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THE EMERGING TECHNOLOGY COMMERCIALIZATION DEGREE

W. Bradley Zehner II, PhD

University of Texas at Austin, IC^2 Institute, Austin, Texas 78705 USA

INTRODUCTION: Technology Commercialization – Perspective

The information age began long ago. The earliest known printed book is the Diamond Sutra which was printed in China in 868 B.C. using clay type. In 1041, movable clay type was used throughout China. The movable clay type did not render clear impressions and wore out rapidly.

During the middle Ages in Europe, books were produced for the Catholic Church using the process of wood carving. Wood carving required the craftsman to carve away the background to create a raised image. The wood carvings wore down quickly and did not allow many copies to be printed clearly.

In 1436 in Mainz, Germany, Johannes Gutenberg, German goldsmith and inventor, realized that casting letters in metal would solve the problems of the wooden type. Additionally, the metal letters were easy to cast, lasted longer, and make clearer impressions on the paper. After a number of experiments with various metals, Gutenberg discovered the right proportions of lead (83%), antimony (12%), and tin (5%) so the metal letters did not shrink when cast. This formula is still used in casting letters today.

By 1440 Gutenberg completed his first press that used metal moving type. In 1452, Gutenberg began work printing the Bible which was completed in 1455 with the publication of 200 Bibles - the first book to be published in volume.

As do many current inventors, Johannes Gutenberg funded his venture via a business arrangement with Andreas Dritzehn, a German business man, who funded the building of the first modern printing press in 1438. In 1450, Gutenberg entered into an agreement with Johannes Fust, a German business man, to build a large Gutenberg press and to print the Bible. Gutenberg failed to re pay his loans to Fust who foreclosed confiscating the press. In 1455, Gutenberg was declared bankrupt.

In 1468, Johannes Gutenberg "died penniless, living on a dole from one of his investors, a classic example of technological success and financial frustration (Drew 1996, 28)."

In 1462, the city of Mainz was attacked by soldiers of the Archbishop of Nassau, and many of the printers fled and disseminated printing technology throughout Europe. By 1476, William Canton set up a press in England. By 1499, printing was established in over 250 cities throughout Europe. Printing technology had diffused and was established "globally" less than fifty years after Gutenberg printed the Bible.

Gutenberg's story is about the commercialization of science and technology. Gutenberg experimented to find the right alloy for the type (science) so he could translate his idea into a commercial product – the Bible (commercial product) via his press (technology).

The challenge of translating new ideas based on science into products and services today is just as formidable as it was in Gutenberg's time. However, new degree programs are emerging – the MS in Science & Technology Commercialization – which educate individuals vis a vis the commercialization process – from science to technology to new products, new services, and new ventures – so that unlike the sad saga of Gutenberg, today's entrepreneur's story can end happily as both a technological and financial successes.

COMMERCIALIZATION CHALLENGES CONFRONTING ORGANIZATIONS

Globally, organizations must confront three major scientific and technological trends:

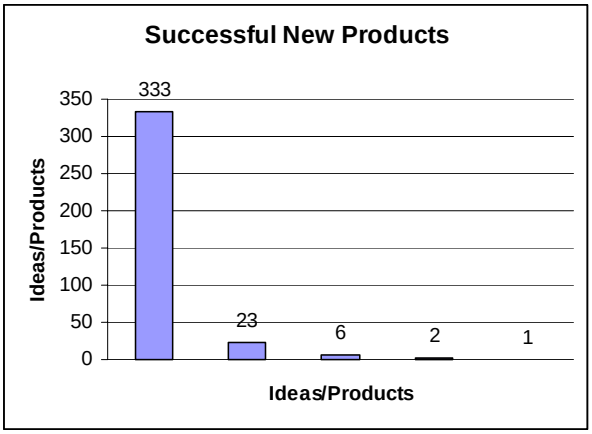
- An exponential annual increase in mankind's sum total of scientific and technological knowledge
- Globalization of scientific and technological knowledge
- An accelerating rate of scientific and technological knowledge diffusion

Over 95% of all scientists and engineers who ever lived are working today generating new knowledge at an accelerating rate. Scientific and technical ideas can now leap from the laboratory to the marketplace in days instead of months or years. Today's scientific or technical knowledge is as likely to be found in Singapore or Bangalore as Boston or Austin. Today's technology explosion is rapidly redefining organizations, competitive advantage, and the marketplace itself.

