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Pipette to Pallet: A Journey from Academia to Entrepreneurship

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Abstract

Philosophers, politicians, and scientists alike have long understood that knowledge and technological advancement play a significant, dynamic role in the wealth ofnations. Subsequently, a thirst for innovation is at the forefront of many political, societal, and philosophical agendas. Academic research has been identified as a primary source of innovationand prodigious funding has supported this commonly held belief. One of the most direct methods for translating academic innovation into economic growth is by commercializing academic research. This process, known as technology transfer and commercialization, has gained traction over recent years by researchers, institutions, and entrepreneurs due to increased exposure of academic commercialization successes. One study found that over a ten year period, the number of annual executed licenses and number of startups launched has doubled. Despite this growth in research licenses and academic grounded startups, there are still two hurdles that inhibit many would-be scientist-entrepreneurs from making the jump from the lab bench to the board room: a lack of resources, and a lack of knowledge of the process to make the jump. Developing methodologies that support scientist entrepreneurs and demolishing the stigma of technology transfer that still inhabits some pockets of academia is critical for the efficient dissemination of knowledge from the laboratory to society. This paper contributes to existing literature on technology transfer by distilling pertinent information regarding thebenefits of technology transfer and highlighting personal experiences to create a framework in which to approach technology commercialization. This framework, presented as roadmap to commercialization could be employed by academics as they embark on their own technology commercialization endeavor. Additionally, the framework could be useful for academic institutions interested in increasing their commercialization output by streamlining their technology commercialization process.

Keywords: Commercialization • Knowledge • Production

Introduction

The classical view of economic production features inputs of labor, capital, and land. The economic value of these inputs is relatively measurable and understood [1-6]. When land has a resource of economic value (oil); investment capital (drilling rig) and labor (drilling rig operators) can be employed to create economic product from the rawinputs. Knowledge, which has been widely identified as the fourth input of economic production, is intrinsically uncertain, difficult to measure, and creates complex outputs that are often difficult to understand. However, knowledge, which can be acquired through formal academic edification or hands-on experience, is the cornerstone of industry-specific innovations. The primary drivers of economic knowledge synthesisare a high degree of human capital, a skilled labor force, a high presence of scientists and engineers, and most importantly, an emphasis on research and development [2]. Baregheh, Rowley, and Sambrook provide the purpose of research and innovation as innovation, which they define as "The multi-stage process whereby organizations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate them- selves successfully in their marketplace"[3].

Government and industry throughout the world recognize the economic potential of properly nurtured academic institutions and the innovation nurtured in their hallways and laboratories. This interaction between government, industry, and academia forms a 'triple helix' that drives innovation and subsequent economic impact through knowledge production and dissemination [4]. The United States government has consistently placed high bets on this link between academic innovation and economic growth. The NationScience Board found that, in 2013 "basic research was about 18% ($80.5 billion) of totalU.S. R&D performance, applied research was about 20% ($90.6 billion), and development was about 63% ($285 billion)" [5].

In recent years, the role of the university has been transforming to meet the increased demand for knowledge-based innovation. This has led to the development of what scholars deem a third-mission of universities; economic development that accompanies research and teaching [6]. The prevalence of this third-mission has led to the emergence of the 'entrepreneurial university' throughout the world. Etzkowitz H et al. explain the rise of entrepreneurialism in the university as "a response to the increasing importance of knowledge in national and regional innovation systems and the realization that the university is a cost effective and creative inventor and transfer agent of both knowledge and technology" [7].

It was this specific series of events that provided an opportunity for my entrance into academic research and eventually technology transfer. As an undergraduate engineering student, I was presented the opportunity to join a research team who, funded through DOD research funds, had created a new material to fight harmful microorganisms. By the time I joined the research effort, the basic science had been completed and the parameters of the grant had been fulfilled. However, rather than move onto the next academic project, our team had the desire, resources, and network in place to test the viability of the technology on the commercial market. We had little comprehension of the effort, time, and resources that would be required to translate this new material from our pipettes to customer pallets. However, we had a desire to realize the potential of our technology on the market, a supportive university environmentpromoting the third mission of economic development, and regional support from investors and a local start-up incubator. With these resources in place, we decided to step out from the microscope and into the market.

As we say in West Texas, there are many ways to bust a bronco. Such is thecase with transferring academic research to commercial products. However, Radosevich identified two primary forms of entrepreneurship associated with technology derived from academic institutions. The classical approach to commercialization is the inventor- entrepreneur (or

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academic-entrepreneur) approach whereby the PI of the project "spins off" a commercial endeavor from the academic research. In this model, the scientist often becomes the president or CEO of the spinoff company and is directly involved in the operations and direction of the company [8]. An alternative to this method is the surrogate entrepreneur approach. In the surrogate entrepreneur model, the technology source (often the academic institution) allows an external individual or entity access to the technology to develop a company [8]. Research shows universities that generate the most start-ups have more favorable attitudes towards this type of entrepreneurmodel [9].

The scientist or PI may be involved with the company in an official role (such as a CTO or R&D position), a temporary or contractual role, or not at all. Both of these models have strengths and weaknesses based on the institutional situation,characteristics of the scientist, and market position of thetechnology.

Interestingly, our commercialization journey included both of these models. Initially, we were approached by an external group interested in licensingacademic technologies to commercialize. We liked the idea of experience that this group brought towards the effort and believed their involvement would increase our ability to raise capital, identify relevant markets, form penetration strategies, and ultimately generate revenue. Our technical team assumed product development roles and had limited participated in business development and marketing efforts. After two years of product development and market research, we came to realize that sometimes a humble hunger for knowledge is more effective than a boastful possession. Though we did not know all of the intricacies of business relationships and marketing practices, we realized that we knew our product very well and had a vision for how it could make meaningful impact in target markets. For us, it made more sense to sever ties with the surrogate entrepreneurial arm and reform our efforts as an inventor-entrepreneur commercialization effort.

