



## Commercializing inventions resulting from university research: Analyzing the impact of technology characteristics on subsequent business models

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### ABSTRACT

One of the key challenges in commercializing inventions arising from academic research is deciding on an appropriate business model for transferring the invention from the academic world to the commercial world. However, there is little empirical evidence to suggest which model to choose. This study attempts to address this gap by examining how characteristics of technologies affect the selection of business models.

We consider four characteristics of technology: patent or other legal protection, specialized complementary assets, commercial uncertainty and technological dynamism. We relate these characteristics to the choice of three basic business models for commercializing inventions. Data for this study were gathered for 42 commercialized inventions.

We found evidence that greater patent or other legal protection for the technology was associated with a greater likelihood that the technology was commercialized by transferring limited rights to the technology to existing firms. We also found evidence that greater commercial uncertainty was associated with a greater likelihood that the technology was commercialized by creation of a new firm or transfer of the rights to the technology to an existing firm. We did not find evidence of a relationship between the importance of specialized complementary assets or technological dynamism and the business model used.

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### 1. Introduction

Universities perform approximately 17% of research and development activities in OECD member countries (OECD, 2006) and are an important source of inventions that may result in new technologies of commercial significance (Chesbrough, 2003). However, universities are not in the business of producing goods and services based on these inventions (Shane, 2004) and, consequently, the commercialization of these inventions typically involves the transfer of knowledge and intellectual property rights to these inventions across organizational boundaries. One of the key challenges in commercializing inventions resulting from academic research is deciding on an appropriate business model for transferring the invention from the academic world to the commercial world. However, there is little empirical evidence to suggest which model to choose. Better understanding of the reasons for different forms of commercialization can help inventors and others involved in the commercialization process to select appropriate methods for commercializing inventions.

Many factors may affect the method selected to commercialize an invention. These include the quality of management available to lead the commercialization effort, the availability of financial capital, external factors and the characteristics of technologies such as the strength of intellectual property protection for the technology (Rothaermel et al., 2007; Shane, 2004; Auerswald and Branscomb, 2003). Many of these factors have been studied in considerable detail. However, the research to date on the effect of various characteristics of technologies on methods of commercialization is limited and has produced conflicting results. The research described in this study attempts to address these issues and asks the research question: How do the characteristics of technologies affect the selection of business models used to commercialize inventions arising from university research?

### 2. Literature review

Inventions arising from university research are rarely ready for immediate conversion into commercial products or services (Rogers, 2003). The conversion of these inventions into products and services is a difficult process. A transformation process involving the integration of both scientific and market knowledge

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is needed to develop commercially viable new products and services based on these new technologies (Fontes, 2005). This transformation process involves a number of activities including technology development, product development and business development. The technology development activities often involve significant changes to the technology to improve the performance, robustness, ease of use and other characteristics of the technology (Shane, 2004). Product development activities involve converting the new technology into a product or service. Customers generally do not buy technology; rather they buy products or services that provide solutions to the problems they face (Shane, 2004). Business development involves acquiring or developing the other capabilities and complementary assets needed to develop, produce and sell products or services based on the technology. These may include manufacturing, distribution, marketing and selling capabilities (Teece, 1986). Universities generally do not have the capacity to perform all of these activities and, consequently, commercialization typically involves the transfer of the invention to external organizations.

Successful commercialization of new technologies involves the interplay of many factors. Environmental influences include market opportunities and differences across geographic locations and differences across industries (Shane, 2004). University institutions, practices and policies and the role of people, particularly inventors, in commercialization are also important (Agrawal, 2001). While there is a growing academic literature on the commercialization of inventions arising from university research (see Rothaermel et al. (2007) for an excellent review of this literature), the research relating the characteristics of technologies to the methods used to commercialize them is limited.