The challenge to science and technology organizations today is how to translate ideas into viable services and products rapidly and at minimum cost. This represents a significant challenge with long odds. Out of 333 ideas, only 23 may be original; six concepts may be patentable; two products may be

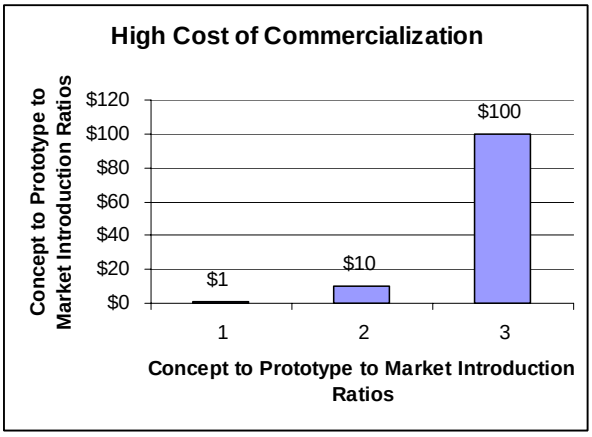
introduced to the marketplace; and only one product ultimately achieves market success (Hansen 1995). Figure 1 shows that 333 ideas are necessary to yield one successful new product.

Figure 1: 333 Ideas to Yield One Successful New Product



An additional barrier to taking a technology product to market is the high cost. The basic science and engineering must frequently be refined from the lab to the prototype to the production stages. Consequently, R&D costs escalate along the product development cycle. A rough rule of thumb is that for every $1 invested in the cost of discovery of the principle, the cost of developing a prototype is ten times the cost of discovery, and the cost of market introduction is ten fold the cost of the prototype (Jolly 1997, 19). Figure 2 shows product development cost ratios from proof of concept to market introduction.

Figure 2: Product Development Costs – Proof of Concept to Market Introduction



However, organizations have no option but to address the technology commercialization issue. The average life span of a company is 12.5 years (De Geus 1997, 2), and the average life span of a service or product is 6 to 36 months depending on the industry. This means the typical organization must commercialize at least 4 to 25 new products during its life.

Science and technology commercialization is the key by which the organizations reinvent themselves and the engine that creates societal wealth. The ability to quickly move ideas from the lab to the market is the critical competitive survival mechanism for an organization.

Some interesting executive challenges are posed by technology commercialization:

- What is the best way to stimulate scientific and technological creativity and innovation?
- Where are best sources of scientific and technological knowledge?
- Can technology commercialization competency be a competitive advantage?
- What is the best mechanism to transfer scientific and technological knowledge?

- What are the stages of the technology commercialization process?
- How can technology markets be identified and defined?
- What does the organization have to know, and when, to be successful at technology commercialization?
- What is the role of the legal system and intellectual property?
- How does the organization create entrepreneurial scientists?
- What is the best way to integrate technologists with business professionals to bring ideas to marketplace quickly?
- How does the organization assess entrepreneurial risk?
- What defines technology commercialization success?

How organizations address these questions ultimately determines their very survival. Organizations that get the answers to these questions right are richly rewarded by the capital markets as the comparison in Table 1 among General Motors, IBM, and Microsoft illustrates.

Table 1: A Comparison of General Motors, IBM, Microsoft (June 30, 2004**)**

	General Motors (GM)	IBM	Microsoft
Year Founded	1908	1911	1975
Revenues – 2003	$185.5 Billion USD	$89.1 Billion USD	$36.8 Billion USD
Number of Employees	349 Thousand	316 Thousand	50 Thousand
Return on Sales	1.68%	8.72%	22.17%
Return on Equity	11.16%	28.07%	10.92%
Return on Assets	.68%	8.13%	8.84%
Cash Flow Per Share	$6.79	$2.79	$1.08
Book Value Per Share	$49.18	$17.21	$6.89
Market Value	$26.89 Billion USD	$147.67 Billion USD	$310.22 Billion USD

Note that General Motors (GM) and IBM were founded about the same time. Today, GM's revenues are twice as large as IBM and are supported by significantly more assets. Yet the stock market values IBM at 5.5 times that of GM. Why? IBM was able to excel at the commercialization of new technology as its markets commoditized, GM did not. IBM was able to introduce new types of innovation while GM could not innovate due to highly entrenched legacy systems (Moore 2004).

Now examine Microsoft which was founded in 1975. Microsoft has revenues twenty percent of GM's revenues and forty percent of IBM revenues; Microsoft's market value is 11.5 times that of GM's and 2.1 times that of IBM. Why? Microsoft is a representative company of the new age where scientific ideas and intellectual property are the critical competitive resources, not financial capital or raw materials or labor as in the old paradigm. Microsoft got the answers to the technology commercialization questions right and was richly rewarded by the global capital markets.

