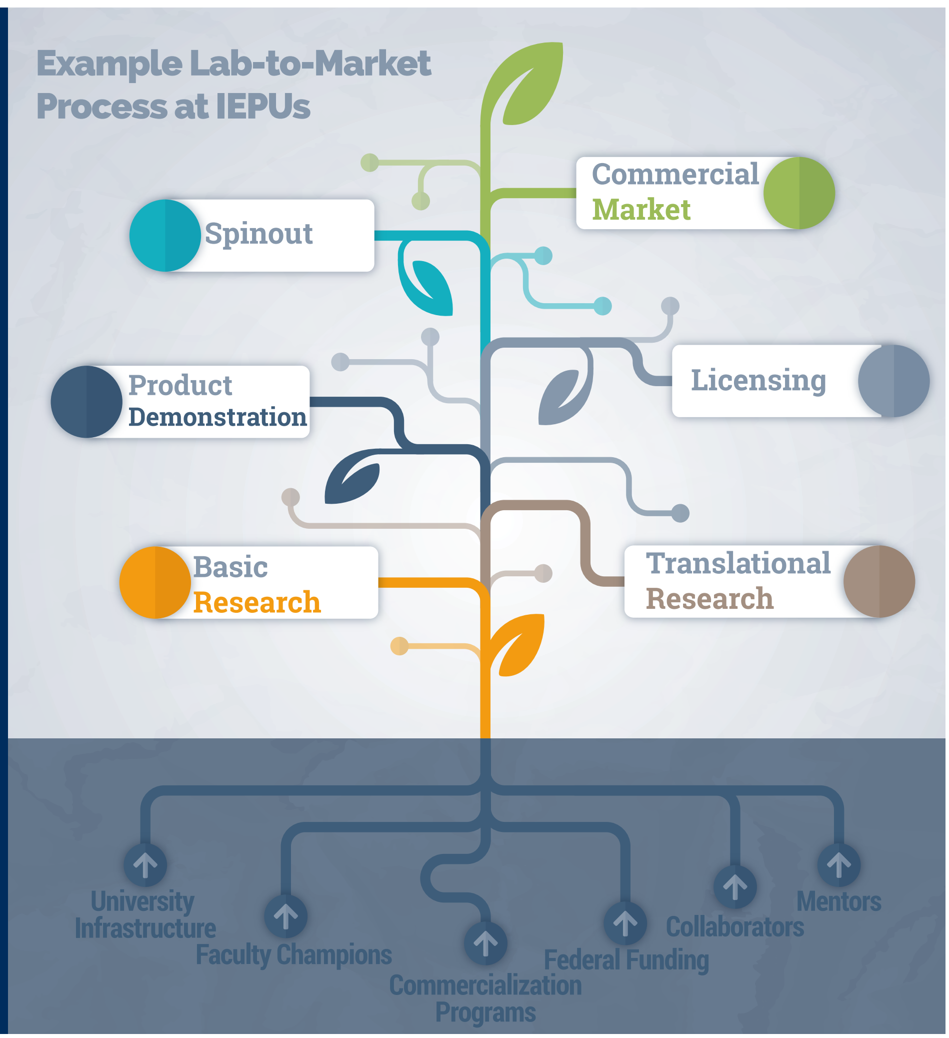
This study explored best practices in technology commercialization across public research universities designated by the Association of Public & Land Grant Universities as "Innovation & Economic Prosperity" universities, or "IEP universities." When best practices are documented and understood, it results in more information shared, gaps filled, commercialization sped up, more companies formed, and research more rapidly benefiting society. In addition to helping solve the nation's technical challenges, universities are relied upon by their regions for economic health and market diversification.

The intent for this study is to improve national competitiveness by providing a practical roadmap

THE PROCESS

IEP Universities encompass diverse approaches to innovation and technology commercialization. The 'typical' process of moving an idea from the lab into the marketplace is as varied as the innovations. However, there are phases that are common.

- Basic research is necessary and foundational.
- Translational research, or applied research, translates these innovations into products compatible with the marketplace. Industry participation often begins during or shortly after this stage.
- The product demonstration stage consists of maturing the technology and understanding the market.
- Licensing includes moving the intellectual property (IP) from the university to a business.
- Spinouts are newly formed companies that are often utilized to launch the product into the commercial market. However, existing businesses are also common mechanisms for technology adoption as well.



for universities based on learnings from past successes around the country. This, in turn, should create the following impact:

- Increased speed to market
- Increased ROI for research funding
- Increased national competitiveness
- Support for a diversified and forward-looking economy

Broader implications demonstrate that there are success "recipes," as is shown in more detail through this study. Many IEP universities are extremely adept at moving research into the market, but one size may not fit all. Best practices at IEP universities included:

- Promoting internal cultures that recognized, rewarded and supported lab-to-market activities as valued academic endeavors
- Hiring experienced staff to champion new innovations and guide faculty researchers through the lab-to-market process
- Utilizing incentives and resources to facilitate sustainable technology commercialization
- Collaborating internally and externally with industry, federal labs and other universities.

There are gaps in the commercialization process, mentorship, and culture – but the solution does not lie with universities alone; there are both government and industry roles to play. Overall, whether they are located in a federal lab or a research university, researchers are driven by solving the country's and world's problems. IEP university successes in translating research can be built upon, expanded, and utilized by federal research laboratories and other universities interested in expanding their lab to market activities.

PUBLIC SUPPORT

While there is general public support for university research, and an understanding that it benefits society, funding streams from many sources are inconsistent at best and trending downward at worst. Note the contrast:

- 83 percent of Americans understand the importance of universities in bringing scientific advancement that benefits society.[1]
- 71 percent of Americans believe research universities are a "major force" in driving U.S. innovation, considerably more than those who said that of large corporations, startup businesses or government.[2]
- Most Americans say that government investments in medical and science research generally pay off.[3]
- Most state efforts to fund university-industry cooperative research have gone by the wayside. Business support for research has declined, and federal research is roughly the same amount of GDP as it was 30 years ago.[4]

This study contributes new insights into how universities can better move innovations from the lab to the market and benefit society as a whole.

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2 University of Chicago. "Most Americans look to research universities for innovation leadership, finds Polsky Center" (2018) https://news.uchicago.edu/story/most-americans-look-research-universities-innovation-leadership-finds-polsky-center
3 Kennedy, Brian " Americans broadly favor government funding for medical and science research" Pew Research Center. (2018) http://www.pewresearch.org/fact-tank/2018/07/03/americans-broadly-favor-government-funding-for-medical-and-science-research/
4 Berglund, Dan (2018) "Trends & Developments, December 2018" presentation, State Science & Technology Institute, annual meeting.

STUDY GROUP AND METHODS

IEP universities are uniquely positioned to excel in technology commercialization with their institutional emphasis on innovation and economic development activities. The IEP university designation was created in 2013 by the Commission on Innovation, Competitiveness & Economic Prosperity (CICEP) at the Association of Public and Land Grant Universities (APLU) . APLU represents a membership network of 241 institutions and affiliated organizations in North America, established in 1887 to focus on strengthening and advancing the work of public institutions through research, policy, and advocacy.

The IEP designation recognizes universities for their activities related to innovation and promoting regional economic development. This diverse group represents both universities that were pioneers in technology commercialization as well as those who are just starting to implement programs and policies to support lab-to-market activities.

