Improving the Quality and Quantity of Innovations: Moving from Lab to Market

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ABSTRACT

Academic investigators who receive public funds to generate technological innovations often struggle to move their project outputs to the marketplace. Though there is no shortage of abstract models for commercializing university technology, few have been reduced to practice in forms that can be easily applied by investigators. In response, this research project has developed an operational model for new product development and technology transfer, and assisted stakeholders in implementation of the model. Future efforts will provide users with a streamlined planning template for articulating and tracking their projects. An evaluation will then assess the impact of the model and its components in increasing successful transfer and commercialization. The field of new product development stands to benefit from this work in two ways. First, it will offer insight into the effectiveness of applying industry best practices to new product development conducted in an academic setting. Second, it will demonstrate how operational models can be used at the policy, organization, and individual levels to influence technology transfer success.

I. BACKGROUND

Federally funded R&D projects are often intended to result in socio-economic impacts that improve quality of life for some segment of the population, while generating economic benefits. The linear model of innovation presumes that investments in upstream scientific activity necessarily result in increased outputs, outcomes and impacts (Godin, 2005). However, research regarding technology transfer (TT) from academia to industry has long recounted the perils found in the "Valley of Death", where so-called promising innovations may flounder due to a lack of public or private support to bring them to the marketplace (Branscomb & Auerswald, 2002).

In contrast, this paper concurs with those who view the technology transfer landscape as a "Darwinian Sea," where plentiful resources are available to commercialize promising inventions (Auerswald & Branscomb, 2003). With this perspective, the outputs being generated by federally funded R&D projects may not be privy to the resources of the plentiful sea, and instead languish in the Valley of Death for good reasons. Project failures have been clearly associated with the absence of market and cost considerations (Galia & Legros, 2004; Miotti, & Sachwald, 2003). For example, it may be that the innovation's market is simply too small to justify expenditures on commercial hardening; or competing products may be available in the marketplace, rendering the "innovation" obsolete before it is ever introduced. Many of these barriers can be avoided if rigorous and relevant analyses are preformed prior to engaging in development activities (Ozer, 1999; Shum & Lin, 2007).

Some argue that technology transfer offices (TTO) at universities should perform this necessary due diligence. However, *if* academic investigators disclose invention information to their TTO, it typically occurs only after a research or development project has been completed (Siegel, Waldman & Link, 2003). Even if academics sought assistance from a highly capable TT office at an early stage, resource constraints would likely prevent the TTO staff from conducting rigorous evaluations of every proposed project (Swamidass & Vulasa, 2009). Therefore, some of the onus for recognizing potential barriers to commercialization falls upon the academic investigator. But, most academics are not trained nor motivated to complete the required due diligence.

In order to improve motivation, funding agencies must change their evaluation criteria to more seriously consider the commercial potential of the innovation projects they are funding. Additionally, at the organizational level, policies dictating rewards systems within Universities must change to recognize the value of academic contributions to the innovation economy (Tommaso & Ramaciotti, 2010).

Assuming that appropriate motivation exists, academic investigators who are trained in a particular scientific discipline often lack the business acumen to complete business and market analyses. How then, is a well-intentioned academic to generate and deliver valuable innovations to industry partners who can take them to the marketplace?

Prior work has demonstrated that academic investigators need operational models and tools to simplify those business and market analyses that can have a profound impact on the viability of their R&D outputs (Golish, Besterfield-Sacre & Schuman, 2008). For example, though an academic may be well versed in evaluating technical feasibility, they might need guidance to know how and when to evaluate competing products, or consider regulatory restrictions. Further, they may lack the skills to consider the price point implications of market demographics or reimbursement regulations when dealing with products such as medical devices.

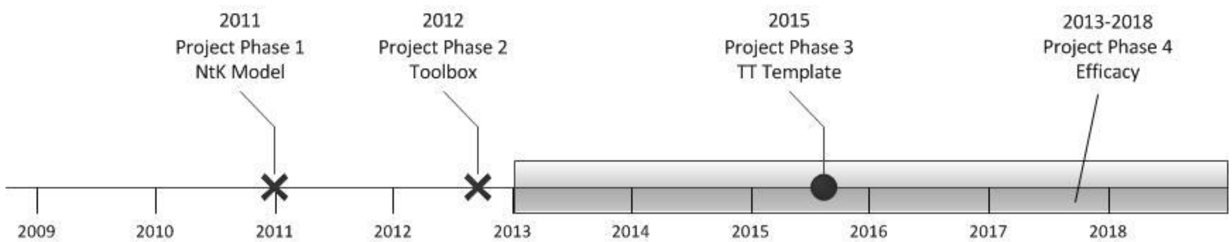
These types of questions present major barriers to academic investigators who are attempting to conduct R&D that will result in commercially viable products. Responding to these barriers is the focus of this research project.

II. METHODOLOGY

A four-phase project is underway to provide academic investigators with information and tools to help them apply industry-standard best practices. For example, properly vetting projects as they progress, and completing the due diligence needed to persuade a manufacturer to commercialize an invention developed outside of their company's walls. As shown in Figure 1, Phases 1 and 2 were conducted from

2008 through 2013. Phase 3 will be completed by 2015, while Phase 4 will be ongoing from 2013 through 2018.

Figure 1: Project Timeline



Project Phase 1: The first phase of the project involved establishing a new product development (NPD) and technology transfer model designed specifically for academic investigators who are charged with generating innovations. This was accomplished through a scoping review of more than 200 academic and practice articles describing the salient components of the NPD process. Article excerpts were compiled in an online database and analyzed to inform the stages and steps necessary for successful NPD. Called the Need to Knowledge (NtK) Model, this framework consists of 58 steps nested within 9 activity stages. Stages are grouped into three major phases named for their outputs: a discovery phase involving research activity, an invention phase involving development activity, and an innovation phase involving production activity. The NtK sheds light on the best practices that are relied upon by private sector NPD professionals, and contextualizes them in a way that makes sense to the academic R&D process (Flagg, Lane, & Lockett, 2013). In effect, it operationalizes the abstract concepts posed by the majority of technology transfer and university commercialization research studies. Table 1 depicts the 9 activity stages and associated gates.