THE INTRINSIC TENSION BETWEEN TECHNOLOGISTS AND MANAGERS

When Kipling (1889) wrote, "Oh, East is East and West is West, and never the twain shall meet.''**,** he could have been referring to technologists and managers. Technologists and managers experience the world differently. Dubinskas (1988, 201) colorfully describes the intrinsic differences between the technologist and the manager: "They, the complete adult realist managers, in their struggles with immediate economic necessity, must contend with immature scientists-dreamers; while from the other side of the table, the far sighted progressive scientists must protect their work – the basis of the firm's wealth – from the myopic, and developmentally retarded managers!"

The manager's fixation is on the stewardship of the organization's financial assets. The manager's goal is to maximize financial return on assets while minimizing market and investment risks. The pressure on managers to produce short term profits is often at odds with the need to invest in R&D programs and new technologies to remain strategically competitive. The resolution to this conundrum is recognition that the organization's ultimate value depends on the level and rate of growth of its cash flow. The long-term ability to sustain an attractive cash flow is dependent on how well the organization commercializes new products that are attractive to customers and the capital markets (Erickson, Magee, Roussel, & Saad 1990). The technologist's primary goal, however, is to generate scientific and technological knowledge. "They [technologists] tend to devalue economic goals in their world value." (Dubinskas 1988, 197)

The dissimilarity between managers and technologists also is reflected in their education. Business programs stress a variety of broad economic skills and the ability to integrate a wide range of social knowledge. In contrast, scientific and technological programs stress a deep understanding of a narrow physical, biological and informational science. These programs produce two vastly different groups of individuals who live in different worlds and frequently have difficulty understanding each other. For wealth to be created and for the organization to survive and prosper, however, the organization must create value for customers. To accomplish this, managers and technologists must work closely together. To this end more and more business curriculums are incorporating courses relating to technology to combat 'techno-illiteracy' (Badawy 1998). The managers and technologists are closely entwined in a symbiotic wealth creation relationship.

WEALTH AND VALUE CREATION

To create a new organization or to survive as a current organization, value must be created for the customer. Value creation crosses and incorporates all the functions of the business firm from R&D to engineering to manufacturing to marketing to customer services. Value creation means cooperation not only across business functions, but between technologists and entrepreneurs in a start-up situation and between technologists and managers at an on-going firm. Cooperation begins with communication. When communication fails, commercialization costs climb and customer value plummets.

Communication presupposes a common language and perspective. MS in Science & Technology Commercialization programs can provide the common language and conceptual frameworks that allow technologists and managers to address scientific, economic, organizational, customer, and competitive challenges in a cooperative manner.

Communication and a common conceptual framework enable the technologist to understand the market, competitive and financial dynamics involved in the commercialization of new technologies. Conversely, the manager appreciates the scientific challenges confronting the technologists. In addition, the manager visualizes new ways that technologies can help address customer needs and strategic positioning for the organization.

MBA, MS IN TECHNOLOGY, MANAGEMENT OF TECHNOLOGY, AND MS IN SCIENCE & TECHNOLOGY COMMERCIALIZATION PROGRAMS

Value creation for customers in today's globally competitive environment demands integration of not only the organization with its external environment but also tight coordination of all internal functions to successfully commercialize new products. Consequently, MS in Science & Technology Commercialization programs must be holistic and integrative in nature and this is reflected in their curriculums. Rather than segmenting the curriculums into separate and discrete functional areas as do most MBA programs, MS in Science & Technology Commercialization programs mirror the 'real world' by emphasizing principles of technology commercialization: creativity, innovation, flexibility,

rapid change, reliance on customer feedback, and integration in a global scientific and market environment in integrated curriculums.

Table 2 compares MBA, MS in Technology, Management of Technology (MOT), and MS in Science & Technology Commercialization (MSSTC) programs. MSSTC programs focus on the creation of new wealth by translating scientific and technical knowledge into products and services. The MSSTC programs educate individuals to operate entrepreneurially - primarily in the early stages of the product and business life cycles. The MS in Science & Technology Commercialization (MSSTC) programs differ from MOT programs and MBA programs in that the MOT and MBA programs focus on the more efficient and effective management of the current organization and operations – previously created wealth – in the later stages of the product and business life cycles. In the MBA programs, the emphasis is on the A – administration. In contrast, the MSSTC program focuses primarily on the early stages – the wealth creation stages of the product and business life cycles.