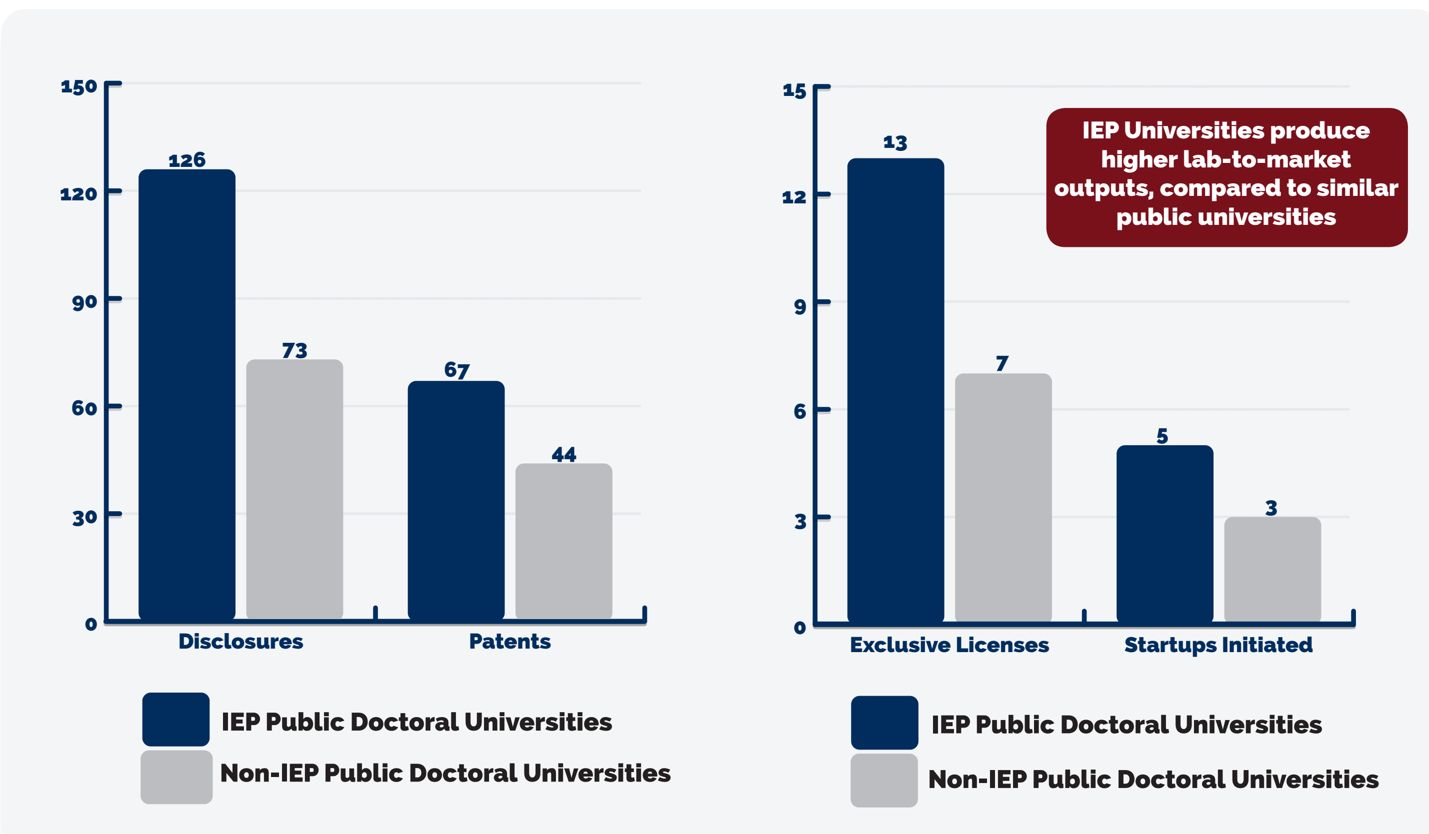
IEP UNIVERSITIES COMPARED TO OTHERS

To better understand how IEP Universities compared with other public institutions, the study incorporated secondary data analysis. **Among a sample of 110 public doctoral universities in the U.S. with detailed technology commercialization output data available between 2012 and 2016, those with the IEP designation produced a significantly higher mean volume of new disclosures, new patents, startups initiated, and exclusive licenses and options.** This demonstrates the unique qualities of this study group with its intentional focus on economic development and innovation.

Measures of technology commercialization volume were determined based on data from the Association of University Technology Managers (AUTM) Statistics Access for Technology Transfer (STATT) Database, which compiles the results from a survey of university technology transfer offices.

UNIVERSITY LAB TO MARKET ACTIVITY

Mean Annual Count from 2012 - 2016 for 110 Public Universities



Source: AUTM STATT (2012–2016)

Sample included 110 public doctoral universities with AUTM data available.

IEP UNIVERSITIES COMPARED TO EACH OTHER

In addition to the overall strong performance by IEP universities, the study team also investigated which IEP universities were producing the highest levels of lab-to-market output among this group (options and licenses issued, licensing revenue, disclosures filed, patent applications, startups initiated). The study observed a notable concentration of technology commercialization output volume in the top 35 percent of the 48 IEP universities with detailed technology commercialization data available between 2012 and 2016. This "High Producers Group" will be referred to throughout this report. The High Producers Group exhibited some distinct best practices that can inform both other universities as well as federal labs in commercialization efforts. It is important to keep in mind that in the U.S. there are vast differences between U.S. universities in terms of external funding, tuition revenue, internal research funding allocated, endowment sizes, infrastructure, and - related to this - relative technology commercialization output volume.

STUDY PARTICIPANTS

A primary aim of the study was to identify best practices among 59 of the IEP universities that could be shared and adopted by other research universities and federal research labs. This study's participants were chosen based on their ability to speak to the most effective and cutting-edge practices in the U.S. for bringing new technologies to market. The study collected and analyzed primary, original data from 261 participants involved in a variety of cross-sector clusters and collaborations:

- 51 interviews with IEP university faculty researchers,
- Ten interviews with affiliates of the federal research laboratories, and
- 200 surveys with IEP survey panel members, with an average of three respondents per IEP university.

The IEP survey panel, as a group, was intended to represent the full breadth of well-informed perspectives on technology development and technology transfer at each the 59 IEP universities. Many of the survey panel members were in leadership roles at their university, and had notable accomplishments in technology commercialization. Each university panel included seven different members to represent university leadership, technology transfer offices, faculty, students and investors.

BEST PRACTICES

The best practices emerging from this study are based on the interviews and surveys from IEP universities. The study groups these into four areas: **culture, champions, incentives, and collaboration**. Many universities were strong in at least one of these areas, with the most productive cohesively harnessing three or four best practices to promote lab-to-market activities. While these four themes clearly emerged throughout analysis, it should be noted that best practice areas are not discreet from one another. Many best practices in "collaboration" are supported by best practices in "champions," such as staff with industry experience, and "incentives," such as clear IP policies that enable collaboration. Best practices in "culture" often align closely with those in "incentives," such as addressing academic and industry needs in commercialization. Because of this, we expect that successful implementation of these best practices will come with broad efforts that address most or all key areas. These four best practice areas help clarify the workings of complex organizations and frame actionable recommendations. They are informed by our findings, and common principles work together to drive successful lab-to-market activities. Applying the identified best practices to specific universities will need to take into account the local technology ecosystems and unique advantages of each university and its collaborators.

LAB-TO-MARKET BEST PRACTICES AT
INNOVATION AND ECONOMIC PROSPERITY UNIVERSITIES

CULTURE 1
Value technology innovation and lab-to-market activities at all levels through cultural norms.

CHAMPIONS 2
Supporting lab-to-market innovation at all levels through champions and organizational programming

INCENTIVES 3
Incentives and resources are vital to support technology commercialization

COLLABORATION 4
Focusing on partnerships to foster, speed and enhance lab-to-market activities

WHAT IS LAB-TO-MARKET?

A vignette of the process

A new discovery showed potential to accelerate the speed of additive manufacturing, a major area of development in industry. As basic science, the method intrigued researchers. But this was also the seed of a technology that could grow into an application with commercial impact.

The researcher sought input from a colleague who had worked extensively with industry. She saw the value in the idea and introduced him to their university's office of technology transfer. Never having his work applied commercially, he had no reference point to anticipate next steps. He felt some relief as the tech transfer office staff member explained how they could assist. There would be evaluation steps first, and if things looked promising, they could work with him to craft the technology into a product. They were well versed in both research and business, and they soon translated the invention into a meaningful proposition for industry.

