Abstract

It has become critical to establish firm and efficient networking base more and more for advanced technology commercialisation. In this paper, several main factors for successful technology commercialisation, in terms of networking platform, are discussed through current technology commercialisation process analysis in the United States: demand-driven approach, reality checks, mentorship building, incentive provision, information channeling, and public supports.

Keywords: Commercialisation Network, Commercialisation Process, Technology Commercialisation

1. Introduction

Technology commercialisation practitioners commonly recognise a large gap between “translational research” (i.e. research that is intended for commercialisation) and actual startups (funded by venture capitalists). At least three stages of development are necessary for the transition: 1) prototype; 2) customer engagement; and 3) ramp up. This gap is known as the “valley of death,” as seen in Figure 1, making the transition from research to startup/commercialisation extremely challenging.

A successful technology transfer and commercialisation intrinsically means the success as a business overcoming the valley of death; a better technology commercialisation network platform must show a superior performance in this matter. All participants in technology transfer and commercialisation such as bench scientists, universities, small- and medium-sized enterprises (SMEs), accelerators and innovation capitalists need to cooperatively operate as a well-integrated body for this task. In the U.S., it is noticed that not only U.S. federal government try to provide a bridge to cross this valley through funding programs such as SBIR/STTR (Small Business Innovation Research/Small Business Technology Transfer) and NSF Innovation Corps (I-Corps), but also local governments are actively engaged in various independent programs; e.g., in the state of Georgia, there are two local government entities, Georgia Research Alliance (GRA) and Georgia Department of Economic Development (GDED)1,2.
2. Main Factors in Technology Commercialisation

We summarise in this section the factors that we identify as critical for building a successful platform. An ideal model would have these factors seamlessly interwoven into the ecosystem.

A good starting point for practical discussions should be to learn from cases of failures. Lee Herron, Vice President at Georgia Research Alliance, documents various failure modes of 119 start-ups under Georgia Research Alliance-funded commercialisation program in the last ten years\(^4\). (Note that Georgia Research Alliance’s track records should not be interpreted as representative of the U.S. or as a reference point that can be directly applied to the case of Korea, particularly given idiosyncrasies associated with the Georgia Research Alliance commercialisation program. Nonetheless, this estimate is fairly consistent with the findings from various players in the technology commercialisation network platform). As shown in Figure 2, 34 startups failed due to technological failure, followed by 32 management dysfunction, 24 market related issues, and 12 poor business model. Surprisingly, only 7 failures were caused by running out of funds and 7 by failed IP protection. These last two factors have been the ones often considered as some of the most significant problems that startups normally face. This overall picture is in fact highly consistent with our own investigation. In this section, we discuss six critical success factors that we identified from our study: demand-driven approach, reality checks, mentorship building, incentive provision, information channeling, and public supports.

2.1 Demand-Driven Approach

The traditional approach to technology commercialisation has been from the supplier side of technology. Talented scholars are supported by R&D grants and contracts, and the supported research somehow produces promising discoveries worth of IP protection and licensing for further commercial development. In this model, TLOs (Technology Licensing Offices) must play the role of protectionists and be responsible for licensing contracts. The inventors may be sufficiently optimistic and passionate about the technology to commit further to start a firm, but only a small proportion of them survive through the stage of scale-up. This channel is still the primary path at top research institutes like universities, which find the channel quite effective. Nevertheless, an early stage technology tends to be fragile and untested, and hence even the inventor may not have the full knowledge of potential use of the technology. Also, for a given technology, the market (i.e., demand side) may find other aspect of the technology for real commercial applicability rather than the aspect that the inventor may have originally considered as having commercial potential. Many startups with great technology fail simply because they could not find the right market for it. Despite the problems in reality, this supply-driven approach has been so ingrained in the technology commercialisation that even the innovation capitalist started with that approach, only to find out soon the model does not work. We no longer live in a world in which one can build a better mousetrap, and then wait the world to beat a path to one’s door. Rather, one should be able to build a mousetrap that the world wants.

