The Triple Helix Model of Innovation and its Impact on Academic Entrepreneurship

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Jacob Morris

Spring 2021

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Sean M. Ferguson, Department of Engineering and Society

STS Topic

The interrelatedness between academic innovation, the government, and the economy has been well documented for decades. All three of these entities have been shown to shape the others, and their interactions can be best described by the Triple Helix Model of Innovation. Generally, government policy has been known to put in place laws and policies to incentivize university-based innovation, which in turn affects the overall economy. While that has been established in many studies, further investigation is needed to determine how academic entrepreneurs pursue or bypass commercialization of their innovative research. Academic entrepreneurship outside the US was investigated, an interview with an academic entrepreneur was conducted, and the Michigan State University Bioeconomy Institute was inspected. These case studies were chosen to shed light on how other countries approach academic entrepreneurship, to gain valuable insight on the thoughts and feelings of an innovator inside academia, and to give an example of a successful entity that turns academic knowledge into transferable goods.

Framework

Currently, there are numerous examples of how science and technology fueled innovation is limited or advanced by government driven policy. For example, a cohort of 166 individual studies outline the initiatives in place for ventures in academic entrepreneurship (Sandström, et al., 2018). On the one hand, there are many incentives in place to encourage academic entrepreneurship (AE) fueled by government policy with intentions of economic stimulation. These incentives allow certain stakeholders and entrepreneurs to facilitate their ideas into tangible

innovation to be subjected to market pressure. Such a scenario is produced when policy provides a startup for entrepreneurship and the overall interests and capabilities of researchers align with the goal of the incentive, as shown in Figure 1.

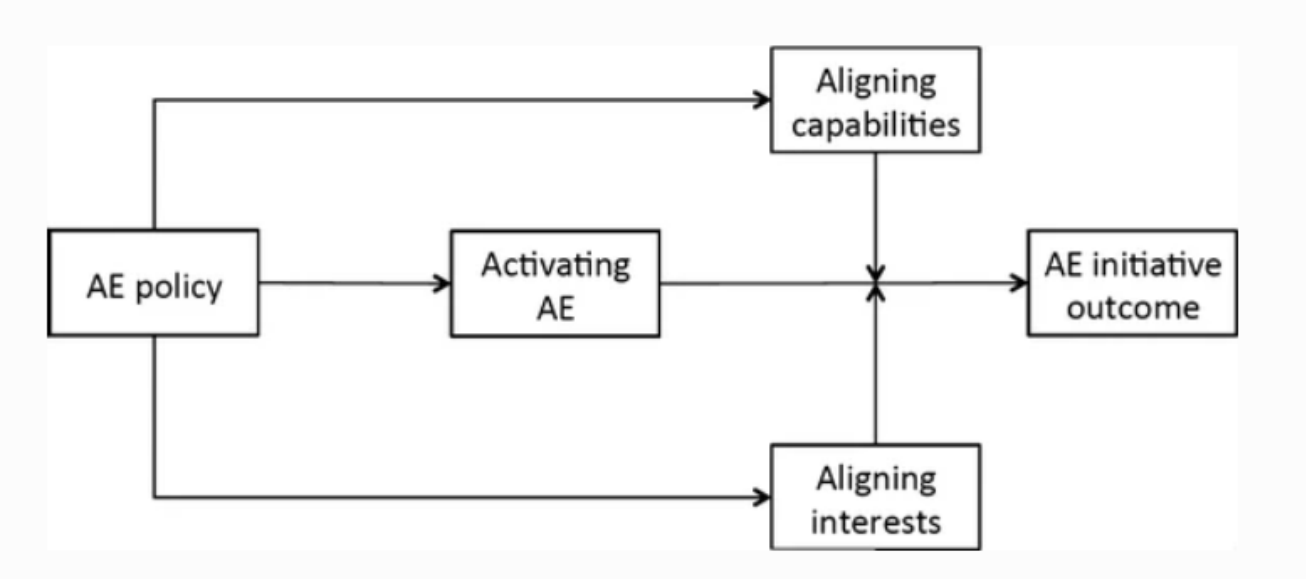

Figure 1. Model for effective Academic Entrepreneurship (AE) incentives

Alternatively, Sandström also notes that there are very few environments built to truly take advantage of these incentives and endure long term. For these initiatives to be most effective, researchers and their partners must be aligned with the intention of the incentive itself. However, oftentimes researchers in academia choose to remain focused on publishing papers, teaching, and conducting other research outside of their AE ventures. This conflict of interest can result in lower levels of productivity and could eliminate the possibility of commercialization, rendering the incentive ineffective. In fact, due to the instability around current