Table 2: Comparative Profiles of MBA, MS in Technology, MOT, and MSSTC Programs

Characteristics	MBA	MS-Technology	MOT	MSSTC
Target Population	Managers	Technologists	Both Managers & Technologists	Entrepreneurs, Intrapreneurs, Managers & Technologists
Foundation Disciplines	Economics & Social Sciences	Science & Engineering	Economics & Engineering	Economics, Social Sciences, Science, Engineering & Entrepreneurship
Orientation	Functional Specialization	Functional Specialization	Integrative	Integrative High Performance –Cross Functional Teams
Decision Criteria	Economic Returns	Scientific & Technology Advancement	Technology to Customer Value & Cost Advantage	Market Focus – Will Customers Buy?
Technology Focus	Product Driven	Process Driven	Integration of Product & Process Technologies	How Can Wealth be Created from the Technology?
Domain	Business Schools	Engineering Schools	Business & Engineering Schools	Business & Engineering Schools
Organizational Structures	Management	Technical	Cross Functional Integration	New Venture Teams

Tim Kennedy, advising a perspective applicant to the University of Texas at Austin MSSTC program writes:

"I have both an MBA and the MSSTC degree. I work in the software industry doing new product development for a large company. I am also in the alumni associations for both schools.

"My perspective on the MSSTC program is that it is much better than an MBA, even one focusing on technology commercialization. Most MBA's, including mine, required 10 core courses on marketing, statistics, accounting, economics, finance, etc. Their focus is primarily on mature companies, especially large ones. You then, as was the case in my MBA, can take four or five specialization courses on technology commercialization. The end result is fragmented knowledge that really does not tie together well.

"The MSSTC program is great because every single course is tailored to focus on technology commercialization. It also can be completed in a year where my MBA took me four years part time. Other good things about the program include the fact that you work with real inventors and real technologies in the project work. That is far better than the typical case studies you get in an MBA. Lastly, because everyone takes the same courses together, you really develop a strong bond with the people on your project teams. It is independent of whether you are remote, or in class. I even made some great friends with several people from Australia, on my team. That network is invaluable as you progress

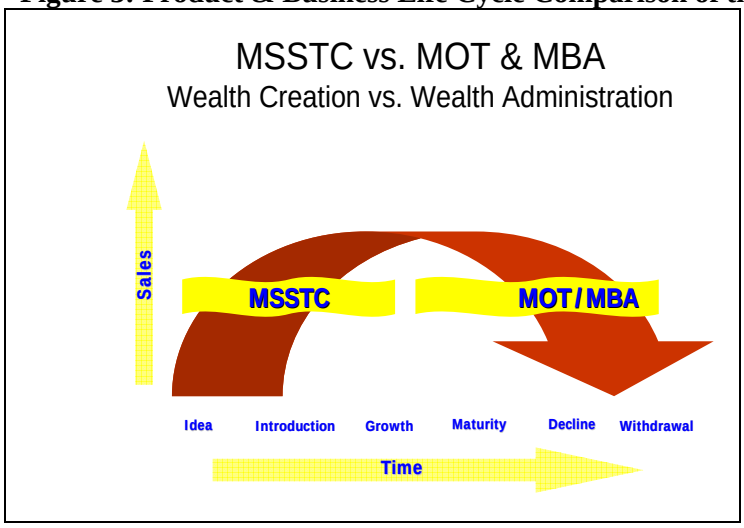
in your career. It is also why I spend so much time working with the MSSTC alumni association as a volunteer.

"The downside to the program is that, by compressing it into a year with 12 courses, instead of the 20 I took in my MBA, some topics like statistics, economics, accounting and finance are more compressed. You still cover a lot of the same information. It just comes at you faster. Having an MBA made it much easier for me, but some struggled a little with that. Also, having 4 courses at a time means more work. It [MSSTC] was more demanding of my time than my MBA."

MSSTC programs are adamant about educating individuals to align technology with market needs. Most new ventures fail due to misalignment between the products or services offered to the market, not because the technology failed or a lack of funding. MBAs and MOTs are, for the most part, fine-tuning organizations and operations in which the market-product alignment is already at equilibrium.