After spending his young career publishing and teaching, the idea of licensing, seeking funding, and working with entrepreneurs felt uncomfortable to the researcher. Conversations with an academic colleague and the well-structured guidance from the tech transfer office helped ease many of these concerns. They clarified what he could expect with licensing, and helped him assess how he might participate to ensure the technology moved forward.

Additional funding was made available by a program at the university to help test the technology in small production environments. A former entrepreneur on staff examined the market and pinpointed areas for application. The tech transfer office assisted with a patent search to help the researcher understand where protections could be filed and establish freedom to operate. The initial steps validated the technology had potential, albeit with a little more development work. With growing confidence in the technology, the researcher was given a reduction in responsibilities for six months while he collaborated with industry and a small business development team.

While the new team was making progress, initial development funds were eventually exhausted. The team secured additional funding, though it took considerable time, demanding constant attention and slowing progress. They also worked to recruit, and retain, additional talent in engineering and business development. The network of the university staff, mentors and successful colleagues helped significantly, but this also added time.

The team managed the early growth challenges. With an established path, guidance, and flexibility, the technology grew into a product. The team associated with the effort found early customers in industry to start application with the help of the business engagement center. The tested technology, market focus, and positive early outcomes were enough to attract private sector investors. The researcher continued to assist development, but was able to return to his academic career. What began as a novel innovation grew into a product that aided industry and provided economic benefit. The path from lab to market was successful.

This brief illustration is meant to aid the reader in understanding the complex issues researchers and IEP universities face in lab-to market-activities. Faculty, business engagement staff, Vice Presidents for Research and other key individuals shared versions of this story, albeit with many twists and turns. This story is simplified but it serves as a frame of reference for understanding best practices.

CULTURE

BEST PRACTICE 1

VALUE TECHNOLOGY INNOVATION AND LAB-TO-MARKET ACTIVITIES AT ALL LEVELS THROUGH CULTURAL NORMS

While universities have always been powerhouses of knowledge and invention, the translation of research into the marketplace is still a relatively new venture[1]. Often universities struggle to balance all the priorities of education, job preparation, research and more. However, many of the IEP universities have balanced these as well as proven their ability to promote innovation and technology commercialization[2] as a priority. This in turn has created an environment for lab-to-market activities to thrive through strong cultural support.

INNOVATION AND TECHNOLOGY COMMERCIALIZATION: A CROSS-CUTTING PRIORITY

To value lab-to-market activities within the university culture, IEP universities recognize these activities as part of the university's overall mission since it helps to drive economic development. As members of IEP universities, study participants naturally had a strong emphasis on economic engagement – half of the faculty discussed the important role their university played in local economic development.

Additionally, support from university leadership was demonstrated through:

- Recognition and rewards (such as "Faculty Innovator of the Year")
- Internal funding of lab-to-market programs and support infrastructure
- Creating policies to reduce the development of silos and duplication of efforts

As one faculty member pointed out,

> "Innovation isn't owned by one area. If there isn't someone at the top that understands that and understands that innovation these days is a collaborative game, then it is going to be difficult because those policies won't be put into place."

EFFECTIVE LAB-TO-MARKET UNIVERSITY CULTURES:

- Value translational research and commercialization activities as academic activities
- Reward commercialization activities through career advancement and public recognition
- Support people, programs and innovations through funding

Building in support from all levels of the university is a key requirement with shared governance. This includes valuing lab-to-market activities alongside traditional academic work. One technology transfer employee echoed the sentiment of faculty, other staff, and administrators within the technology commercialization realm stating:

> "An absolute must is a culture change within faculty members. Many faculty view commercialization as something evil and opposite to knowledge dissemination, not realizing that turning their basic research results into products or services will make their invention a lot more useful, accessible, and available for intended customers/user."

While all IEP universities promoted the value of lab-to-market activities, cultural support and acceptance were the areas most cited as needing to change across all universities. For faculty interviewees, cultural change is reflected by growing recognition and value of lab-to-market activities. Technology commercialization is still often viewed as a step outside of the mission of traditional academia, especially in the social science disciplines.

More than half of the faculty interviewed described how they overcame cultural barriers in academia and with university leadership. The acceptance of lab-to-market activities

1 Technology commercialization has been present at some IEPs for decades, while others have only begun to support offices for these activities, such as a technology transfer office, incubator, etc.

2 Throughout the study, technology commercialization and lab-to-market will be used interchangeably. These terms refer to the process of taking an initial innovation from a "lab" into the marketplace for an end consumer. Translational research refers to the initial process of shifting from basic research into applied research.

is still only slowly being adopted throughout university settings. In the surveys, one in three respondents mentioned "culture" as the most significant barrier to supporting dynamic and creative technology innovation activities. For example, faculty and staff explained this cultural resistance could be within the university at large, while other times it was described as being specific to a researcher's department or to a university president. Researchers at FRLs also face similar challenges, and could benefit from similar cultural support.

Supporting an innovation culture in the university will ultimately help attract more industry support as well. Collaboration is discussed in the fourth Best Practice, but it should be noted here that addressing cultural limitations in the university sets the stage for productive industry relationships.

PROCESS STEPS FROM LAB TO THE MARKET:

- Disclosure or provisional patent
- Evaluate the innovation
- Market discovery
- Protect the Intellectual property (often through a patent)
- Product development
- Licensing
- Prototyping
- Launch

These steps are usually within order, often these steps happen in tandem or even out of order, depending on the technology. Health-related inventions also have significant additional processes for testing. Also, this does not consider the necessary steps for a spinout.

REDUCTION OF BARRIERS TO FACILITATE LAB-TO-MARKET ACTIVITIES

Administrative processes at successful innovation universities speed the process of moving an idea from the lab and into the market. These efficient processes provide clear direction on next steps and also transparency in decision making. Increasing administrative efficiency and streamlining processes was identified by survey respondents as the third most needed change to promoting more technology innovation and commercialization (in addition to changing cultural resistance and increasing funding).

Administrative barriers mentioned by respondents included confusion about next steps within the process, disagreement between the technology commercialization units and other departments on the priority and value of the activity (reflected in funding levels), as well as the policies around intellectual property (IP) and technology commercialization. For example, faculty members shared finding conflicting messages from leadership on wanting to support technology commercialization, but also wanting to protect the university IP and ability to maximize the revenue for the university. These are competing priorities when negotiating with industry, and the faculty can get caught in the middle.

Addressing administrative barriers could be a valuable strategy for lower volume universities seeking to best leverage their resources.
The study found that universities that were particularly efficient in their commercialization output, as based on lab-to-market activity per research dollar, had nearly one-third fewer mentions of obstacles by faculty interviewed when compared with even the High Producer Group. These observations suggest that universities, large or small, can benefit from addressing obstacles, such as administrative barriers. It is possible that smaller universities are more flexible in their management practices and responsive to barriers that can exist among university operations. The nature of the obstacles and the university's potential ability to better address these requires further investigation.

FACULTY MOTIVATIONS AND CAREER GOALS

In addition to the importance of cultural values of lab-to-market activities, the personal values of the faculty were also significant. When discussing translational research, more than three out of four professors interviewed mentioned their own personal motivations and interest in this type of work[3]. As one faculty member said:

> "None of us became university faculty because we wanted to make millions of dollars. There's other ways to do that. It's because we want to have a positive impact. Using our little piece

3 Many also expressed the need for continued basic research with more than half reporting that they had conducted basic research at some point during their career. A little less than half reported having some level of applied industry experience. Almost all the faculty interviewed identified either "lab-to-market" or "applied research" as their most prevalent area of research focus.

of expertise, we want to make society better. (Commercialization) is a way to do that."

Additionally, faculty respondents often mentioned their personal passion for the research to impact society by going beyond a conference presentation or journal publication into a more mainstream application. This was a key mechanism that drove them to take the research outside of the "lab" and into some type of application.