The transition into an inventor-entrepreneur model was not seamless, but it gave us the opportunity to learn more about the areas of business from which we had been shielded while also leveraging our technical knowledge to minimize pain points of potential customers. Just two months after making the transition, we began generating revenue and have since grown our customer base, product list, and market presence. The roadmap for commercialization presented in this paper focuses on the inventor-entrepreneur model that we have implemented in the second stage our technologytransfer journey. However, the surrogate-entrepreneur model has been proven effective in multiple industries. It is in the best interest of the inventor to consider both models when developing a path tomarket.

Roadmap

As hopeful inventor-entrepreneurs, we often found (and still sometimes find) ourselves spending large chunks of time developing contraptions to overcome molehills, but had little insight into traversing the mountains required to reach our ultimate goals. Creating a website is a necessary, worthwhile task; but who are we attempting to reach through this website we are creating? And, once we reach them, what do we want them to do? And, more importantly, how will that action transport us closer to being a "real company." Furthermore, what is a "real company" anyway?

We came to understand, through the tutelage of our local incubator, that iteratively answering these questions was at the crux of our success. As we answered these questions, a roadmap for commercialization began to develop. This roadmap, developed from our personal experience and supported by literature, is outlined through the remainder of this paper.Effort was taken to construct the roadmap in a manner broad enough to encompass the diversity of technologies that arise from academic research and yet specific enough to provide tactical information to hopefulentrepreneurs. The hope of this outline is to hew out a path through the fog, identify some of the obstacles that may be encountered, and allow readers to invest resources in the most impactful areas early in their ownjourney.

Evaluate Market Potential and Resources

Among the diverse scope of research questions, it is important to realize that not all research innovations can or should be commercialized. However, the realization that the deliverables of a particular project will not be suitable to technology transfer should not be used as a meter by which to grade the validity of the experimentation. Rather, all projects should be evaluated on the basis of how the learning will advance the field of understanding. Not all experiments have to be performed with the intent to commercialize. However, the sooner that a potential entrepreneur can recognize the ability of a project to, with adequate invention, creativity, and resources; be propagatedto commercial scale the better. For many academics, evaluating the potential of an idea to be produced on a commercial scale comes fairly naturally. The difficult, and yet more critical, investigation entails somehow determining if it is possible to convince a reasonable number of individuals or businesses to trade their resources for youridea.

Market potential

Ralph Waldo Emerson was purported to have proclaimed, "If a man has good corn or wood, or boards, or pigs, to sell, or can make better chairs or knives, crucibles or church organs, than anybody else, you will find a broad hard-beaten road to his house, though it be in the woods" [10]. Markets have undergone a prodigious change since these words were first spoken. However, we can surmise the perfect markets were as much a rarity in Emerson's time as they are today. Very rarely is the best idea, the most cost effective solution, or the highest quality good delivered to customers at the correctmarket share. Economists today recognize dozens of inputs extemporaneous the actual product that impact the viability of a commercial endeavor. However, academics in the twenty first century seem to suffer from the same widget-centric fallacy as philosophers in the nineteenth century. Kirchberger and Pohl [11] analyzed 108 peer-reviewed articles and found that of eleven factors associated with success in technology transfer ventures, the market value of the technology was the most under-researched. There are numerous companies who have fallen victim to a lack of market potential. However, the research problem mindset prevalent in academia means that technology transfer endeavors may be especially susceptible to this type of roadblock.

Fletcher and Bourne [12] point out that scientific exploration is almost entirely "production-led": scientists investigate based on intellectual curiosity, technicalexpertise, and resource availability, not necessarily the need for the specific technology outside of the laboratory. There is often very little consideration to market potential in basic scientific research, which allows for vast creative license and ingenuity but can easily produce technologies with limited market viability. However, the modern economy has made it no longer feasible for suppliers to be "production led" or to "find out what your factory can make, and then go sell that." Rather, manufacturers must analyze the needs present in the market and leverage their production resources to fulfill those needs.

Making the transition from a production-led to a market-led mindset is one of many mental pivots that academics turned entrepreneurs must make. Etzkowits [13] argues that such a transition may even be the first and most important milestone in the journey.

Developing sensitivity towards realistic market potential is an especially difficult pill for some to swallow, including our team. Even after all that we have learned through the commercialization process, we still find often find ourselves with ideas for new productlines or spin-off applications that we pursue out of our own desire to create the product, not out of an identified need for the product in the market. Building from ideas rather than data is not a recipe for commercial viability. Literature suggests that it takes, on average, the distillation of 3,000 ideas to create one commercially successful product [14]. Therefore, early in the technology transfer process, and continually throughout the endeavor, entrepreneurs should critically consider the actual value a technology has within specific markets and temper their commercialization aspirations against that potential added value.

Resource availability

Deep down, many inventors, even those who are market-led believe that a good enough products with the correct market fit will succeed regardless of the other factors in the equation. However, a majority of successful entrepreneurs will attribute their success to a host of factors extemporaneous to their superior widget or prodigious market need. It takes significant resources to make the leap from the warm academic laboratory into the cold, often harsh world of free-market economics. The term 'resource' could be used to describe virtually every dollar, relationship, skill, and connection to be employed in the commercialization effort. When a technology starts within the walls of an academic institution, there is an additional layer of gears that, when properly aligned, can serve as excellent resources and provide significant traction in the commercialization effort. Hopeful entrepreneurs can save time and more efficiently allocate resources if, early in the commercialization process, time is taken to analyze which of these resources (institution and external) are present in the current situation, which could be accessed easily, and which will require significant energy to secure.Our background in combustion synthesis led us to view the flow of these resources into a sustainable business as a self-propagating reaction. Because we work with energetic materials and more generally, fire, we have an appreciation for the effortit requires to ignite and control combustive materials. In order to create such a reaction, the necessary materials must be procured and then combined in correct ratios. An external energy must then be applied to initiate the reaction. Once the reaction begins, the correct conditions must continue to exist in order to sustain the flame. When examining the resources required for successful commercialization, these steps: prepare, initiate, and sustain; can be compared to the availability of capable human capital (prepare), influx of necessary financial capital (initiate) and presence of sufficient support networks (sustain).