Colyvas et al. (2002) considered 11 inventions from Columbia University and Stanford University. Based on their examination of these case studies, they found that inventions that were 'ready to use' out of the laboratory did not require exclusive licenses in order to encourage firms to commercialize the technology and in most cases (three of four instances) were licensed nonexclusively to the commercializing firms. They also found that exclusive licenses were important to encourage firms to undertake the development risks associated with embryonic inventions.

Shane (2002) examined 717 licensed patents from the Massachusetts Institute of Technology and found that when patents are not effective, technologies are likely to be licensed back to the inventors. In another study using the same dataset, Shane (2001, p. 216) considered the commercialization of technologies through the establishment of a new firm. Based on his examination of these data, Shane concluded that "more important inventions, more radical inventions, and inventions with a broader scope of patent protection were more likely to be commercialized through the creation of new firms". Nerkar and Shane (2003) built on this study by further examining the 128 new firms founded to commercialize new technologies. They found that technology radicalness and patent scope reduce firm failure but only in fragmented industries.

del Campo et al. (1999, p. 294) analyzed the attempt to commercialize superconducting quantum interference devices. They concluded that "licensing may be the best strategy when the proprietary position of the intellectual property is narrow or unpatentable and when the capabilities of the developer are limited". Further, they concluded that start-ups need inventions that represent a core technology with a large market potential and, if possible, multiple product applications to compensate for the high risks involved in creating a start-up firm.

Wright et al. (2004) examined four high tech start-up firms from universities in the United Kingdom. In each of the four cases, Wright et al. found that the technologies involved could be

considered disruptive innovations (Christensen, 1993) suggesting that start-ups are an appropriate method of commercializing such technologies. They also found that licensing was not a viable option in these four cases because potential licensing firms did not have the know-how or tacit knowledge to undertake the required technology development activities.

Thursby et al. (2001) surveyed 62 technology transfers offices at U.S. universities and found that 60% of the survey respondents indicated that large companies were more likely to take late stage technologies and that small companies were more likely to take early stage technologies.

Using evidence from many of the studies described above and from semi-structured field interviews of people involved in the formation and development of start-ups from the Massachusetts Institute of Technology, Shane (2004) summarized the characteristics of technologies that support commercialization by creation of a start-up vs. commercialization by licensing to an established firm. Shane concluded that start-ups are used to commercialize new technologies that are radical, tacit, early stage, general-purpose, provide significant value to customers, involve major technical advances and have strong intellectual property protection. Licensing to established firms is used to commercialize new technologies that are incremental, codified, late stage, specific-purpose, provide moderate customer value, involve minor technical advance and have weaker intellectual property protection.

Taken together, this research suggests that different business models are appropriate in different circumstances and that successful business models reflect an appropriate fit between the invention, the inventor, and the commercializing organization. Further, this research suggests that the characteristics of a technology do affect the selection of method used for commercializing the technology. However, there are important limitations to the evidence obtained. The primary limitation is that the evidence is derived from one large sample from a single university and from a small number of case studies from other universities. There is a need for evidence from additional studies and from universities other than the Massachusetts Institute of Technology.

A number of important issues arise from the research on the characteristics of technology. The first is that all of the above studies focus on licensing and start-ups as the choices for commercializing a new technology. However, there is very limited use of theory in any of these studies to indicate what the differences are between these methods of commercialization and why they are important. In addition, there is very limited use of theory in any of these studies linking the characteristics of technology to the method of commercialization.

A second limitation is that little attention has been paid to the business models used by start-ups. The discussion of start-ups focuses on start-ups that develop new products or services based on the technology. This is not, however, the only way that start-ups can commercialize a new technology (Druihe and Garnsey, 2004). Both of these issues are addressed in this study.

### 3. Hypotheses

We consider four characteristics of technology: (1) the patent or other legal protection for the technology, (2) the importance of specialized complementary assets, (3) the commercial uncertainty associated with the technology and (4) the technological dynamism associated with the technology. We relate these characteristics to the selection of three basic business models for commercializing the technology: (1) creation of a new firm to produce goods or services based on the technology, (2) transfer of substantially all of the rights to the technology to an existing firm

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