initiatives, this study goes on to suggest that there could be alternative ways to facilitate the transfer of academic invention into societal goods and services.

Like lackluster incentives, as explained by Forsberg et al. (2018), the patent system presents its own obstacles to the academic community when attempting to foster academic innovation. For instance, there have been ethically based restrictions incorporated into patent legislation when regulating research in the field of biotechnology. These restrictions are in contrast to the ideals of the academic community, which tends to advocate for a more "open science" approach to promote discovery and innovation. This divide can lead to academic innovation being halted before it even has the chance to start. This friction has even prompted policy to be written in a confusing or misleading fashion, to further spite the academic community. This schism between the patent system and the academic community exemplifies another possible hurdle for academic entrepreneurs to jump, hindering the opportunity for their innovations to be funded and ultimately commercialized.

The Triple Helix Model of Innovation highlights the overarching relationships between academia, the government, and the economy. Since the 1960s, there has been international debate regarding how large of a role colleges and universities should take in the transfer of knowledge and generation of technology for the greater society (Etzkowitz & Leydesdorff, 2000). Some looked to the current system to quantify overall "market pull" or "technology push" in order to define such roles, but the current system at the time was deemed insufficient to adequately incorporate these parameters. It has been noted that academic

publications and patents on marketable technology are produced from vastly different systems. In the United States, various programs were created to close this gap and incorporate both industry and academia via public policy. A powerful subset of these programs includes: the Small Business Innovation Research program (SBIR), the Small Business Technology Transfer Program (STTR), the Advanced Technology Program (ATP), and the Engineering Research Centers of the National Science Foundation (Etzkowitz & Leydesdorff, 2000).

Additionally, many ventures in science and technology have been seen as a valuable cog in the economy and have been thought to improve economic outcomes (Berman, 2014). For example, the America COMPETES Act of 2007 and a similar bill passed in 2010 were signed into law in order to "increase the economic competitiveness of the United States" and to "[develop] a globally competitive STEM workforce" (Berman, 2014). Yet, Berman points out that there is no sound evidence that the programs these policies create and the subsequent funding into them correlate to economic growth. In fact, this move towards economization of research and innovation can come at the expense of acquiring crucial knowledge, solving critical problems, and other societal benefits. The overall efficacy of these policies calls into question the efficacy of the Triple Helix Model itself.

Alternatively, rather than creating policies to make academic innovation more available and incentivized, some have argued to change the way that innovation is governed via the patent system. Parthasarathy (2020) argues that both patents and intellectual property should be more regularly subjected to political and policy-based discussion. By more closely controlling IP and policies that exist to regulate it, it is believed that innovation and discovery could be made

optimal for societal benefit. Allowing researchers and academic entrepreneurs to more freely explore ways to contribute to the greater good could allow innovation to flourish. This can be accomplished through a refurbishment of the patent system which would eliminate systemic barriers to discovery, and possibly even benefit the economy.

Exploratory Study of Entrepreneurship Programs

Further research into the Triple Helix Model of Innovation and how it applies to academic entrepreneurs is needed to understand the impact it has on overall academic innovation. An investigation will take place to see how each helix ultimately enables or discourages academic innovation. It could be found that innovation is degraded because there is too much of a focus on commercialization and not enough on pure ideas to help others. On the other hand, marketability could be seen as a driving factor for innovation and motivate more researchers and professors to pursue such solutions. Both a deeper dive into existing literature and conducting interviews with essential stakeholders could shed light on this situation. For example, known academic entrepreneurs seeking to further their field of work via innovation could provide valuable insight into the current system. This could point towards these stakeholders leaving the Triple Helix network and collaborating with a third-party group to carry out business. Additionally, research into organizations that serve as an example of larger bodies that help facilitate academic innovation into marketable products, will be conducted. Furthermore, the options presented towards academic inventors are more motivated to help others, rather than those looking to commercialize, will be explored: mainly, whether or not the same funding and encouragement would be provided.