While faculty did want their research translated into the marketplace, there was a strong desire among many to license it, and then return to their own research interests. Only five percent of the faculty interviewed wanted to be a CEO of a spinout company. Instead the majority wanted to return to their research, citing a desire to stay within academia for the intellectual freedom. As one faculty member noted:

"I like to develop these technologies, give birth to them, and then let them go."

Often the desire to stay within academia and not venture into industry was connected with strong self awareness by the faculty member of his or her lack of skills in technology commercialization and business management. As one faculty member shared:

"We're researchers; we want to put this in the hands of professionals. If this is going to have an impact on society, there needs to be a corporation that's going to take this mission full time. So we decided to license the technology rather than try to commercialize it ourselves."

However, a few faculty do become CEOs even though they do not have the appropriate skill-set; there were many comments on the problems this can cause, including actually preventing commercialization. While a small minority (5 percent) did pursue the role of CEO, most faculty were actively seeking industry professionals (often with the assistance of university staff) to take it to market. Researchers at FRLs likely have similar motivations in their desire for their research to translate into a mainstream application, but most do not want to run a spinout company.

The choice of a faculty member to remain in academia, but still pursue lab-to-market activities could be a learned activity, and not left solely to personal preferences. Some interviewees described a pathway for academics to become "socialized" as an entrepreneur, meaning learning the value and process of technology commercialization through peers. They insisted that entrepreneurial "socialization" was not likely to occur through a single workshop or class, but instead, grew organically from repeated interactions with entrepreneurial-minded professionals both inside and outside of the university. Lab-to-market activities sustained momentum at universities with serial faculty researchers who did not pursue a CEO role but instead were supported by a strong technology ecosystem.

CHAMPIONS

BEST PRACTICE 2

SUPPORT INNOVATION AND COMMERCIALIZATION AT ALL LEVELS THROUGH 'CHAMPIONS' AND ORGANIZATIONAL PROGRAMMING

TECH-ECOSYSTEM CHAMPIONS, PROGRAMS, AND MENTORSHIP

Moving innovations from the lab into the market is best facilitated by the right people in the right places that can translate and connect academic and industry needs. This support varies from university to university and could include university tech commercialization staff, academic leaders or departmental peers.

Personal assistance through the lab-to-market process was commonly institutionalized through programs. For example, these programs help researchers evaluate their ideas, test innovations in the market, and gain feedback faster. Programs are often focused on demystifying industry needs and help researchers evaluate their innovations for commercial use. For example, I-Corps, an NSF-funded program, was commonly discussed as a strong program for customer discovery and understanding the needs of the market. Receiving design advice early on in the process could reduce the need for "gap" funding later, and help ensure that the technical product looks more like investors might expect by the middle stage of technology development.

Additionally, effective programming utilizes champions with strong industry and commercialization experience to guide faculty and other stakeholders through the lab-to-market process. **In 90 percent of the High Producer Group, lab-to-market programs were lead by experienced industry professionals.** Universities benefit greatly from recruiting talented people who have launched new technologies into the marketplace. In addition to moving ideas forward, experienced professionals can help identify technical limitations or lack of market opportunity, which can be just as helpful as identifying a successful technology. Showing faculty why an idea may or may not work ultimately contributes to commercialization efficiency.

Longevity and consistency of programming also emerged as a factor. When surveyed about their university's most effective program, a majority of respondents were likely to select programming that had been established for several years. Respondents from the High Producers Group were even more likely to discuss a tech commercialization program or initiative that had been in existence for at least four years (76 percent, compared to 55 percent), and were twice as likely to report that the total cost of the program since initiation was more than $2 million. As with any type of program, both longevity and consistency in funding are key components for successful innovation and technology commercialization.

TALENT IN COMMERCIALIZATION

The people within the technology ecosystem are critical components. Twenty-seven percent of survey respondents identified champions in lab-to-market programs as the reason for its success. Additionally, 12 percent of survey respondents called attention the need for more experienced commercialization talent in staff positions as well as faculty roles. This gap in talent was identified as an obstacle to improving lab-to-market activities.

Respondents also identified talent retention as a related issue. As people in both academia and administration are approached with enticing offers, leaders can emphasize the 'public good' mission of the universities to retain these key employees. The intellectual freedom and pursuit of knowledge provided by universities is a key asset that top performing universities highlight to retain faculty and foster innovation.

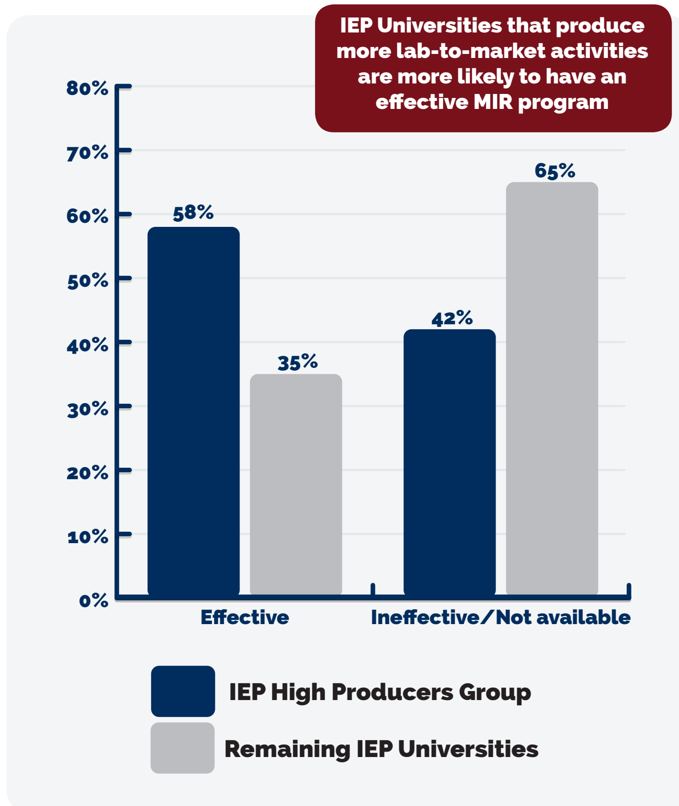
A strong program institutionalizing this type of assistance is often through an entrepreneur or mentor-in-residence program. These programs match faculty researchers with experienced lab-to-market professionals to provide advice and strategic insight into the development of both the technology and its movement into the marketplace. Faculty, business engagement, technology transfer staff, and Vice Presidents for Research were surveyed about the quality of their current mentor-in-residence program. The High Producer Group reported more effective programs when compared with the remaining universities, demonstrating that **effective mentorship programs are linked with higher lab-to-market outputs.**

Yet there is still a need for continued growth in this area. The absence of mentorship through a champion was listed as the third most common obstacle by faculty (after legal obstacles and conflicting cultural priorities). In interviews, faculty discussed the need for a champion who could help them understand, negotiate, and meet requirements for commercialization. This was mentioned across departments and administrative units for all levels of faculty - from junior to tenured.

Direct coaching on the viability and continued development of the innovation also coincided with assistance on working with industry. More than half of faculty interviewed mentioned the need for programs to address the knowledge gap in this space, indicating that while it is present at some universities there is still an appetite for more. Unfortunately, providing additional coaching and learning opportunities such as these are constrained often by budgets and time.

MENTOR-IN-RESIDENCE PROGRAMS

Reported by selected Survey Respondents, n=98



BUSINESS MODEL COACHING

Matching the right business model to an innovation is a fundamental step to success. If a new venture is to scale, it needs a sound business model. Champions need technical knowhow, an understanding of product development, and business development capabilities to facilitate this well. The business model can also impact how a faculty researcher engages with the process. Licensing may require participation for only a brief period while a licensor gains access to the innovation. Further developing IP into products and services could require a researcher to commit time and energy. A champion helps articulate these considerations.