Further, there are several conditions for this TLO-as-platform model to work well. First of all, it requires a constant inflow of inventions with high commercial potential. This condition is not easily met for many local areas without research-active universities. Another condition is that TLOs must perform the role of platform with passion. This is closely tied to a well-designed incentive scheme for TLO as well as for the inventors.

While these conditions are still far from being met, there appears a gradual shift from the supply-driven approach to the demand-driven approach. Some innovation capitalists such as IP2Biz initially started from the inventor side, but eventually shifted the search focus to identifying the demand for technical solutions from client firms. Attempts of comprehensive involvement across multiple phases of technology commercialisation is based on the realisation that successful startups must need-driven (i.e., no need = no business) but such need is not always apparent a priori, which necessitates an extensive market testing up front.

Therefore, the demand-driven and need-based approach seems increasingly crucial for enhancing the success rate of technology commercialisation by complementing the existing TLO-based model.

2.2 Reality Checks

According to Herron\(^2\), about 500,000 startup companies are formed each year in U.S. A great majority of them are not considered technology-based as only 9.3% have pending or issued patents. As can be expected, the mortality rate of startups is very high; only half of them stay in the market after 7 years of operation. Only 10.9% grows...
up to reach over one million in revenue. In short, startup success itself is a rare event. While there could be many reasons for failure, we can simply summarise these as the lack of sustainable market for proposed innovations. The hard truth in technology commercialisation is that there is no road map that guarantees a startup’s success. This underlying insight makes it important for an entrepreneur to ‘try to fail’ well in advance. One of the main missions of business incubating institutes is to educate its portfolio startups to test the market by approaching it with the early-stage technologies. Getting timely feedback from potential investors and consumers help the startups avoid the naïve presumption that the technology will work as proposed or that a ripe market is somewhere out there waiting for the technology to be commercially available. Many university professors naively believe that their own technology is so important and often overestimate its commercial value, though it still requires significant time and resources just to get a real market sense.

One important takeaway is that many of the failed companies should never have been started in the first place; these firms would not have started if they had gone through serious reality checks, which would have saved plenty of resources from being wasted and these resources could have been redirected toward better alternative uses.

2.3 Mentorship Building

It is obvious how critical it is for start-ups to learn from experienced industry experts and entrepreneurs in a timely and systemic manner. This point is fairly consistent across the players we covered in the platform. Most startup supporting teams in business incubating institutes are required to work with an industry mentor. A number of those institutes maintain hundreds of fellows or more than that who provide industry expertise and market-based feedback to the technologies and business ideas. Mentoring includes regular, scheduled meetings with staff, who also link awardees to corporate executives for practical guidance and marketing tips. In helping the regional SMEs, local governmental organisation routinely brings in corporate executives who provide advice for technology commercialisation and marketing.4

### Table 1. Start-up failure modes

| Reason of Failure         | Details                                      | # of Cases |
|---------------------------|----------------------------------------------|------------|
| Start-up failure modes    |                                              |            |
| Run out of funds          | Cash mismanagement ability                   |            |
|                           | Unable to attract follow-on funds            |            |
|                           | Adverse funding market conditions            |            |
| Poor business model       | Model inconsistent with market structure      |            |
|                           | Inappropriate pricing model                  |            |
| Technology fails          | Development takes too long                   |            |
|                           | Failure in trials                            |            |
|                           | Non-reproducible product                     |            |
| Management dysfunction    | Poor start-up team chemistry                 |            |
|                           | Incomplete or non-complementary skill set of team | 32        |
| Failed IP protection      | Misjudgment during due diligence             |            |
|                           | Insufficient claims awarded                  | 4          |
| Market related issues     | Misjudgment market dimensions or dynamics    |            |
|                           | Stolen market (i.e., new competitor)         | 24         |
|                           | Adverse market dynamics                      |            |
| Relocation                | Faculty member relocates                     |            |
|                           | Company moves out of state                   | 6          |
Mentoring and advising are critical for successful technology commercialisation at least for two accounts. First, mentoring helps reduce startup failure. Since principal investigators (typically professors in universities) do not necessarily adequate management skills, informal mentorship and advising can help avoid mismanagement, thereby reducing at least the management-related startup failures.