Table 1: The Need to Knowledge Model Framework

NtK Phases	NtK Stages	# of Steps
Discovery Phase (Research Activity)	1. Define problem and solution	5
	2. Scoping	3
	3. Research to generate discoveries	9
Invention Phase (Development Activity)	4. Build business case	13
	5. Implement development plan	4
	6. Test and validate prototype invention	4
Innovation Phase (Production Activity)	7. Production planning	13
	8. Launch innovation	4
	9. Post-launch review	3

Since its completion in 2011, NtK Model has been used in the creation of technology transfer plans and grant proposals by federally funded academic investigators. However, additional unmet needs have arisen from those who have applied the NtK model to their work. In particular, users called for the tools necessary to complete the steps and stages of the NPD process, as well as further guidance in planning for TT and commercialization.

Project Phase 2: Phase 2 of this project was completed in 2012, producing a toolbox documenting 79 existing tools that can be used to complete the NPD process (KT4TT, 2013). The toolbox organizes tools into 5 competency groups: electrical engineering (13 tools), mechanical engineering (4 tools), material science (15 tools), business (40 tools), and universal design (7 tools). As an example, among the 40 business tools are analytic hierarchy process, concept testing, and quality function deployment. Each of the 79 tool entries lists the tool name, description and summary of applications, relevant citations, tool advantages and disadvantages, applicable regulatory considerations, target audience for use of tool output, NtK steps where tool use would be appropriate, and resources for implementing a tool. The toolbox has been made freely available on a project website with links through the NtK Model webpage, represented by small red toolbox and wrench icons.

Project Phase 3: The toolbox is currently being used by academic investigators funded by multiple federal agencies. However, end users have requested changes to the toolbox interface, as well as a template for generating TT and commercialization plans. As such, the third phase of this project will include the incorporation of the toolbox into an interactive planning template that will guide academics through the selection and application of tools as they navigate the NPD and TT processes. This template will allow users to customize the informational feedback to fit their situation and needs.

For example, if an academic investigator is intending to generate a prototype that will be transferred to an industry partner for commercialization, the template may ask "What competing products are currently available in the marketplace to meet the need your prototype will address?" To answer this question, the template may suggest the use of tools such as market structure maps and competitor benchmark matrices. Without this type of guidance, academics are often at a loss for what questions to ask and how to answer them. The template will ease the NPD process by eliminating the guesswork and offering the resources needed to improve the chances of a successful launch.

Project Phase 4: A summative evaluation study will be conducted to determine the effectiveness of the NtK model, and its toolbox and template. A sample of academic investigators will participate in this longitudinal analysis, which will explore academic TT activities and outcomes, including use of TT resources. A mix of personal interviews and annual reporting documentation will inform the study, and data analysis will be ongoing throughout.

This test will indicate if the model and tools are improving TT outcomes, and provide information to guide potential refinements of the NtK model, the toolbox, and the template. Refinements are expected to increase the effectiveness of the NtK model, toolbox and template by adapting them to better fit the needs of different stakeholder groups.

III. RESULTS AND DISCUSSION

The results of this work have implications for many stakeholder groups. First, they will provide sector-level and university policy makers with information regarding the effectiveness of operational level tools for improving the success of TT efforts sponsored by their respective organizations. This information can be used to guide policies and recommendations on both levels, while also helping to shape reward systems in ways that recognize the TT related accomplishments of academic investigators.

For those academic investigators who are interested in improving the success rate of their TT efforts, this work will offer an evidence-based set of tools that can be instrumentally applied to their R&D projects. As more academic investigators adopt the NtK model and become more adept at carrying out the model's stages and steps with the assistance of the template and appropriate tools, an increase in successful technology transfers is expected to be realized- thereby benefitting the reputations of the academics themselves, their home universities, and funding agencies, while also providing to the marketplace needed innovations, which will benefit society in general. Likewise, manufacturers should begin to see collaboration efforts become easier and more efficient because they will no longer need to educate their academic partners on the NPD process.

This work also creates new research opportunities for management, new product development and technology transfer researchers. In particular, research is needed to translate the best practices employed by private sector practitioners into a context that resonates with academics investigators conducting TT. The development and implementation of practical tools that one can "take back to the lab" and use in their day to day work offers boundless opportunities for data gathering, tool construction and evaluation.

IV. IMPLICATIONS

In order to achieve wide-spread adoption of best practices, funding agencies and universities that employ academic investigators must adopt evaluation standards and provide rewards that recognize academic inventions and innovations as valuable outputs. Appropriate systems to incentivize application of best practices are growing, but have not yet been widely adopted. For example, at the policy level, the Department of Education's National Institute on Disability and Rehabilitation Research is now requiring many of its technology grantees to develop technology transfer plans within their first year of funding to demonstrate the commercial potential for their R&D projects. At the organizational level, the University of Arizona is now including innovation-related criteria in its promotion and tenure decisions, stating that in addition to traditional scholarly activity, the University will now also consider "cross-cutting collaborations with business and community partners, including translational research, commercialization activities and patents." (University Communications, 2013).

These positive changes are encouraging, but additional work is needed to determine the best strategies for expanding this systemic change throughout universities and funding agencies across the nation. Management and new product development researchers can help by exploring ways that best practices from industry can be transferred to public sector activities.

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