Human Capital/Investigator Strengths

The best hammer on any jobsite would also make the worst screwdriver on another. Likewise, a brilliant scientist does not always a great entrepreneur make. Many, in fact, have argued that academics should stay out of free enterprise as a matter of principle and preservation of academic integrity [15]. It is, therefore, imperative that potential entrepreneurs evaluate their own strengths, weaknesses, and passions to determine if their particular skill set can be effectively translated from the laboratory to the boardroom. Much like mathematical skills or CAD ability, business acumen is an acquirable skill, though the path of acquisition for this particular skill set is far less regimented or straightforward than learning calculus. It often requires lessons from the school of hard knocks in addition to textbooks and lectures. However, it is more thanpossible to go from square one to successful entrepreneur under the right tutelage, ask any MBA professor or business coach.

So the question isn't "can I complete this journey?" but rather "should I embark on this journey." You can learn to network, but is running a business, managing people, serving customers, and taking money in exchange for the delivery of your goods, really what sets your heart on fire? Or, would your time, heart, and mind be better served exploring in the laboratory?

If it is determined that the journey should be undertaken, then the next question is do you have the necessary time to devote to the endeavor? The degree of engagement with the commercial endeavor is going to be highly correlated to the time commitment required as well as the career risk undertaken and subsequent potential economic stimulus gained from the effort [12]. Time manipulation is a zero-sum game. Every minute is an investment in something, whether the yield is fruitful or wasteful. In most cases, every hour of effort invested in a new enterprise is an hour taken away from research, administration, teaching, self-edification, or family. "Managing a tech transfer company while maintaining my position in academia and my commitment to family has a unique flow to it. For me, the passion that I intrinsically have for innovation in the laboratory and the immense possibilities for our growing company drives me forward on bothfronts. Flexibility is also a key factor for me as priorities and tasks in all parts of my life are constantly in flux."

Regardless of the entrepreneurial talents and time devoted to the work, there will undoubtedly be obstacles that require specialized skill sets and experience to overcome. Our journey has led us to believe it imperative for hopeful scientist-entrepreneurs to assemble a team of partners and mentors to fill in the gaps ofknowledge, experience, and skill required to successfully transfer the technology to the market. The value of a functional team has been well demonstrated in academics, athletics, and business. For technology transfer teams, it is especially useful if some members are concurrently involved in industry and the commercialization effort.As found by Franklin et al, [9] technology transfer efforts have the greatest chance of success when there is a combination of academic and surrogate entrepreneurs involved. As shown in (Figure 1), we found that within our company, each influx of human capital resulted in a sharp increase of some type in our business model. We can even look back now and judge the success of various hires on the subsequent increases in the relevant metrics within the business. Capable human capital is an absolute requirement for a successful transfer of technology from the laboratory to themarket.

Even with the perfect mixture of human capital in place, a reaction requires activation energy to initiate the reaction. Entrepreneurial finance, which primarily refers to the early stage finance mechanisms that are utilized to lift the venture into the startup phase, are often supplied by the investigator's personal network [16]. However, a plethora of funding opportunities abounds including venture capital investment, joint stake investment from industry partners, and personal financing through loans or assets. Very early in our commercialization journey, we were offered the opportunity to receive a financial investment from a few different venture capitalist groups in exchange for a stake in what would become a company. However, we found that Ellen Rudnick words rang absolutely true in regards to our various investment groups "It's not just about money, it's about chemistry" [17]. We reached a point where it was necessary to restructure our equity holdings to primarily lean on a venture capital group that was based in our region and had an extensive history of successfully investing inlocalbusinesses. Bringing these particular investors into the endeavor was incredibly beneficial, if not obligatory given the startup costs and long buying cycles in our particular industry. In addition to the financial backing, our investment group has also provided guidance, exposure, and access to markets that would have taken significant resources to break into ourselves. The financial backing allowed us to invest far more time in the effort than would have been possible had we self-funded the startup.

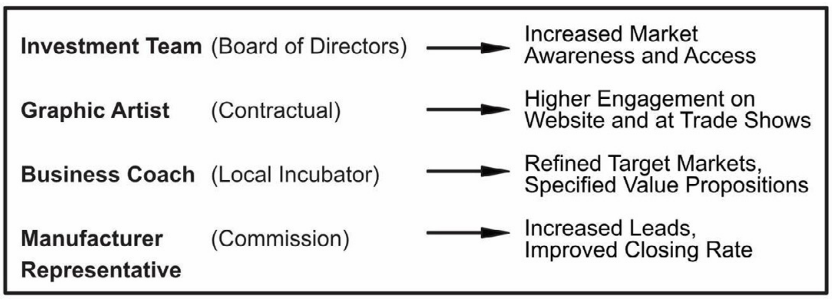

Figure 1. Influx of human capital and subsequent business outcomes.