Second, mentors have a much better sense about industry, market, and end users, and hence the market-related failures can be mitigated through their input. Since about half of startups fail because of these types of snags, a desirable technology commercialisation network platform must offer an environment in which mentoring and advising are embedded, while they remain incentive compatible (i.e., are given incentives to continue providing mentoring and advising).

There are three distinct groups of potential mentors identified.

The first of them includes industry experts who themselves have had successful startup experience and are currently seeking next career opportunities. These people are normally the ones who are looking for promising startups that they can ultimately join as top management to grow them successfully. They often make their own capital investment in the startup they are interested in.

The second group represents successful (serial) entrepreneurs who are now retired from business but want to help out younger entrepreneurs in starting firms. These people get paid for their involvement but are normally prevented from taking equity shares in startups they advise.

The third group includes senior executives at large firms. These people are either alumni of the university that the startup is based on, or those who do the voluntary service for the cause of building the business community in the region.

### 2.4 Incentive Provision

Any ecosystem cannot be sustained over a long horizon if incentives are not well aligned. From this perspective, we need to revisit the motivation behind each player’s participation in the technology commercialisation network platform. Needless to say, for-profit entities such as innovation capitalists, venture capitalists, paid consultants, and technology community centers are incentive compatible: they will each choose an optimal level of participation and efforts to maximise their own payoffs. Notably, there are also non-profit organisations in the network. As long as they have exclusive members to care for, there seem to be few incentive-related problems.

The most serious incentive problem may be occurring on the side of inventors, who even try to bypass TLOs and secretly spin off a firm. Most universities do not factor performance in technology transfer and commercialisation into performance reviews, promotions and tenures, and funding allocations for their researchers. Thus, particularly the junior faculty in the tenure-track finds no urgent reason to allocate their time and efforts into technology transfer and commercialisation. Nor are TLOs provided with sufficient incentives to act as dynamic facilitators or accelerators. They are normally short-staffed, even to review applications for IP prosecution and not knowledgeable enough about individual inventions to properly assess their technological potential and marketability. In the U.S., federal laboratories and government-funded programs are not designed to set a priority on technology commercialisation. According to a White House report, “Lab-to-Market Inter-Agency Summit: Recommendations from the National Expert Panel” (2013), experts point out the general lack of incentives in the system as a critical problem that needs to be addressed in order to enhance technology commercialisation even in the U.S.7 Hence, an effective incentive design appears to be a key to building a successful platform for technology commercialisation.

### 2.5 Information Channeling

SMEs’ informational needs exist about technology and market, and providing an environment for SMEs to access useful information at a low cost is very important, in terms of technology commercialisation. However, finding relevant information on available technology and commercialisation projects is not an easy task even for large corporations.

One of the potential problems in using TLOs as a platform is that their staff typically lacks sufficient knowledge about both the inventions and the corporate needs. In fact, the Lab-to-Market report (2013) proposes “technology translators” as a solution to this information asymmetry problem that hinders technology transfer and business development. Hence, constructing an effective system of information services appears critical, particularly for SMEs who lack resources to reach out external and professional consulting services for their specific information needs7.
Studies show that small firms have a higher rate of innovations per employee, more patents per employee and output per dollar spent than do large firms. While large firms have resource advantages, the typical features of small firms such as prompt decision-making, internal flexibility, lack of bureaucracy, and entrepreneurial spirit enable them to maintain or develop competitive advantages. The challenge for SMEs is to remain innovative as they grow. They need to not only remain flexible and thus better able to respond to a changing environment, but also have the information available regarding that environment in order to know how to respond most effectively and efficiently.

