Commercialization of innovations: an overarching framework and research agenda

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Abstract

Purpose – The commercialization of innovation, which is key to entrepreneurial success, is a combination of several entrepreneurial activities. Building on research from fields of management, strategy, entrepreneurship, economics, and marketing, the paper summarized the extant literature to develop a framework of commercialization and an agenda for future research. The paper aims to discuss these issues.

Design/methodology/approach – Extensive review of literature, which was comprised of 194 articles across 62 journals in the fields of management, strategy, entrepreneurship, economics, and marketing.

Findings – The literature was categorized into six broad themes of entrepreneurial activities: sources of innovations, types of innovation, market entry (capabilities and feasibility), protection, development, and deployment. Most of the research papers that were reviewed were concentrated on single theme.

Practical implications – Given the identification of six key themes of entrepreneurial activity leading to the commercialization of innovations, research questions were posed as a means to move the research forward by integrating the themes.

Originality/value – This is the first paper in its kind to integrate 194 papers from 62 journals to provide a comprehensive framework of commercialization of innovations.

Keywords Commercialization of innovations, Innovation commercialization pathway, Innovation sources

Paper type Research paper

Introduction

Innovation is often described as the lifeblood of organizations and, within a corporate setting, the true value of innovation is manifested in outcomes such as commercialized products (Schendel and Hill, 2007). A firm's ability to commercialize innovations can help dominate current markets or develop newer markets, which contributes to continued industry leadership (Wallsten, 2000; Salamenkaita and Salo, 2002). Thus, success in commercialization of innovations is of strategic importance to firms (Nerkar and Shane, 2007).

Entrepreneurial activities surrounding commercialization of innovations often start with idea generation and end in product launch. However, estimates suggest that,

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of every 3,000 new-innovation ideas, only one is commercialized into a successful product (Stevens and Burley, 1997). Therefore, it is clear that the generation of ideas is not sufficient to commercialize innovations. Despite this low probability of translating innovations into products, the need to successfully commercialize is crucial. Consequently, firms often find themselves aiming three to five years in advance at an elusive future new-product target (Grove, 1996; Burgelman *et al.*, 2006). Further, globalization has put more pressure on firms to commercialize innovations and to expand into global markets (Huygens *et al.*, 2001; Hamel and Getz, 2004). Such pressure generates an increased pace in innovating and commercializing, which not only helps the innovators to be successful but also raises the bar for the competitors.

Past research has connected the ability to successfully commercialize innovations with firm's capabilities (Damanpour, 1991; Pennings and Harianto, 1992; Dougerty and Hardy, 1996; McGrath *et al.*, 1996; Teece *et al.*, 1997), human resource practices (Scott and Bruce, 1994; Nerkar *et al.*, 1996), the nature of top-management teams (Bantel and Jackson, 1989; Howell and Higgins, 1990) and the external environment within which the firm operates (Milliken, 1987; Keats and Hitt, 1988; Abrahamson and Rosenkopf, 1993; Wade, 1996; Wade and Hulland, 2004). Despite the need to understand how to successfully commercialize innovations, the literature does not provide an integrative framework.

The importance of innovation commercialization is evident in practice as well. In 2010 a McKinsey survey estimated that only 39 percent of executives felt that their companies are good at commercializing new products. In the same survey, one-third of them identified innovation commercialization as one of the foremost challenges and 43 percent said the bigger challenges included choosing which ideas to move forward. Academic research echoes these sentiments. For example, Chiesa and Frattini (2011) argued that many products in hi-tech industries fail due to poor understanding of the commercialization process. Yet there is no clear understanding, in management theory and practice, of how commercialization decisions influence the market failure of new high-tech products (Chiesa and Frattini, 2011). When taken together, this evidence points to the fact that we need to better understand the process of innovation-commercialization. Therefore, in this work, we conduct a review of the literature to better understand the underlying themes, integrate the pertinent findings, and identify avenues for future research.