However, after getting into the business of starting a business, we realized that there are more options for generating startup capital than what we had been aware of, some of which require less or no equity in exchange for funding. There are a number of programs funded by local economic development offices, state or university based offices, and national or governmental offices that offer capital to startup and early stage businesses. Recently, crowd funding has also risen in popularity for traditional entrepreneurs as a source of financing. But the success of this source has yet to find significant footing in academic technology transfer efforts [16]. The federal government SBIR and STTR programs represent the largest seed-stage funding sources for companies in the world, totaling more than $2.2 billion each year [18]. Our team pursued several of these programs and eventually won sizeable funding through a business plan competition hosted by our local economic development office and small business incubator. For us, the experience gained from preparing a business plan and pitching it to external groups was even more valuable than the funding received from the program. There are many online resources for exploring venture capital and seed funding resources, however local startup incubators and economic development offices are also good places to begin the search and may have information on regional opportunities.

Regardless of the source, to successfully translate a technology the venture requires enough capital to not only secure rights to the technology and establish a business, but also to fund that business through to solvency. There has been significant research devoted to the "valley of death" that claims a large number commercialization endeavors on the path to solvency [19-23]. The phrase "valley of death" refers to the bottom portion of the curve formed when the cumulative profit and loss of a company is graphed against time. Osawa and Miyazaki [19] showed that overcoming this valley of death is critical in achieving success of a product and, in the case of products that represent a large portion of a firm's overall revenue, the success of the entire business. A leading indicator of a company's ability to overcome the valley of death is the ability of the business to finance operations through the valley and into solvency (Figure 2).

Support Networks

When the proper human capital is in place, and the necessary financing is available, many startup ventures will have the resources to ignite a commercial flame. However, fire, much like a fledgling company, is a dynamic phenomenonthatrequires specific environmental inputs in order to be sustained. For a startup technology transfer, establishing a network of support around the company is an incredibly valuable endeavor that helps nurture the flame through the early stages of startup andgrowth. Starting a company is hard. As a mentor of mine told me, "If you knew what it took to start a company, you'd never do it." As an entrepreneur, you are continually forced to operate outside of your comfort zone. Your mind is stretched to problem solve (which we love as academics). However, unlike many academic challenges, often the solution that you derive for a particular business issue (like not selling enough products) is difficult to test and it can be incredibly frustrating to troubleshoot the results when the desired outcomes are not met. The ambiguity that tends to accumulate among many decisions, actions, and outcomes at a startup enact a significant toll on the emotional fortitude of any founder. We have found that the best way to maintain perspective, sustain a steady influx of wisdom, and nurture emotional fortitude is to establish and maintain a matrix of groups and individuals around the business that are invested in the success of the endeavor.

This support network will be based on the geographic location of your startup and product space. This matrix will look different for every company, but most will feature nodes that function as sounding boards, marketing advisors, time-management guides, motivation coaches, perspective mentors, and human resource consultants. Our system consists of a select few pivotal colleagues at our university, our local startup incubator (which is also associated with our university), board of directors, and personal mentors for each of our co-founders. The most important relationships in our business, however, are the ones that exist between each of the cofounders. There are certainly many successful businesses that have been established by a single founder, but these authors consider such feats to be extraordinary. The relationship network between our co- founders keeps everyone grounded, motivated, and upbeat. When combined with the insight of our external network we consider ourselves to be well supported, yet we still actively invest time and resources in expanding our network to increase our durability as well as invest in the networks of others. Networking groups can be found through the Kauffman foundation (www.kauffman.org); America's Small Business Development Centers (www.americassbdc.org);

Intellectual Property and Patents

Often, research within a university that has potential for commercial value will be identified by the technology transfer office without beckoning from the PI. If a research work has not yet been identified by the TTO, the PI can initiate the process by presenting the project as a potential patent to the TTO. Stevens and Burley identified an informal screening process that major firms use to separate ideas from patentable technology; these 5 elements in this process can be applied towards any research project as a screening mechanism for potential economic viability [14].

Several leading entrepreneurial experts have recently began teaching methodologies for IP protection that do not rely as heavily on traditional patents. In some industries, speed to market and established brand awareness in the market are as useful (if not more) than traditional patents (cite Lean Startup, One Simple Idea). Though thismodel has found

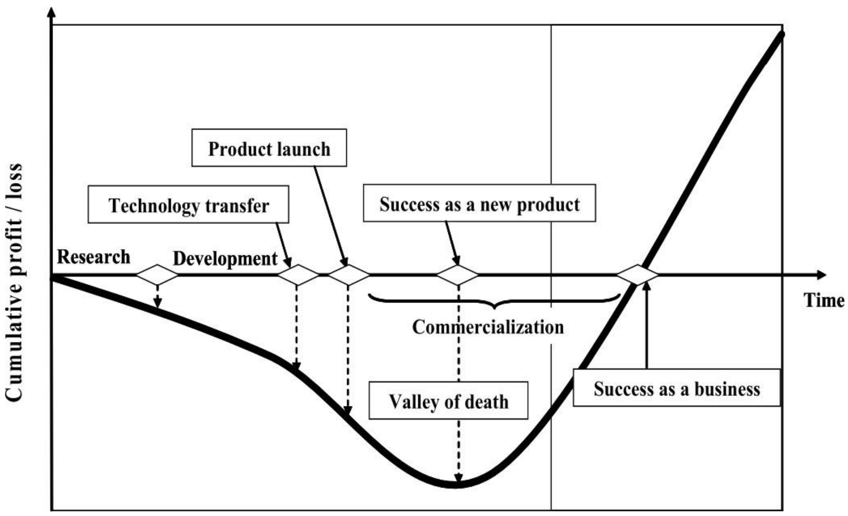

Figure 2. Valley of death for startup venture.

traction in traditional entrepreneurism, the intrinsic nature of technology transfer almost necessitates a formal patent on the technology before true commercialization can begin. At most universities in the US, the process of applying for, receiving, defending, and licensing a patent is handled by the university technology transfer office. This process, which has been well studied and documented by Van Norman and Eisenkot [24] is unique to each institutional system but often looks similar to (Figures 3 & 4).