DEPARTMENT CHAIR AS PROTECTOR AND CHAMPION

The department chair can be a key protector and champion when moving a technology forward towards commercialization. Often the department chair points the faculty member to resources to support innovation activities or provides release time from teaching or service obligations. Additionally, he or she can provide advice on balancing publishing and lab-to-market activities based on how promotion and tenure committees will review the work.

More than three out of four faculty interviewed preferred engaged leadership support for their lab-to-market activities versus disengaged leadership. Especially prior to obtaining tenure status, department-level support can make or break a commercialization effort. Many faculty members mentioned support and advocacy on behalf of their work from a department chair playing a pivotal role in their lab-to-market accomplishments. One faculty member shared how her department leadership was key in her commercialization efforts by saying,

> "I give my department chair at the time a lot of credit and then the following chair was also incredibly supportive."

Department-wide support was also important, often demonstrated by the faculty mentoring process and department meetings. One department chair in the biological sciences noted,

> "We use positive adjectives to describe (technology commercialization). When it comes to mentoring of junior faculty, we do encourage this. We talk to them about opportunities in their labs as they're developing, to not miss an opportunity. It is something that we spend time on."

Additionally, the activity of a peer can encourage other faculty members to explore commercialization for their research. A faculty member who leads research programs shared that after someone commercialized within a liberal arts department the dialogue changed.

> "Now the faculty are looking at that and saying, 'Oh. Well, if she can do that with her team, maybe I can do that with my team.' And that's all it takes– once you get those one or two champions who have a success, everyone else kind of looks at it and says, 'Maybe I could see myself doing that too.'"

While these types of cultural changes take time to unfold, it demonstrates that even changing topics on a meeting agenda, and the language used to describe the activity, can help faculty researchers feel more recognized and valued within their departments. Department chairs and academic peers play a key role in leading these efforts. Leaders within the FRLs could potentially apply similar concepts within team meetings and facilitating encouragement of the activities.

A few anecdotes were shared by faculty who felt that students and postdoctoral fellows were important in the lab to market process and often well-suited to run a startup or spinout. Some thought they were more tolerant of the lean and challenging first years of growing a successful startup. This could be an opportunity for universities to support innovation by investing even more resources into mentoring and supporting students and postdoctoral fellows to take a product to market.

BEST PRACTICE 3

INCENTIVES AND RESOURCES FOR TECHNOLOGY COMMERCIALIZATION

Evaluating the realm of incentives highlights some of the most distinct differences between academia and industry. Incentives emerged as a best practice theme for several reasons. First, they reflect the values of an organization, which draw on the culture and established practices. Addressing cultural differences is an important topic throughout the study. Second, incentives are structured around desired outcomes, and the willingness to modify incentives depends on an organization's ability to adapt. In industry and commercialization activities, incentives change depending on strategic goals and contextual factors. In academia, to change incentives where long-established norms exist is difficult and, in some cases, even provocative. Last, well-defined incentives bring clarity and structure to goals, which is often lacking in nascent or novel collaborations, such as lab-to-market work. Lack of structure and risk management have been well-documented as obstacles, and incentives are an important element in addressing these issues.

INCENTIVES AND RESOURCES OVERVIEW

POLICIES
- Promotion and Tenure Policies
- Leave Policies
- Legal Policies

FUNDING
- Internal Funding
- External Funding
- Gaps in Funding

ASSETS AND INFRASTRUCTURE
- Research and Tech Parks
- Incubators/Accelerators

$ POLICIES

The policies impacting lab-to-market incentives are broad, from legal and intellectual property agreements to faculty leave time and standards for promotion and tenure. The two most commonly mentioned internal incentives for lab-to-market activity are promotion & tenure and advantageous, transparent legal agreements.

Promotion and tenure

A quarter of the faculty interviewed mention promotion and tenure as a key incentive, with almost 75 percent of those faculty stating mechanisms to reward lab-to-market activities were already in place. However, while universities are moving toward incentives within promotion and tenure, only a minority have enacted the change. Additionally, the value of lab-to-market activities varies greatly by department and traditions within academic specialties.

The use of promotion and tenure as an incentive for lab-to-market activity is an innovative, but difficult, movement away from traditional academic activity. Faculty at research universities are still expected to teach and engage in administrative service activities, while also publishing and securing grant funding. Reflecting this, 44 percent of the faculty interviewed said their department's tenure and promotion policies were a barrier at some point in lab-to-market activities. The diverse survey respondents also mentioned it with one-in-ten citing it as the most significant barrier for enhancing technology commercialization at their university. As one faculty member noted:

> "The incentives aren't really set up for me to work on a problem (in the marketplace or society); the incentives are set up for me to write about this problem, and maybe to supervise students about this, but not really to solve the problem."

Changing the criteria for promotion and tenure is difficult since the process is decentralized and involves changes to the cultural value of translational research, as discussed above. However, for faculty, these changes can provide validation and incentives for their activity.

Departments with established processes to weigh commercialization efforts were typically within engineering, computer science or agriculture. Departments outside of the applied sciences are using these departments' policies as guides for encouraging and rewarding technology innovation for their faculty. One in four faculty talked about their department's efforts to weigh commercialization work in tenure considerations. Support can give clarity and greater confidence to faculty who wish to explore developing their IP without sacrificing research career goals.

One angel investor succinctly summarized sentiments on this topic throughout the technology ecosystem stating,

> "Faculty acceptance that translational research (and technology adoption) is as important as basic science and fundamental research. Both are necessary - it is not either/or."

Leave Policies

Translational research activities are often supported with leave or release policies. This incentive was a common theme mentioned by faculty members (other incentives included champions, legal policies and valuing the activity in promotion and tenure). The availability of leave time to pursue commercialization activities demonstrated it was valued and supported. In some cases the leave time was simply labeled a sabbatical and other times recipients received releases from teaching. The flexibility gave faculty space to pursue their ideas. It was not clear from the responses how often this was paid time, however it was referenced as valuable. For example faculty discussed:

- Weekly leave time for entrepreneurial activities
- Sabbatical leave time for work related to an innovation and company startup
- Reduced teaching loads
-

Policies to Manage Conflict of Interest, IP, And Legal Issues

Innovative universities utilized well-structured policies and legal agreements including favorable boilerplates for faculty researchers, common licensing terms, and clear options for IP transfer, provisional patent filing, and licensing. These policies should be formed and documented in a transparent manner so that researchers and industry partners alike can understand common outcomes and IP options. Many IEP universities make a deliberate effort to navigate legal issues and policies in an inclusive manner that ensures all parties achieve goals, which often depended on talented legal staff.

However, this area is still a struggle for many universities. Legal issues, including patenting, conflict of interest and IP rights, were the most commonly mentioned obstacles to commercializing technologies. When discussing obstacles, 40 percent of faculty interviewed mentioned legal issues, far exceeding other obstacles mentioned. As discussed in other best practices, mitigating these obstacles is critical for supporting lab-to-market.

Additionally, 30 percent of faculty interviewed highlighted the need for incentivized and transparent legal agreements to increase lab-to-market activities. Specifically they requested that any legal agreement to be structured in a manner that incentivizes both the inventor and the investors. Alongside this was the request that agreements be as standardized as possible, as many faculty lack the knowledge to expertly navigate this realm. One faculty survey respondent shared that there was a need to:

INCENTIVES

> "streamline the IP process with a faculty entrepreneur-favorable IP legal boilerplate. The negotiation process is broken and unfortunately discourages faculty from working inside the university system....I found the IP negotiations physically draining and passion-killing."