A survey on small manufacturing firms in the U.K. shows that small manufacturers have the greatest information needs for their customer markets, followed by information about technology, competitors, and legislation. For the majority of the firms they interview, external information is primarily sought to solve a particular problem. Most of the technological information sought by the smaller firms is not specific to their industry. In contrast, SMEs looked for very specific, detailed market information, which appears convincing as most of them operate in niche markets. The manufacturing SMEs' most preferred methods to acquire information are trade journals and the internet (both cited by over 80% of the respondents), followed by informal networks. Analysing Nigerian manufacturing SMEs, Sawyer, find that these SMEs have a relative preference for internal information sources over external ones, while they do not find a systemic difference between personal and impersonal sources. Wood, who studies SMEs in the hospitality and tourism sector in the U.K., reports the predominance of informal and internal information sources (over formal and external ones). He points out that the SMEs underutilised important wider market intelligence owing mainly to resource constraints. Ngamkroekjoti and Speece (2008) examine the Thai food processing industry and find a different result that firms prefer personal, but mainly external, sources regarding customers, competitors, and suppliers. Overall, the majority of studies point out that SMEs have some tendency to depend more on internal sources for information, which stands in contrast to the scanning behaviour of larger organisations.

### 2.6 Public Support

The role of public support program seems crucial particularly given the general lack of private institutions to bridge the wide gap between inventions and commercial products. Because of the fragile nature of early stage technology and the long lead time between a source technology and a commercially viable product, private institutions such as venture capitalists typically hold their investment until the technology is proven and the startup reaches the scale-up stage for mass production. It is thus the area for public agencies such as the local government to step in and bridge the gap so that fledgling but promising startups can successfully cross the valley of death. Though it is almost impossible to measure the net effects of public support system, the fact that over 20 states in the U.S. are currently running some version of public support programs seems a clear evidence for its importance.

It should be noted that a simple money transfer program would not work. The policy programs encompass more central matters for successful commercialisation such as technology refinement, education, mentorship, market intelligence, and team management. Even between programs that do provide funding, there is differentiation in the timing (early vs. late stage) and format (grants vs. loans) of the funding. This type of coordination across programs helps maintain the balance between the insurance of conservative investments and the support of breakthrough technologies.

### 3. Conclusion

There is a need for a better concerted effort across government agencies for technology commercialisation. In the U.S., there has recently been a serious call for improved coordination across government agencies, programs, and initiatives. In response from the President, a group of field experts and specialists forged a recommendation report titled ‘Lab-to-Market Inter-Agency Summit’ to the government administration. This group of advisory members makes one very specific recommendation: create a High-Level Office of Innovation and Federal Technology Partnerships to leverage cross-agency synergies, to enhance policy efficiencies, to strengthen public-private partnerships, to optimise federal laboratory commercialisation, and to adapt and implement innovation best practices.

Korea has various programs and initiatives, both at the central government and local municipalities toward technology commercialisation. Thus, there appears to be an imminent call for a systematic investigation on this aspect. Such duplication can potentially lead to an overin-
vestment and an overly complex system for entrepreneurs to navigate through. The downside of the redundancy may well overshadow the potential upside of ensured coverage. Hence, it seems worth pursuing improved coordination and concerted systemisation across government-led activities in this area.

It has been recognised that the general shift to market-pull approach to commercialisation and the emphasis on reality checks of technology validity through intense test of the marketability20. Nevertheless, the supply-oriented mentality seems to still prevail the mindset of most inventors. Therefore, business incubating program should be designed to provide inventors with a more demand-oriented spirit. Also, we find that incubators and accelerators, operating under state-funded programs, offer various opportunities for mentoring and advising in order to reduce the mortality rate of startups, particularly in their early stage.