Neither academia nor government has been accused of moving with exceptional haste. As imagined, this trend is not reversed when the two entities must mesh to executea task such as patenting an academic technology. The length of time that between when a technology is "discovered" and when the university chooses to file a patent can vary drastically. One the patent application is filed, it take, on average, between 2 to 3 years for a patent to be issued [25]. For us, this process took almost

Five Elements of a Patentable Technology in Major Firms

1. The idea passes muster with an informal peer review and literature review.
2. The idea seems to actually work in the laboratory, and it is likely to be reducible to practice.
3. The concept has a glimmer of commercial utility.
4. The idea appears to the inventor to be new and novel.
5. Laboratory management, if present, sometimes wants to help decide whether the disclosure should be submitted.

Figure 3. Five elements of a patentable technology in major firms.

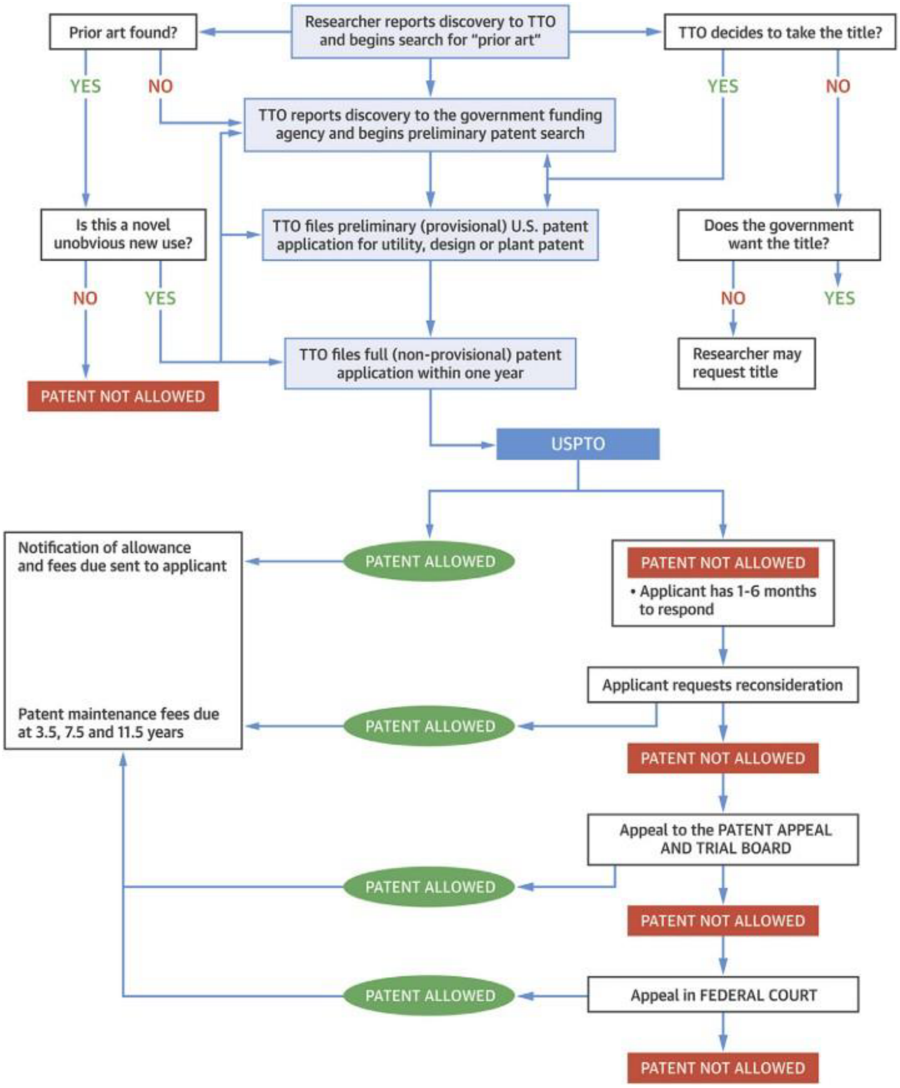

Figure 4. Overview of common TTO patent process.

4 years. However, once patented, the outlook for a research work making it to the product list of a commercial company improves almost insignificantly. Kneller found that between 2% and 50% of all university patent applications are eventually licensed [25].

Develop Business Model

Demonstrative of the entrepreneurial novices which we were, we made it very deep into our technology transfer journey before we even thought to develop a business plan. We had documents; written plans for executing certain tasks, timelines to achieve goals, a copious amount of white papers and reports on the effectiveness of our technology, but nothing that could be disguised as even a rudimentary businessplan. Looking back, we cannot believe that we failed to recognize the value contained in such a document or the knowledge that would be gained by creating it. Engaging in the business writing process produced a statistically significant inflection point in our operating procedures, financial management strategy, marketing efforts, andrevenue. Once the resources available to a future entrepreneur have been analyzed and prepared for utilization, a logical next step could be constructing a business plan.

The term business plan is well recognized nomenclature that describes a document outlining the purpose, value, scope, operational mechanisms, and required resources for a business to succeed. However, as we learned about the various aspects of the document; the way in which it is constructed, applied, and changed over the life ofthe business, we realized that the classical term “plan” is not the most astute title. We discovered that a business plan is not a blueprint of how to build a successful business.

Such a document would present well to investors, look nice when bound in a three ring binder, but would be outdated soon after the ink dries. Rather, as engineers, our team found it helpful to view this document as a model rather than a plan. Schematics are written to be executed, but models are built to be tested. A robust model accounts for as many relevant inputs as possible, and is constructed with the expectation of augmentation over time. Models can be exploded to analyze the interaction of certain pieces and subsystems individually. Most importantly, models are built so that various inputs can be applied and subsequent results analyzed. Then, changes to the structure are made, the inputs are reapplied, and changes in the results are compared. As Steve Blank has often stated “no business plan survives first customer contact.” Therefore, plans should be written and executed with the intention to iteratively analyze the functionality of the model and augment as necessary to improve effectiveness and efficiency. Our team utilizes the Business Model Canvas (Figure 5) developed by Osterwalder, Pigneurand Clark [26] as a canvas for our model creation and iteration. The Business Model Canvas is also a valuable to tool sketch out the business model before delving into each topic more in a traditional business plan.