More in-depth research was conducted to further examine the Triple Helix Model of Innovation. It was intended to use ideas and concepts from the Triple Helix framework to reveal what goes on within university settings. In particular, academic entrepreneurship outside the US was investigated, an interview with an academic entrepreneur was conducted, and the Michigan State University Bioeconomy Institute was inspected. These case studies were chosen to shed light on how other countries approach academic entrepreneurship, to gain valuable insight on the thoughts and feelings of an innovator inside academia, and to give an example of a successful entity that turns academic knowledge into transferable goods. This analysis of said case studies was done in hopes of comparing and contrasting different systems and their impacts on economization of academia-based technology. Ultimately, the need for a fourth helix to be added to the existing framework is realized, so that academic innovation can be better commercialized.

Case Study: Academic Entrepreneurship in Ireland and Sweden

Similar to the United States, economies in Europe can struggle turning academic innovation into commercial success. As a result, a study was conducted in Ireland and Sweden to examine the frequency and fashion of academic entrepreneurship in each country. A closer investigation into how these two countries approach economization of university-based technology could be applied to the system in the U.S.

On one hand, Sweden is a nation whose government funds university led research and development, supports programs that link universities with industry to encourage technology transfer, and place technology-based firms near universities

to further foster technology development (Klofsten & Jones-Evans, 2000). On the other hand, the Irish government directs more funding towards traditional sectors, such as food and metal production, leaving the technology sectors to be outsourced to foreign companies (Klofsten & Jones-Evans, 2000).

Nearly 2,000 responses from academics in Ireland and Sweden were recorded reporting on the current state of academic entrepreneurship in each nation. While 69% of them had contact with industry in some capacity over the previous 5 years, the activities weren't centered around entrepreneurship: they were more geared towards consulting, contract research, and large-scale science projects (Klofsten & Jones-Evans, 2000). Furthermore, as supported by the literature, nearly a third of respondents stuck solely to their university duties of research and teaching (Klofsten & Jones-Evans, 2000). Of those that were in contact with industry, less than half of them were proactive seeking out possible partnerships (Klofsten & Jones-Evans, 2000). This could be due to a lack of marketing by universities that would highlight the impact they could have on technology transfer. Lastly, Irish academics reported their universities were more supportive of academic entrepreneurship than their Swedish counterparts and because of this, they were more likely to use their industrial liaison office (ILO), connecting them with contacts within industry (Klofsten & Jones-Evans, 2000). This is a peculiar finding mostly because of the funding and resources the Swedish government invests in to facilitate technological transfer between universities and the economy. These results speak to the influence universities can have on technology transfer between their employees and the economy through their encouragement, or lack thereof.

Case Study: Malaysia and the Hybrid Triple Helix

From the 1950s to the 1970s, collaboration between the universities, government, and industry in Malaysia were virtually non-existent, as "university academics were considered civil servants" instead of drivers of innovation (Sarpong, 2017). However, in the 1970s, Malaysia began to move away from the "statist" Triple Helix model and more towards a hybrid version, giving universities and their employees more power and authority (Sarpong, 2017).