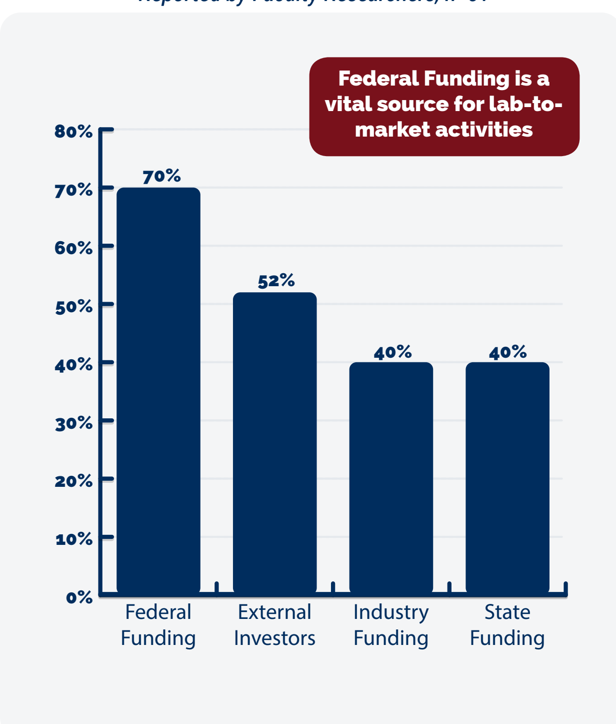
More than one in three survey respondents (39 percent) described the long and sometimes difficult legal contract negotiation process, and either real or misperceived inflexibility in negotiating licensing, intellectual property, and exclusivity issues. While a plug-and-play option for all situations is not feasible, precedents and common terms should be made available to inform future decision making. FRLs would likely benefit from similar practices that would reduce risk and uncertainty for researchers and investors.

$ FUNDING

As a technology matures, funding is vital to its continued progression from the lab to the market. IEP universities were able to diversify funding sources and ensured adequate funding was available for the early, middle and late stages of technology development. Blanketing all stages in funding required collaboration with the surrounding communities and industries as well as understand the fund internal to the university.

TRANSLATIONAL RESEARCH FUNDING

Reported by Faculty Researchers, n=51



Internal Funding

Internal funding at a university provides necessary support to foster technology commercialization, especially in the early stages. Of the faculty interviewed, half reported that internal funding assisted them in their lab-to-market activities. Internal funding was most often geared towards early stage activities. However, a few faculty mentioned grants that assisted at a later stage of commercialization activities. Internal funding for collaborative work is strong among IEP universities, with nine out of ten of those surveyed reporting that internal funding existed at their university to support interdisciplinary collaborations on lab-to-market activities. These are typically small seed funding grants. For example, one university offered seed funding for faculty to patent their ideas and move them down the path of commercialization. Additionally, universities have looked for more unique mechanisms for seed funding, including engagement of the alumni base.

External Funding

External funding plays a vital role in facilitating lab-to-market activities – especially federal funding. Of the faculty interviewed, federal funding for translational research was the most common type of external funding, with 70 percent utilizing these funds. The next most common type of funding was from external investors, with 52 percent of faculty interviewed reporting this support. External investors included angel funding, venture capital (VC) or foundation funding. State and industry funding are also important sources, with around 40 percent of the faculty researchers indicating each of these funding sources supported their innovation or technology commercialization activities. State funding was cited for its key role in maturing technologies through supporting programs at universities.

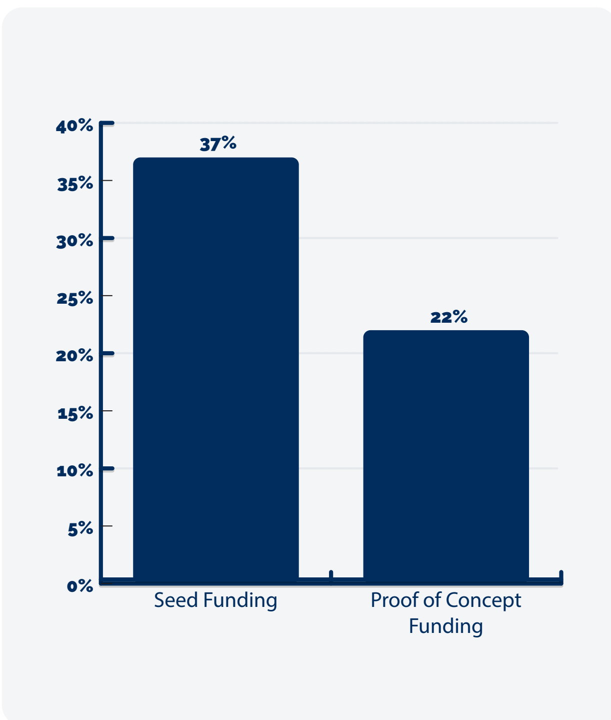
Venture capital funding is present in all states with IEP universities, however its volume varies significantly, according to data gathered from PitchBook. In the High Producers Group, the average number of VC firms in the respective states outnumbered the average number of VC firms in the remaining IEP group (excluding New York and California). While VC firms are only one source of funding for lab-to-market activities, this demonstrates the important role the local ecosystems plays in lab-to-market activities.

Gaps in funding

Unsurprisingly, funding was the most often mentioned need to improve lab-to-market activities from survey respondents. The most requested types of funding by survey panelists mentioning this need (n=45) were early stage, seed-type funding (37 percent) as well as proof of concept funding (22 percent). These needs reflect the frequent requirements of industry to see a proof-of-concept before they are willing to invest in a lab-to-market venture with a university partner. Within the larger ecosystem, the funding and programming work together to move a technology toward maturation.

MOST CRITICAL GAPS IN FUNDING

Reported by Survey Panelists, n=45



Many faculty researchers interviewed said the most acute need was for "gap" funding, which is typically defined as funding to fill the "gap" after federal grant funding opportunities have run out, yet before a minimal viable product or proof of concept is ready for external funding. Only one-fifth of survey respondents stated that their universities had gap or proof of concept funding.

ASSETS AND INFRASTRUCTURE

Assets and infrastructure are important resources for commercialization. The assets within a university - such as research parks and incubators - provide stepping stones for a technology to continue to progress and move forward.

IEP universities are widely invested in both internal assets (business engagement offices, technology transfer offices) and external assets (incubators, accelerators, research parks). High Producer IEP universities are particularly committed to hosting business engagement centers and business incubators.

- Those in the IEP University High Producers Group were 22 percent more likely to have a formal business engagement center compared to remaining IEPs and 39 percent more likely to host a business accelerator or incubator

Tech Parks and Research Parks

Technology and research parks provide dedicated space to mature technologies. Most of the IEP universities (75 percent) had developed one of these as an asset.

Incubator and Accelerator Programs

More than half of the faculty researchers interviewed mentioned incubators or accelerators at their universities. However, only a few mentioned how these assisted - most of these were too new for faculty with lengthy lab-to-market experience to have utilized them.

In reviewing the IEP universities, the study team identified that 81 percent of IEP universities had developed an incubator or accelerator.

BEST PRACTICE 4

COLLABORATION FOCUSED ON TECHNOLOGY COMMERCIALIZATION

Successful collaborations should be an outcome of the preceding best practices. University support for innovation, champions that mentor faculty and manage programs, and incentives that establish clear goals and rewards all work together to fuel collaboration. Strong collaborations stand apart as both a best practice and an illustration of what can be achieved.

Interviewed faculty talked extensively about collaboration: 90 percent positively discussed their experience with cross-sector collaboration, 61 percent discussed collaborating internally with other departments on lab-to-market activities, and 50 percent mentioned working with other universities. The priority of cross-sector collaboration is unique in the lab-to-market space, while the internal collaborations and working with other universities is a common practice within academia. The academic collaborations are focused on broadening the scope and solutions of a project, while most work within cross-sector collaboration is focused on commercialization.