There are a plethora of resources available on developing a business plan. In our experience, the true value was found not in the specific topics included in the plan itself, but rather in the exercise of examining the intricacies of our business and aligning them with long term milestones and expenditures. The US Small Business Administration (www.sba.gov) is a useful resource to begin the business plan writing process. Likewise,there are a number of useful resources to teach the process of utilizing the Business Model Canvas. Strategyzer (www.strategyzer.com) has been an especially helpful tool for us.

Execute Business Model

Once a business model has been developed, the next step is to execute. If a paradigm transition has not yet occurred in the mind of the future entrepreneur, this is the point in which it must. It is imperative that the focus be turned away from the technology itself and onto the customer and operations that will allow the business to reach and help said customer. This sounds like an obvious shift, but a technology-centric mindset has a habit of lingering among academics, especially those who have birthed the

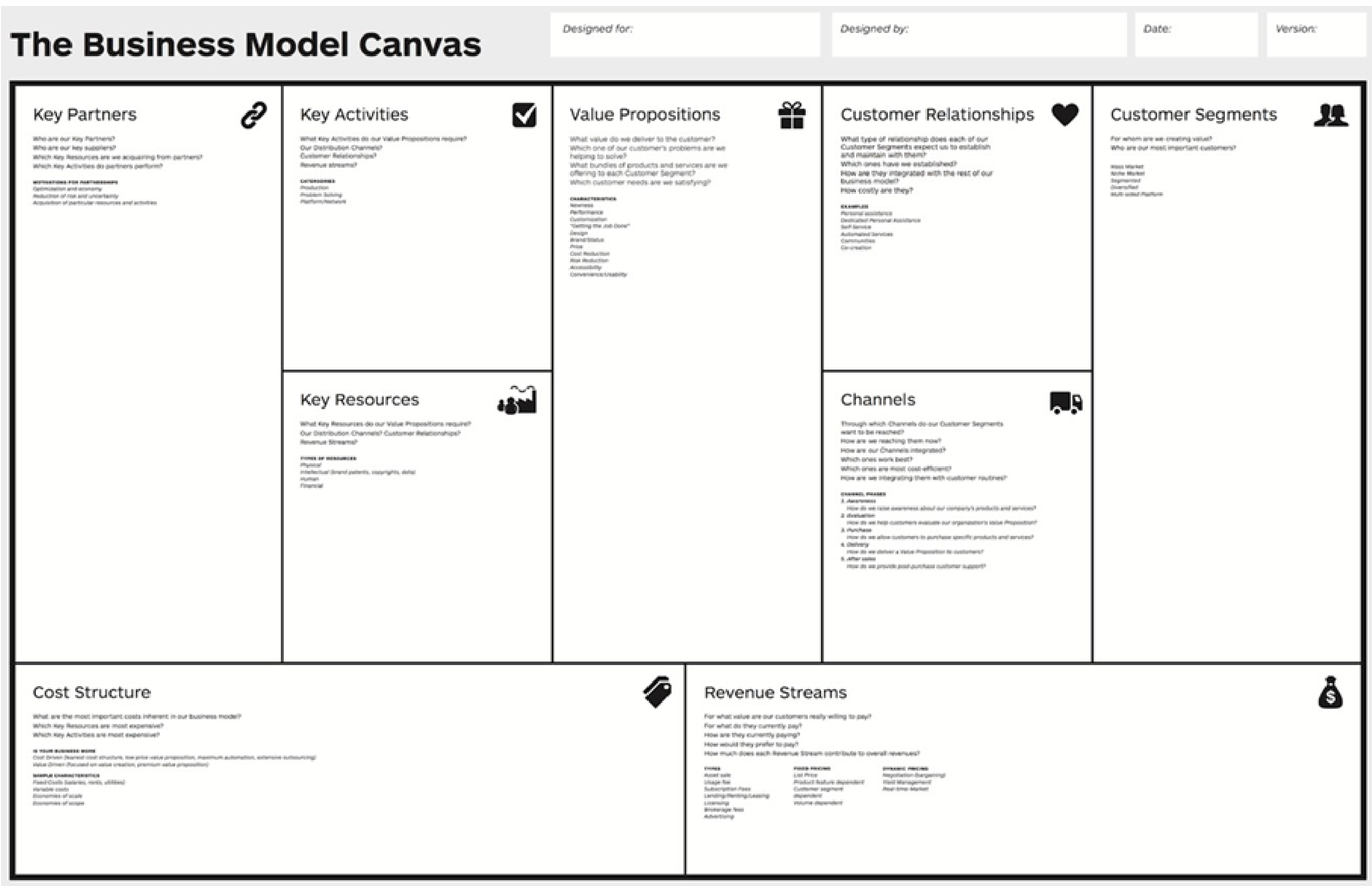

Figure 5. The business model canvas.

Figure 6. First Sale of product developed using lean model method.

technology into the world directly. When we turned the first draft of our business plan into our business coach for feedback, we now know that he had to hold back a laugh. We had laboriously shrunk the background, design process, testing procedure, effectiveness, and application of our technology down to a concise five page section. Our coach took joy in telling us it needed to be two paragraphs. That story highlights our inability to accept that the technology works, that it will continue to perform as the testing shows it will, and that anyone who will buy it will cares far less about whether it works or not and far more about why buying it will make their life better. Our customers do not purchase our products because they perform as we say they do. Performance is intrinsically expectedin any product that has reached the market. Our customers buy because they understand how that performance will solve their problem. This marks the transition that had to occur in our paradigm. Our job was no longer to convince the world that the technology works, our task was now to convince a specific segment of the world that they need to purchase it. A key lesson for us was that, in most cases, the customer motivationforpurchasing had very little, if not nothing, to do with the fact that the product performs as we profess.