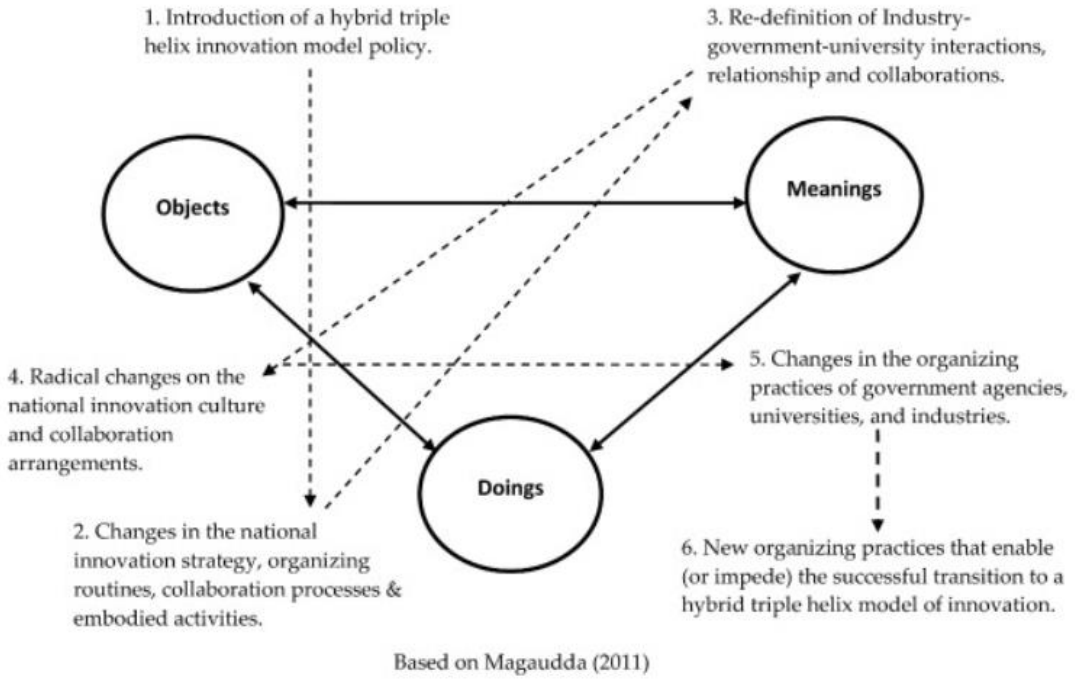

Figure 2: Strategies by which Malaysia moved towards a more modern Triple Helix model. Redefining industry-government-university interactions could be key in bettering current Triple Helix.

As seen in Figure 2, this increase in power "encouraged [universities] to engage in some research into appropriate technologies to solve local problems" (Sarpong, 2017). Because of this, the country's first science and technology policies were established, encouraging cooperation of industry, universities, and foreign

companies to develop new technologies (Sarpong, 2017). At a time when the three helices weren't working together, the drive to solve problems proved fruitful, as this policy was successful in the agricultural arena in 1987 (Sarpong, 2017). This shows the merit in creating innovation(s) that pursue problem solving instead of purely chasing commercialization. To further advocate cooperation between the three entities in the Triple Helix, Sarpong suggests a practice of "collective entrepreneurship." Essentially, he calls for better and more effective communication between universities and the other spheres to facilitate academic innovation because "the universities don't know what the companies are looking for (Sarpong, 2017). Moreover, he insists a connection between the three would be beneficial, noting "they can work together to achieve greater feats" (Sarpong, 2017). While 20th century Malaysia isn't representative of the vast majority of nations utilizing the Triple Helix today, this case study is still valuable. Key elements, such as the pursuit of problem solving for general social good rather than looking to only commercialize and strengthening communication between the three branches, can lead to better outcomes.

International Commercialization of University-Generated Knowledge

A study was conducted on universities in Portugal, Estonia, India, and the United Kingdom (UK) investigated their effectiveness in commercializing university generated knowledge on an international scale. The two main factors that spelled success were favorable intellectual property (IP) rights and common intellectual ground between universities and industry (Kalantaridis, 2017). Previous literature showed that university-based technology transfer was successful in settings that protected IP rights, in countries such as Finland, Singapore, the UK, and the US