IN-PERSON NETWORKING

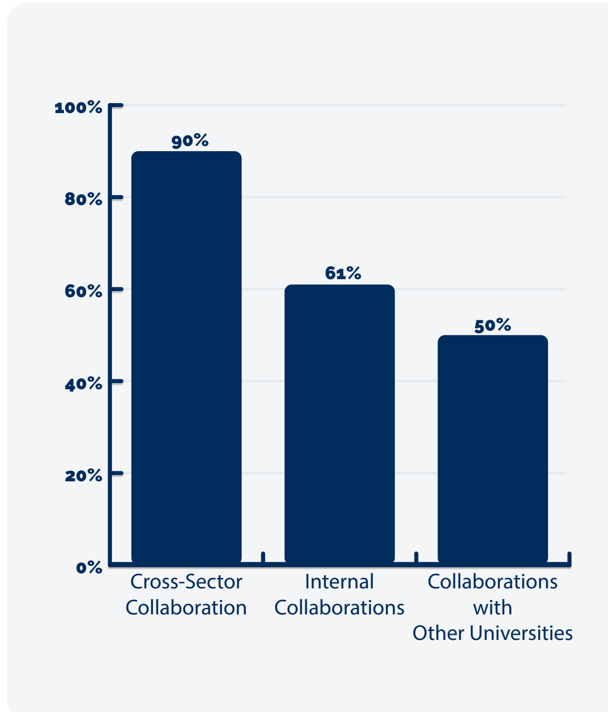
In-person networking is fundamental to driving collaboration. Most interviewees who had participated in successfully launching a company mentioned in-person networking as the most effective method for initiating collaborations. For example, a professor with experience collaborating with industry reflected:

> "For my specific case, most of my collaborations come out of direct contact. In some cases, because I go to specific conferences where those R&D people are, so they see my research, then we discuss it. In some cases, the company has a problem and they do a little research and contact me. In some cases, the direct connection I have is through people I work with, who refer them to me. That in some ways has been the most successful way."

While the motivations for those looking to collaborate may vary depending on their position, enabling them to meet with others in person is essential to ensuring that they get the help they need. These meetings can start in

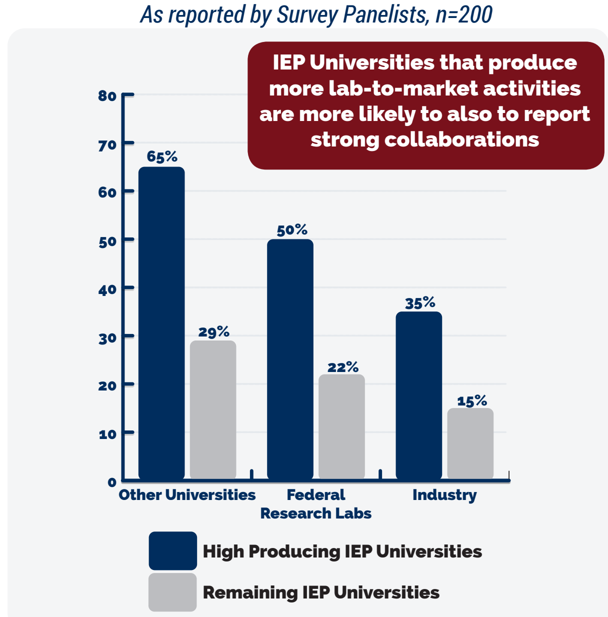
TYPE OF LAB-TO-MARKET COLLABORATION

Reported by Faculty Researchers, n=51



"OUR COLLABORATIONS ARE ADEQUATE"

As reported by Survey Panelists, n=200



several ways, such as mutual connections, conferences, career fairs, unconferences or hackathon-type competitions. Some universities and federal labs (such as Los Alamos) have successfully created "Main Street" spaces for connecting with startups and businesses through incubators and accelerators, or created "co-locations" on campus or shared industrial spaces, through research and tech parks.

At universities where staff were knowledgeable of faculty expertise, faculty spoke of "key" introductions by staff facilitating the movement of their technology from lab to market. Some anecdotes from faculty cited the periodic loss of such expert staff as a significant drain to innovation, and attributed the losses to poor retention practices, such as non-competitive pay or a lack of a professional development path for staff in tech transfer roles. These observations recall the importance of having the right people involved in programming and incentives.

INTERDISCIPLINARY COLLABORATION WITHIN THE UNIVERSITY

Interdisciplinary collaboration was a key mechanism within successful innovation universities for facilitating translation research activity. Faculty interviewed discussed interdisciplinary collaboration as a means to expand both potential solutions and increase resources for lab-to-market activities, which parallels academic research collaborations. One faculty member highlighted:

> "The research of the twenty-first century is inherently collaborative. The big breakthroughs are not going to come from a lone genius sitting in their lab working by themselves. It's going to be large collaborations where you have folks who bring a diversity of expertise to the particular project."

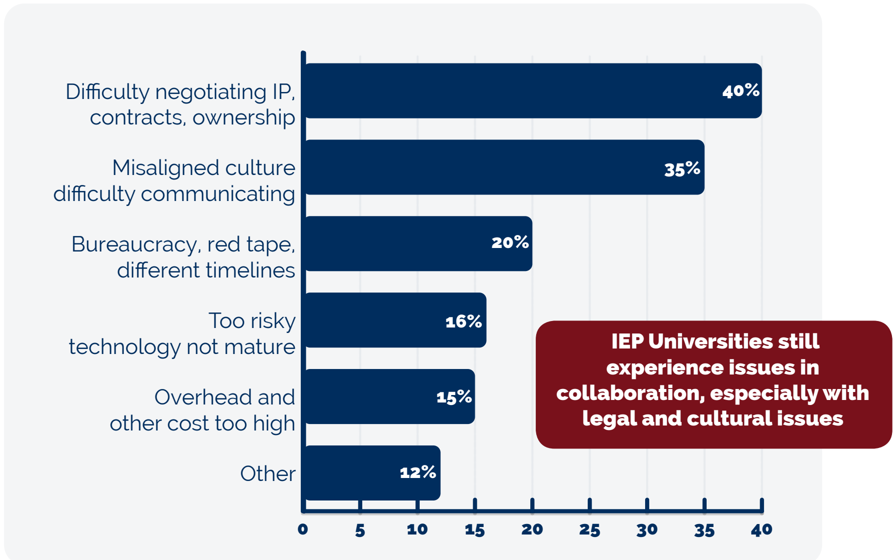
Other reasons cited for interdisciplinary collaboration among the faculty included adding skillsets to the project or working with new departments to facilitate commercialization. One university's incubator hosted a meet-and-greet for researchers from different departments to share ideas and develop new relationships.

However, there is still room for further developing internal collaborations. Around half of survey respondents thought more internal collaborations were needed, while closer to two-thirds thought more collaborations were needed across disciplines to remain competitive.

INDUSTRY (CROSS-SECTOR) COLLABORATION

Strong industry relationships emerged as a key practice for IEP universities. For faculty researchers, engagement with industry was via sponsored research or through business partnerships. More than half of faculty interviewed (53 percent) engaged with industry through a sponsored research agreements. These relationships often provide avenues for further collaborative innovation work. Almost half of

PERCEIVED REASONS FOR BREAKDOWNS IN INDUSTRY COLLABORATIONS
Reported by selected Survey Panelists, n=82



these faculty interviewees (47 percent) are also seeking business partnerships with industry in which to place their technology.

Selected survey panelists (faculty, Vice Presidents for Research and university business engagement staff) were asked about perceived reasons for breakdown in industry collaborations. This open-ended question yielded the above graph. Legal and cultural issues emerged as the most prevalent in this open-ended survey question. Members of industry were not surveyed as this was outside of the study group. However, the responses do highlight some key areas needing continued investigation.

FEDERAL RESEARCH LAB COLLABORATIONS

Compared with public research universities, federal research laboratories (FRLs) are notably more constrained in some areas by their mission, by federal policy, and by their sponsoring government agency in their ability to directly engage in mid-to-late-stage lab-to-market activities. FRLs thus rely heavily on their university and industry partners to move technology products and processes out of the FRL system, and into the hands of people who can use them.

IEP University survey respondents reported a desire to increase collaborations with FRLs, with 63 percent stating more partnerships were needed with regional FRLs and 71 percent stating this was true for FRLs outside of the region.

In the interviews with the federal research labs, collaboration with universities was supported and expected. Many labs were working to reduce administrative barriers to collaborate more with universities and industry. Thus while there is the desire from both IEP universities and FRLs for collaboration, there is additional potential.