Commercializing an academic technology is, in many ways, backwards from the way that products are usually brought to market. In most circumstances, a firm or inventor recognizes a problem impacting a specific population and then develops a product that can be delivered to the person or business for economic gain. However, in many technology transfer endeavors, the “product” has already been developed but the “problem” and “population” may be only partially defined or not recognized at all. So, the task of an entrepreneur in this situation is to determine who could potentially want to buy the product (population), developing a deep understanding of the situation and beliefs that lead them to a place where they may want to buy (problem), and figuring out a way to deliver the solution (product) to them in a cost effective, sustainable, and profit- generative manner.

There are three questions that drive the actions of an early startup. Who wants to buy? Why do they want to buy? How do we deliver the product to them? The business model is a methodology for developing an answer to these questions. If we treat the value proposition as a research hypothesis, then we use the flow of the business model to construct an experiment to test that hypothesis under certain conditions. For instance, we believed that we could use a derivative of our technology to inhibit the growth of mold and mildew in buildings. We utilized our business model to test this hypothesis assuch:Overarching Hypothesis (Value proposition): Technology that inhibits the growth of mold and mildew in buildings would be a valuable product to multiple populations.

Assumption 1: One population that would be interested in the product is customers with young children are interested in protecting their children from the risk of air-borne mold spores.

Assumption 2: In order to activate these customers, they need to be:

A. Educated on the harmful nature of air-borne moldspores

B.Made aware of the prevalence of mold in USbuildings

C.Exposed to our product that would solve theirproblem

Assumption 3: Activated customers would be interested in buying a product, packaged as a liquid in a single-serve bottle, that could mixed into interior paint to prevent the growth of mold.

Assumption 4: These products could be manufactured cheaply enough that activated customers are willing to purchase them in large enough quantities to justify the product.

Assumption 5: Potential customers could be reached, activated, and sold to online.

As you can see, from an experimental design perspective, the complexity of the experiment grows exponentially as assumptions are developed to test the overarching hypothesis. Accurately identifying all of the relevant assumptions and hypothesesassociated with selling a product is where a research background can shine. However,designing methods to cost effectively test the most important assumptions and hypothesis is where the art of business integrates with the science of experimentation. Our team found that the best way to resolve these incongruencies was to start with small, important tasks first, and execute them really well. It is far more beneficial to have a concise, specific, well tested webpage to direct traffic to than an expansive, expensive, and untested website and mass marketing campaign. While designing this test constructs, it is also advisable to keep the operation as lean as possible. We are not scared of large expenditures, but we are incredibly strategic with how we allocate financial and human resources to make sure that the most important things are being done first and that time is allocated to reflect our goals. During the course of testing and executing the business model, you will undoubtedly experience the euphoric feeling of closing your firstsale.

Close the First Sale

There is a tendency among aspiring entrepreneurs to build and build and build a product, delivery system, supply chain, and brand. Then, once everything is perfect, press play and watch the sales roll into this perfect sales funnel that you have put intoplace. We did that for 18 months and did not generate a single dollar of revenue. Though there were a plethora of problems that we now recognize in our systems looking back on those early days, I know that one primary issue we had was this “build it and they will buy it” mentality. While this system may work for a well-tested product in an established market segment (like selling lemonade at a soccer tournament) it is not an effective way to build a business around a product that has not been previously exposedto the market. Our experience revealed that a sell-build-tweak-sell-build format is much more efficient when bringing a new product to market. In other words, entrepreneurs should iterate quickly and release new product versions often.

This methodology, which has also been laid out well in *The Lean Startup* and many other entrepreneurial resources, means that sales are not completed goals but rather data points for potential pivots. Each dollar of revenue generated (and each dollar of revenue that was expected but not generated) serves as an opportunity to learn and optimize the product presented to the next set of customers. The processes forces entrepreneurs to be customer rather than product focused. It hurts far too much to spend six weeks designing a new box design for your product, only to find out that customers would rather the product not have a box at all! This method also prevents dogma, forces efficiency, and keeps the entire company nimble. As Reid Hoffman, founder of LinkedIn, has famously quoted, “If you’re not embarrassed by the first version of your product, you have launched too late.” This ideology, which has become a mantra in the world of startups but unfortunately has yet to find traction in the proofreading of academic publications, allows startups to stay small and nimble much longer than traditional company growth trajectories.

This lean business operating system also means that new products generate revenue far more quickly than those with long, comprehensive development cycles. When we launched the first version of our mold inhibiting paint additive, we had only 8 weeks between conception of the product and first revenue. Though we ended up actually losing money on the transaction (pesky shipping charges), we were thrilled to have established a data point so quickly in the process, Figure 6. For us, operating leanand iterating quickly affords us time to gain traction in new markets without managing a huge payroll and complex supply chain. The limited resources required in the lean model also allow us the freedom to explore new product ideas and markets without risking our limited resources.

Close the Rest

As sales begin rolling in, the focus can shift slightly away from iterative product development and onto systematizing the business to facilitate growth. As fun as it was for us to receive an order from our website, prepare the requested product, package that product, create a shippi ng label, and take that individual product to the UPS store, we knew that process would never be sustainable model for our business. We had to systematize our procedures, engineer batches, and create repeatability into all of the recurrent tasks in the business.