(Kalantaridis, 2017). This claim was supported in the study, as institutions that didn't have the best knowledge generating capabilities but possessed strong IP rights were successful (Kalantaridis, 2017). The other factor that greatly influenced technology transfer was a relationship between universities and industry that featured common intellectual and institutional ground (Kalantaridis, 2017). The primary mission of universities is to educate and conduct research, while business ventures for industry are motivators. There is also a challenge of time horizons, universities are much slower in development, for successful interaction to occur. It was illustrated that regardless of primary occupation, if the players within the university-industry network were cognitively aligned, desired outcomes were achieved (Kalantaridis, 2017). For example, the authors reiterate prior research noting the importance of reconstructing development of more than just incentives, but entire norms of behavior as "researchers." They note, "interestingly, however, academics may also occupy a position as knowledge users (bridging fields) in instances where they lead or are involved in spin-off activity. This position necessitates the adoption of norms associated with the entrepreneurial act opening up the scope for incongruity and conflict with traditional scientific norms" (Kalantaridis, 2017). This study highlights how impactful possession of strong IP rights and university-industry cooperation can be when attempting to commercialize university-developed innovation. Because IP rights are often fought over within the U.S. system, lessons learned from this study could be helpful in Triple Helix reform particularly in key institutions within university settings like TTOs.

Technology transfer offices (TTOs) are in-house entities that handle the commercialization of research done and products made at universities. According to the literature, incentives to pursue a patent via TTOs are helped or hindered by the perceived costs of interacting with them (Goel & Göktepe-Hultén, 2018). A study conducted in Germany showed academic inventors bypassed university associated TTOs for various reasons: higher education, industry connections, professional experience, and IP rights (Goel & Göktepe-Hultén, 2018). The study showed inventors with PhDs chose to either go solo or connect with potential investors rather than engaging with TTOs (Goel & Göktepe-Hultén, 2018). Additionally, those with professional experience and/or industry connections chose to forego TTOs because they felt it was unnecessary (Goel & Göktepe-Hultén, 2018). Working outside the university and within the industry meant TTOs wouldn't be granted access to IP rights that they would if they were involved.

In short, there are various reasons that caused academic inventors to avoid obtaining a patent through university sponsored TTOs on the way to commercialization of their technology. Similar to the study involving AE systems in Portugal, Estonia, India, and the UK, IP rights are shown to be a factor in academic entrepreneurship being produced. Likewise, more protection of IP rights within the university setting could correlate to a greater incidence of AE commercialization.

Case Study: Interview, Dr. Jeremy Kent

To gain further insight into the current Triple Helix system, an academic entrepreneur was interviewed. Dr. Jeremy Kent is a physician practicing both family medicine and sports medicine in the University of Virginia Health System. The

University of Virginia is a state school with mandates to produce knowledge for the public good. Within UVA, there are several different research and design institutions for faculty including: Licensing and Ventures, Center for Innovative Technology, STTR awards offices, Commonwealth Research Commercialization Fund, and more. He is currently pursuing a provisional patent for a double-barreled syringe device along with my capstone group. Dr. Kent has produced pieces of academic innovation in the past and continues to pursue others currently as well.

A little over two years ago, Dr. Kent identified certain inefficiencies with administering musculoskeletal injections, a procedure that was becoming more common in his line of work. To mitigate that inefficiency, Dr. Kent conceived a syringe device that had two barrels with novel technological features that would both expedite the procedure and make it less painful for the patient. While Dr. Kent's main priority wasn't commercialization, he still thought his device had economic potential. At the very least, he wanted to produce it so other doctors could use it and patients would have a better clinical experience. He presented the idea for his device at an idea symposium held in the medical center, but didn't receive a lot of interest. When prompted if he and his technology had ever been directed to the SBIR or STTR programs, Dr. Kent responded that neither of the programs are advertised and that "[physicians] have to do the digging to get off the ground" (J. Kent, personal communication, March 30, 2021). Furthermore, Dr. Kent noted that his only connection to any entity associated with the Triple Helix was with a contact in the UVA Licensing and Ventures Group because they briefly discussed possible patent infringements.