A critical challenge may be the difficulty in building a sufficient pool of experts that can help foster the market-oriented approach to invention and technology commercialisation. The Lab-to-Market report suggests an upbringing of ‘technology translators’ who can bridge the perceptual gap that exists between government agencies, university bench scientists, the private sector and investors. This implies that commercialisation experts also feel the information gap across players in the technology commercialisation ecosystem. Building a network of specialists is better achieved through an informal, community-based model as evidenced in the case of the Silicon Valley21. Likewise, we believe that promoting a reference-based information channeling between network participants could be an effective model for establishing the information basis for the proposed global technology commercialisation network platform in Korea. It is perhaps in this area that government agencies can provide a critical support through their extensive reach to human capital across fields and across regions.

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5. References

1. US Small Business Administration; 2013; Available from: http://www.sba.gov/
2. NSF Innovation Corps; 2013; Available from: http://www.nsf.gov/news/special_reports/i-corps/
3. Osawa Y, Miyazaki K. An empirical analysis of the valley of death: Large-scale R&D project performance in a Japanese diversified company. Asian J Tech Innovat. 2006; 14(2):93–116.
4. Herron L. Management of technology lecture slide. 7 Jul 2013.
5. Cooke P. Strategy for regional innovation systems: learning transfer and applications. Cardiff: Centre for Advanced Studies Cardiff University, 2001.
6. Lab-to-market inter-agency summit: Recommendations from the national expert panel. White house conference center; 2013 May 20.
7. Watts R, Courseault C, Kapplin S. Identifying unique information using principal component decomposition. In: Khalil T, Lefebvre LA, Mason RM, editors. Management of technology: the key to prosperity in the third millennium. Elsevier Science, Pergamon; Oxford: 2001.
8. Pavitt K. The size distribution of innovating firms in the US 1945–1983. J Ind Econ. 1987; 35:291–316.
9. Bommer M, Jalajas D. Innovation sources of large and small technology-based firms. IEEE Trans Eng Manag. 2004; 51(1):13–8.
10. Fairtlough G. A marriage of large and small: R&D for healthcare products. Bus Strat Rev. 1996; 7(2):14–22.
11. Tanabe T, Watanabe C. Excellent business performance in a services oriented economy. J Serv Res. 2005; 5(1):5–20.
12. Lang JR, Calantone RJ, Gudmundson D. Small firm information seeking as a response to environmental threats and opportunities. J Small Bus Manag. 1997; 35(1):11–23.
13. Trumbach CC, et al. Technology mining for small firms: Knowledge prospecting for competitive advantage. Technol Forecast Soc Change. 2006; 73:937–49.
14. Reed FM, et al. Information acquisition for technological innovation and technology strategy in small Firms. IEEE International Conference on Engineering Management, IEMC ’02; 2002. 2002; 1.
15. Sawyer OO, et al. Executive environment scanning, information source utilisation and firm performance. JApplManag Stud. 2000; 9:95–115.
16. Wood, E., Marketing information systems in tourism and hospitality small-and medium-sized enterprises: a study of Internet use for market intelligence. Int J Tourism Res. 2001; 3(4):283–99.
17. Ngamkroeckjoti C, Speece M. Technology turbulence and environmental scanning in Thai food new product development. Asia Pac J Market Logist. 2008; 20(4):413–32.
18. Radauer A, Walter L. Elements of good practice for providers of publicly funded patent information services for SMEs – Selected and amended results of a benchmarking exercise. World Patent Inform. 2010; 32:237–45.
19. Lee GK. Understanding the timing of ‘fast-second’ entry and the relevance of capabilities in invention vs. commercialisation. Res Poli. 2009; 38(1): 86–95.
20. Nevens TM, Summe GL, Uttal B. Commercialising technology: What the best companies do? Harv Bus Rev. 1990; 68(4):154–63.
21. Wonglimpiyarat J. Commercialisation strategies of technology: lessons from Silicon Valley. J Tech Tran. 2010; 35:225–36.