While FRLs and IEP research universities are both research organizations, there are opportunities for FRLs to adopt the best practices of IEP universities. Interviews with researchers at FRLs suggest that there are more resources to be tapped in the national labs. IEP universities and other technology development entities could better utilize these resources to their mutual benefit. Potential resources include FRL tools, infrastructure, testing facilities, patents, processes, standards, funding opportunities, and other potential collaborations.

CONCLUSION

IEP universities are at the leading edge of best practices for public universities. They should inform and guide universities nationwide in their commercialization endeavors. As an already select group among universities, IEP universities are experimenting, testing ideas, and fostering lab-to-market activities. Best practices emerged from key findings in innovation and technology commercialization. These practices focus on **culture, champions, incentives and collaboration**.

Universities with a strong cultural emphasis on innovation promote its value both internally to the university and its faculty, as well as externally to the surrounding community. Strong technology ecosystems are dependent upon champions - experienced professionals assisting in the maturation of a technology through expert guidance and mentorship. Incentives are vital to motivate and reward new ideas, while resources provide the necessary environment for continued growth. Finally, key collaborations are necessary throughout the process to foster ideas and to access resources throughout the ecosystem.

Key findings of the study emphasize the importance of strong programming led by experienced commercialization professionals who work alongside faculty, and offer assistance early and often. Talent retention of both staff and faculty within the lab-to-market ecosystem is vital for long-term sustainability. Successful universities allow and encourage lab-to-market programs to utilize broad resources and tap into commercialization knowhow from industry and entrepreneurs. This includes supporting both experienced people and broad resources appropriately. The structure also serves to decrease the risk for lab to market activities.

There are programs that have demonstrated they are working well, and there is opportunity to satisfy a growing interest in research innovation. Faculty are finding increased opportunities to connect with industry in ways that impact the world. In service to this, transparency and clear IP agreements are reasonable expectations for any collaboration. There is a perception among many that licensing and commercialization steps are opaque or even unfair. This demonstrates the need for appropriate people and programmatic responses. Whether a champion, a mentor, or an advocate, the value of experienced and knowledgeable support staff with industry and technology commercialization experience cannot be understated.

Universities face increased demands for innovations that can serve the public good through commercialization or other access. These best practices form a foundation that can guide, grow, and evolve as IEP universities experiment and implement lab-to-market ideas. It is expected that this study will encourage more faculty researchers, university staff, and investors to lend their perspectives and ideas. There is need for greater program evaluation, measurement, and training that can help inform and develop the lab-to-market path.

This study has been a broad and satisfying look at this ecosystem. Many topics led to new threads where additional study could provide value. Further areas for study include gaps and opportunities in lab-to-market pathways within emerging technology sectors, mechanisms to facilitate faster commercialization from federal research labs to the market through university partnerships, and the vital role of the student entrepreneurial community within a university.

IEP universities enrich the country, and the world, with their scholarship, ideas, and innovations. This study of their best practices can support university leaders who recognize in their organizations the great potential of economic engagement. It is hoped this study will help expand the vision of what is possible.

METHODOLOGY

This study focused on 59 North American public research universities sharing a designation from the Association of Public and Land Grant Universities (APLU) recognizing their dedication to supporting Innovation and Economic Prosperity (IEP) both on campus and in their surrounding region.

Original data was collected from the following:

- 51 interviews with IEP university faculty,
- 200 surveys with IEP survey panel members, and
- Ten interviews with staff at federal research laboratories in leadership and research roles.

The faculty members and survey panelists were identified and recommended by the IEP university key contact, who was usually the Vice President of Research. Each IEP university designated a 'key contact' within its application to APLU for the designation.

FACULTY AND FEDERAL RESEARCH LAB INTERVIEWS

The 51 IEP university faculty interviewees were researchers who had been at the university for at least seven years, and had experience moving a technological product or process from the lab into the market. Many of the faculty had notable accomplishments in technology innovation, including the invention of widely-used technologies, authoring a large number of accepted patents, or founding successful tech startups and businesses.

Seven affiliates and official representatives of the federal research laboratories were also interviewed at: 1) The Sandia National Laboratories; 2) Frederick National Laboratory for Cancer Research; 3) The Pacific Northwest National Laboratory; 4) The Lawrence Livermore National Laboratory; 5) The Los Alamos National Laboratory; 6) The Massachusetts Institute of Technology Lincoln Laboratory; and 7) The National Renewable Energy Laboratory. Three additional federal research laboratory affiliates were interviewed on a confidential basis.

The study team conducted semi-structured interviews lasting between thirty and sixty minutes. These interviews were professionally transcribed. Researchers read and qualitatively coded each transcript to identify common themes and characteristics of the lab-to-market process to identify best practices.

SURVEY PANEL

The IEP university survey panel (n=200), as a group, was intended to represent the full breadth of well-informed perspectives on technology development and technology transfer at each the 59 IEP universities. Many of the survey panel members were in leadership roles at their university and had notable accomplishments in technology commercialization.

Each of the following survey-panel types were recommended by the IEP University Key Contact to represent the following positions for the university:

- The IEP University Key Contact, or Vice President of Research (or equivalent unit);
- A staff member from a technology transfer office (or equivalent unit);
- A staff member from a business engagement office (or equivalent unit);
- A researcher who had experience moving a technology (which could be a technological product or process) from lab to market;
- A doctoral or postdoctoral student who is (or recently was) actively engaged in lab-to-market activities on campus;
- A current (or recently) university-affiliated student, faculty, or staff member who represented a well-informed, yet non-traditional or alternative perspective on technology commercialization; and
- An angel investor or outside funder of technology development at the target university.

On average, three panel members responded from each IEP university. Quantitative data from the survey was aggregated for this study and open-ended questions were coded into common themed-responses.

AUTM AND IPEDS DATA

Measures of technology commercialization volume were determined based on data from two main sources: the Association of University Technology Managers (AUTM) Statistics Access for Technology Transfer (STATT) Database, which compiles the results from a survey of university tech transfer offices and the Integrated Postsecondary Education Data System (IPEDS) from the National Center for Education Statistics (NCES).

The team drew from five of the AUTM “Big Six” measures, which are widely-used indicators of lab-to-market output volume. These included:

- Mean Annual Count of Options and Licenses Issued (2012-2016)
- Mean Annual Gross Licensing Revenue (2012-2016)
- Mean Annual Count of New Disclosures Filed (2012-2016)
- Mean Annual Count of New Patent Applications Filed (2012-2016)
- Mean Annual Count of Startups Initiated (2012-2016)

From IPEDS, the team evaluated annual research expenditures from 2016 and 2017. Of the 59 IEP Universities, complete and comparable data was available for 48 universities. Most often exclusions were based on lack of data for a specific campus. The IEP designation is campus-specific, and some universities only report system-wide data to AUTM.

AUTM data from 2012-2016 was averaged over the five-year period for comparison to other public doctoral universities as well as to other IEP universities. In comparing IEP universities to each other, a notable concentration of output volume from the AUTM data was noted in the top 35 percent (n=17) of the universities. This group is labeled “High Producers Group” throughout the report.

PITCHBOOK DATA

Venture capital firms data was collected from PitchBook for current totals. Total VC firms in each state with an IEP university were determined from the number of firms present, minus those that went out of business, were acquired or merged.

SUMMARY STATISTICS FOR AUTM INDICATORS OF LAB-TO-MARKET OUTPUT

From 2012-2016, n=48

	Annual Count of Options and Licenses	Annual Gross Licensing Revenue	Annual Count of New Disclosures Filed	Annual Count of New Patent Applications Filed	Annual Count of Startups Initiated
Minimum	1	$20, 124	7	4	0
Maximum	53	$34,704,990	410	241	18
Mean	13	$5,370,949	126	67	5
St. Deviation	12.6	$8,881,736	111	61	4.4

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