When asked why he waited to pursue this syringe until this year through the Capstone program, Dr. Kent gave various reasons. For example, he voiced concern about losing IP rights when working with the university or outside companies. He also expressed his disdain with the cost of contracting to an outside company, sullying his desire to continue with the project alone. In regards to working with the university, Dr. Kent explained that because he is a university employee the school would take roughly 70% of whatever he produced. This ultimately discouraged him from going to the university with his idea, adding "it gives you little incentive to work on your idea because they take almost all of it from you" (J. Kent, personal communication, March 30, 2021). Instead, he chose to work with my Capstone group because we didn't pose the same threats as the university and businesses did. Our group was attractive to him because we were free of charge, we wanted to advance the device (and not immediately take it to market), and we have technical engineering skills he doesn't. Consistent with the literature, Dr. Kent said he wouldn't leave his practice to pursue this project full time: the risk isn't worth the possible reward.

In short, Dr. Kent wasn't aware of Triple Helix resources, was weary of working with the university, and didn't want to outsource his technology to a company. However, he was comfortable working with a Capstone team that shared his drive to advance the device, and one that wouldn't take his idea as their own. This interview highlighted possible improvements to the Triple Helix. If academic entrepreneurs are presented with investors or other technically skilled entrepreneurs, their technologies could have a greater chance at development and eventually be subjected to market pressure.

Case Study: Michigan State University Bioeconomy Institute (MSUBI)

The Michigan State University Bioeconomy Institute (MSUBI) is an educational institution that was established to turn biotechnology and chemical processes into marketable products. In fact, the MSUBI have "successfully scaled numerous technologies across various industries from lab to pilot scale with a 100% success rate" (Michigan State University Bioeconomy Institute, 2020). The MSUBI has two sites of operation, Holland and East Lansing, and each offers different services to both for-profit and non-profit groups. While not every piece of academic innovation will be biotechnology or a chemical process, the system the MSUBI employs could be applied to better the Triple Helix.

The East Lansing site of the MSUBI is a fermentation facility that serves as the manufacturing hub for the biotechnology or chemical process(es) being examined. This site is equipped with modern equipment, modern instruments, and computer-based control systems to produce the innovation of choice. Besides state-of-the-art technology, the East Lansing plant can also serve as a bioprocessing and scale-up facility for the group they are assisting. When a new product or technology is developed, it is crucial to test the feasibility of mass production of said product. The MSUBI collaborates with the interested party to "develop and map the best plan for [the group's] innovations and scale-up" (Michigan State University Bioeconomy Institute, 2020). By seeing the manufacturing and scalable potential of their biotechnology or chemical process(es), innovators can better determine the next step(s) to commercialization.

On the other hand, the Holland site offers extensive lab space for experimentation and features a business incubation system to better guide those looking to market their technology. The lab space is open to rent for development and study of technology, and can also serve as an arena for task specific trainings. The Holland location also partners with Lakeshore Advantage, an economic development agency, to provide innovation groups with various services. These services include: business planning, technology assessment, market development techniques, and facilitating connections with service providers, local talent, and potential sources of funding. The Holland facility also is home to a 100-person auditorium that hosts monthly research and business development seminars, which could be useful when looking for business partners or investors in the early stages of a product. In short, the business incubator gives entrepreneurs and innovators the tools they need to better prepare their biotechnological innovation(s) to be subjected to economization and market pressure.

The MSUBI is an organization known for turning new technology into commercialized products. Even though the MSUBI tailors to biotechnology and chemical processes, the techniques they utilize to take innovation "from the lab bench to the pilot plant" can be applied to the Triple Helix (Michigan State University Bioeconomy Institute, 2020). The MSUBI's ability to deliver mock manufacturing and scale up environments, offer research testing and design labs, and give access to a business incubator to help products be taken to market is valuable when investigating how innovation can be commercialized. With features like these, the Triple Helix Model of Innovation could better facilitate academic innovation towards economization.

Discussion: A Fourth Helix?

This study establishes the basis of the relationship between the government, industry, and academia, which is modeled by the Triple Helix Model of Innovation. These three entities work together to commercialize academic innovation via government incentives, university-based technology transfer offices, and the patent system. This study also examines academic entrepreneurship outside the United States, gains perspective from an academic entrepreneur and key stakeholder, and analyzes the MSUBI, an institution that has success in commercializing academic technology. All of this was done to not only gain a deeper understanding of the Triple Helix itself, but also to compare and contrast with other academic innovation spheres and apply their successes to mitigate the shortcomings of the Triple Helix.