For us, the process of systematization started by analyzing how a “standard” lead percolates through our business. Company B saw our booth at a trade show, they responded to our follow-up email and wanted to know if we could incorporate our antimicrobial into their X line of products. We believed the request was possible so we enacted NDA’s, shared the necessary technical information, created samples for testing, shared test results, and worked out a contract for putting a pilot project inplace. Systematizing this process required distilling the outcomes down into key tasks, and then normalizing those tasks between different leads. We then assigned specific employees to manage certain aspects of the lead flow and created systems to expedite the flow through each step in the process. Once this system is in place, then, in theory, allwe have to do to generate more pilot projects is attend more trade-shows. The follow-up emails are automated, the response system is set up to receive replies, the legal paperwork is ready for slight modifications, the laboratory is ready to receive samples for testing, and the format for result presentation is in place. The machine has yet to putter along as smoothly as that, but the systems are in place and being refined after each lead is sorted through the chain. We believe that this system is how we grow from one-off projects to repeatable, consistent sales and, subsequently a robust business that has moved from a startup into an industry leader.

For our team, the journey from measuring our material by the pipette to now delivering product by the pallet has been an incredible story of personal growth. Our inexperience in the realm of businesses enabled us to see many challenges and opportunities more creatively than if we had been burdened with decades of experience in international trade and business to business sales. However, we fully acknowledge the benefit of experience and the wisdom that can be gained from analyzing the insight of others. Subsequently, we hope that the five steps within this roadmap provide a practitioner's perspective on initiating and managing a technology transfer endeavor. For readers who may be uncertain about undertaking such a task, we urge you to start. Delve into the market potential of the technology, begin analyzing your resources and human capital, explore potential finance sources, and develop a model of how the business might operate should you decide to breathe life into the idea. Should you decide that the model is executable, we can say, unequivocally, that pursuing the commercialization of your technology will make you a better researcher, scientist, communicator, and member of your community.

References

1. Palmintera D, Joy J and Lin E. “Technology transfer and commercialization partnerships.” Reston, VA Innov Assoc (2007).
2. Audretsch DB. “Standing on the Shoulders of Midgets: The U.S. Small Business Innovation Research Program.” Small Bus Econ 20(2003): 129-135.
3. Baregheh A, Rowley J, and Sambrook S. “Towards a Multidisciplinary Definition of Innovation.” Management Decision 47 (2009): 1323-1339.
4. Etzkowitz H and Leydesdorff L. “The Future Location of Research and Technology Transfer.” J Technol Transf 24 (1999): 111-123.
5. National Science Board. Research and Development: National Trends and International Comparisons. Sci Eng Indic (2016): 1-105.
6. Frye JH and Readings B. “The University in Ruins.” History of Education Quarterly 37(1997): 208.
7. Etzkowitz H, Webster A, Gebhardt C and Terra BRC. “The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm.” Res Policy 29 (2000): 313-330.
8. Radosevich R. “A model for entrepreneurial spin-offs from public technology sources.” Int J Technol Manag 10 (1995): 879-893.
9. Franklin SJ, Wright M and Lockett A. “Academic and surrogate entrepreneurs in university spin-out companies.” J Technol Transf 26 (2001): 127-14.
10. Lienhard JH. “Inventing modern: growing up with X-rays, skyscrapers, and tailfins.” Choice Reviews (2013).
11. Kirchberger MA and Pohl L. “Technology commercialization: a literature review of success factors and antecedents across different contexts.” J Technol Transf 41 (2016): 1077-1112.
12. Fletcher AC and Bourne PE. “Ten Simple Rules To Commercialize Scientific Research.” PLoS Comput Biol 8 (2012): e1002712.
13. Etzkowitz H. “Innovation Lodestar: The entrepreneurial university in a stellar knowledge firmament.” Technol Forecast Soc Change 123(2017): 122-129.
14. Stevens GA and Burley J. “3,000 Raw Ideas = 1 Commercial Success! Res Technol Manag 40 (1997): 16-27.
15. Pelikan J. The Idea of the University A Re-examination. Yale University Press (1992).
16. Audretsch DB, Lehmann EE, Paleari S and Vismara S. “Entrepreneurial finance and technology transfer.” J Technol Transfer 41 (2014): 1-9.
17. Kellogg S. “Start-ups: In search of venture capital.” Nature 472(2011): 379-380.
18. Marek KW. “The National Heart, Lung, and Blood Institute Small Business Program: A Comprehensive Ecosystem for Biomedical Product Development.” JACC Basic to Transl Sci 1 (2016): 660-665.
19. Osawa Y and Miyazaki K. “An empirical analysis of the valley of death: Large-scale R&D project performance in a Japanese diversified company.” Asian J Technol Innov 14 (2011): 93-116.
20. Barr SH, Baker T, Markham SK and Kingon AI. “Bridging the Valley of Death: Lessons Learned From 14 Years of Commercialization of Technology Education.” Acad Manag Learning Edu 8 (2009): 370-388.
21. Frank C, Sink C, Mynatt L and Rogers R. “Surviving the “valley of death”: A comparative analysis.” J Technol Transf 21 (1996): 61-69.
22. Butler D. “Translational research: Crossing the valley of death.” Nature 453 (2008): 840-842
23. Theses G, Elizabeth GK and Elizabeth K. “Bridging the valley of death: The rhetoric of technology transfer.” Acad Manag 8 (2017).
24. Van Norman GA and Eisenkot R. “Technology Transfer: From theResearch Bench to Commercialization: Part 1: Intellectual Property Rights Basics of Patents and Copyrights.” JACC Basic to Transl Sci 2 (2017): 85-97.

25. Kneller R. "Technology transfer: a review for biomedical researchers." Clin Cancer Res 7 (2001): 761-774.

26. Osterwalder A, Pigneur Y and Clark T. "Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers." Wiley (2010).

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