Figure 3 illustrates the major differences between the MSSTC degree and the MBA and MOT degrees. Note that MSSTC programs focus on the idea, introduction, and growth stages – the entrepreneurial stages of the wealth creation processes. MSSTC programs attract individuals who feel psychologically comfortable dealing with the ambiguity associated with the high-risk, high-reward challenges of introducing new technologies to new markets. These individuals may be entrepreneurs or may be intrapreneurs within large established organizations. MSSTC students are individuals who enjoy the role of "pioneer."

Figure 3: Product & Business Life Cycle Comparison of the MSSTC vs. MOT & MBA Degrees



Individuals enrolling in MSSTC programs are willing to differentiate themselves in the labor market by pursuing a new degree. The well-traveled path is to earn the MBA, which over 120,000 individuals do travel annually in the US. The path less traveled is to earn the graduate MOT degree of which approximately 1,500 are awarded annually. The pioneering trail is the MSSTC degree which currently is trod by less than 100 graduates annually.

There are approximately thirty universities globally that offer courses in technology commercialization, but only five offer degrees in technology commercialization. Table 4 presents the five universities offering graduate degrees in technology commercialization.

Table 4 Universities Offering Graduate Degrees in Technology Commercialization

University	Degree	Date Started	Country
University of Texas of Austin http://msstc.ic2.org	MS in Science & Technology Commercialization	1996	USA

University of Adelaide www.ecic.adelaide.edu.au	MS in Technology Commercialization PhD in Technology Commercialization	2001 2004	Australia
University of Alberta http://mba.bus.ualberta.ca	MBA in Technology Commercialization	2002	Canada
University of Lodz http://www.uni.lodz.pl	MS in Science & Technology Commercialization	2004	Poland
University of Washington http://depts.washington.edu/cte/phd_overview.shtml	PhD in Technology Entrepreneurship	2003	USA

The MS in Science & Technology Commercialization programs of the University of Adelaide in Australia and of the University of Lodz in Poland are direct derivatives of the University of Texas at Austin. Both the Adelaide and Lodz programs were modeled after the University of Texas at Austin's MS in Science & Technology Commercialization program. The University of Texas at Austin worked with the University of Adelaide and the University of Lodz to start their MS in Science & Technology Commercialization programs by sharing experience, lessons learned, and intellectual property.

The University of Alberta offers a concentration in technology commercialization in the MBA program. The University of Washington's PhD program in Technology Entrepreneurship is part of the University of Washington's long-standing and pioneering commitment to the study of entrepreneurship.

FORCES DRIVING THE EXPANSION OF TECHNOLOGY COMMERCIALIZATION PROGRAMS

The demand for technology commercialization programs will continue to expand as more organizations begin to recognize the links among R&D, strategy, customer value and competitive advantage. Technology commercialization programs meet a real organizational need, namely the bridging and integration of technology and business. Most technology commercialization programs will continue to be executive programs since newly minted MBA and MS technologists' focus tends to be on utilizing technical skills early in their careers. As an individual's career progresses, there is more emphasis on dealing with the more strategic commercialization issues of integration across functions.

Another force driving the technology commercialization programs is the fact that many organizations are developing intellectual property that does not support their primary business. The challenge is to commercialize and monetize these intellectual property assets. For example, IBM generates over $2 billion annually in licensing intellectual property.

SUMMARY

Since the University of Texas at Austin's MS in Science & Technology Commercialization program deals with a large number of subjects, topics and conceptual frameworks, it can do not so in the depth sufficient to satisfy individuals who wish to become deeply steeped in a particular discipline. The MS in Science & Technology Commercialization program is about introducing the individuals to the range of disciplines that are necessary to create wealth – to translate an idea grounded in science or technology into a business – and the inter-relationships among the various disciplines can be integrated to achieve a successful outcome. A successful outcome is defined as the creation of value for the customer, competitive advantage for the organization, and increased wealth for the investors.

The focus of the MS in Science & Technology Commercialization program is on the entrepreneurial commercialization process – the process of matching the technology to the marketplace – not the technology per se. Most new products and business fail not for technological or financial reasons but due to a misalignment between the market and the product. The successful MS in Science and Commercialization Technology graduate is able to analyze the market – product – technology interrelationships. A basic tenet of the MSSTC program is that it is not the technology per se that

creates the value but the complex web of relationships among market need, organizational purpose, scientific process, and people leadership interacting dynamically together that generates customers and competitive advantage and wealth.

As the MS in Science & Technology Commercialization graduates appreciate and communicate the complex relationships associated with the entrepreneurial wealth creation and job creation processes, they can confidently lead their organization forward into new opportunities for wealth creation with "speed, simplicity, and self-confidence (Tichy and Charan 1989)."

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