Moving forward, adding another helix to the Triple Helix Model of Innovation should be considered. This extra helix would see universities pairing academic entrepreneurs with angel investors or other entrepreneurs to pursue completion of their technology. As seen in Ireland, it is more important for universities to encourage this entrepreneurship than to simply provide innovation programs nearby, as seen in Sweden. This pairing would include numerous resources to help the entrepreneurs realize the potential of their technology, similar to how the MSUBI provides for their clients. Within this branch, there would be a path with commercialization as the main motive, and one path focused on pursuing knowledge carrying ideas to fruition. The Malaysian case study proved problem solving to be a driver of innovation, so it should be included as an option in this new helix. By giving entrepreneurs this choice, motivations of all parties involved can be aligned, which has been shown to be a barrier to progress in the current

Triple Helix. Furthermore, by pairing these innovators with entities independent of their university, IP rights would be protected, an important issue highlighted in Germany, Estonia, Portugal, India, and the UK. Oftentimes, engineers, doctors, and other academics are risk averse and don't want to pursue something at the expense of their main profession. This structure would give academic innovators access to resources that would aid in both the technical development and market assessment of their innovation, putting them in the best possible position and alleviating that pressure.

Inherently, there are limitations to this research. For example, there are certain environments (Malaysia, Germany) that aren't directly comparable to those seen in the US. The US isn't a developing country like 20th Century Malaysia was, nor does it have as strong a pull to forego university TTOs as in Germany. Additionally, an interview was only conducted with a stakeholder from the academia helix, not from the government or industry, which gives an incomplete picture of the entire system. Lastly, despite the MSUBI claiming a 100% success rate for turning biotechnology and chemical processes into marketable goods doesn't ensure long term success: the technology was simply made marketable.

References

Berman, E. P. (2014). Not Just Neoliberalism: Economization in US Science and Technology Policy. *Science, Technology, & Human Values*, *39*(3), 397–431. https://doi.org/10.1177/0162243913509123

Bioeconomy Institute. (2020, January 15). https://bioeconomy.msu.edu/

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy*, *29*(2), 109–123. https://doi.org/10.1016/S0048-7333(99)00055-4

Forsberg, E.-M., Hanssen, A. B., Nielsen, H. M., & Olesen, I. (2018). Patent Ethics: The Misalignment of Views Between the Patent System and the Wider Society. *Science and Engineering Ethics*, *24*(5), 1551–1576. https://doi.org/10.1007/s11948-017-9956-5

Goel, R. K., & Göktepe-Hultén, D. (2018). What drives academic patentees to bypass TTOs? Evidence from a large public research organisation. *The Journal of Technology Transfer*, *43*(1), 240–258. https://doi.org/10.1007/s10961-017-9595-7

Kalantaridis, C., Küttim, M., Govind, M., & Sousa, C. (2017). How to commercialise university-generated knowledge internationally? A comparative analysis of contingent institutional conditions. *Technological Forecasting and Social Change*, *123*, 35–44. https://doi.org/10.1016/j.techfore.2017.06.013

Klofsten, M., & Jones-Evans, D. (2000). Comparing Academic Entrepreneurship in Europe – The Case of Sweden and Ireland. *Small Business Economics*, *14*(4), 299–309. https://doi.org/10.1023/A:1008184601282

Parthasarathy, S. (2020). Approaching intellectual property scholarship differently: A qualitative research review and agenda. *Science and Public Policy*. https://doi.org/10.1093/scipol/scaa010

Sandström, C., Wennberg, K., Wallin, M. W., & Zherlygina, Y. (2018). Public policy for academic entrepreneurship initiatives: A review and critical discussion. *The Journal of Technology Transfer*, *43*(5), 1232–1256. https://doi.org/10.1007/s10961-016-9536-x

Sarpong, D., AbdRazak, A., Alexander, E., & Meissner, D. (2017). Organizing practices of university, industry and government that facilitate (or impede) the transition to a hybrid triple helix model of innovation. *Technological Forecasting and Social Change*, *123*, 142–152. https://doi.org/10.1016/j.techfore.2015.11.032