This paper makes two major contributions. First, we define and provide conceptual boundaries around commercialization of innovations via an overview of the broad range of literature that has addressed it, from which we identify six main themes: sources of innovations, types of innovation, market entry, which includes both capabilities and feasibility, protection, development, and deployment. Second, we highlight omissions in the existing literature, and identify and discuss the issues and questions that need to be addressed by future studies. For the purpose of this paper, we will focus mainly on product innovation and those processes that are geared towards developing a product. The importance of service innovation notwithstanding, it remains outside the scope of this work.

What is commercialization of innovation?

Belying the idea that commercialization of innovation is a simple construct are the multiple definitions, conceptualizations, and operationalizations that have emerged across studies. Commercialization of innovation refers to the activities required for

introducing an innovation to market (Kelm *et al.*, 1995; Narayanan *et al.*, 2000; Kwak, 2002; Andrew and Sirkin, 2003; Nambisan and Sawhney, 2007; Nerkar and Shane, 2007). Nerkar and Shane (2007) measured commercialization of innovation as the early indication of commercialization, operationalized as the first sale of the target product or service. However, when an innovation is introduced in the market, only technology enthusiasts typically procure in the early stage, and such enthusiasts comprise less than three percent of the market (Moore, 1991, 2000). The larger mainstream market is comprised of pragmatists and conservatives, and hence a successful commercialization is one that captures this mainstream market (Moore, 2000). Reaching the mainstream market in this manner is often difficult, and the threshold for "successful" commercialization of an innovation will likely lie somewhere between these two extremes – single sale on the one hand and saturating the mainstream market on the other. We therefore define the ability to commercialize an innovation as a firm's capacity to bring a product into a market and reach the mainstream of the market beyond the initial adopters.

For the purpose of this paper we will focus mainly on product innovation and the processes that are geared towards developing a product. For instance, firms often patent a process in order ultimately to create a product, with an example being the process of brewing coffee. These processes lead to construction of an apparatus such as a better coffee maker (16 – pump espresso), which are then sold as products. Hence these processes fall within the scope of our work.

Methodology for literature review

Review strategy

We surveyed the theoretical and empirical studies in leading management, strategy, entrepreneurship, economics, and marketing journals to date. We first searched articles in the Web of Science, JSTOR, ABI/INFORMS, and EBSCO Host databases using the terms "commercialization" and "innovations" and their derivatives (e.g. commercial). We did not restrict ourselves to searching the abstracts; rather we included those search terms for the entirety of the articles. In order to capture a comprehensive view of the topic across fields, we did not limit our search to any set of specific journals. After removing the overlapping articles from the databases, we were left with 194 unique articles from 62 journals across all five disciplines of management, strategy, entrepreneurship, economics, and marketing.

In order to categorize the journals into disciplines, we looked into the scope and objectives of each of them. The ones that are categorized within clear disciplines had clear statements in their objectives tied to contribution within those fields. 12 journals, focusing mainly on innovations and technology transfer were termed as "interdisciplinary". Their scope and objectives had an interdisciplinary flavor inspiring contribution from multiple fields. Two journals, *The American Journal of Sociology* and the *IEEE Transactions on Engineering Management* were categorized as "others." Table I shows the distribution of journals and citations across the disciplines. It also shows the number of articles by discipline, number of articles by journal, their respective citations and average citations per article. While most journals had only one article, the *Strategic Management Journal* and *Journal of Management Studie*s had 29 and 20 articles, respectively. The *Strategic Management Journal* also had the most citations at 31,908. Administrative science quarterly had the highest number of citations per article at 5,086.

Discipline	Journal name	No. of articles	Citations	Citations/ article
Economics journals: 13 (21%) articles: 23 (12%)	*The American Economic Review*	5	3,975	795
	Brookings Papers on Economic Activity	1	3,229	3,229
	Cambridge Journal of Economics	1	414	414
	The Economic Journal	1	6,244	6,244
	Economics of Innovation and New Technology	1	449	449
	Journal of Economic Behavior & Organization	1	739	739
	Journal of Economic Literature	2	7,996	3,998
	Journal of Political Economy	1	2,240	2,240
	Journal of Urban Economics	1	1,217	1,217
	The Quarterly Journal of Economics	1	1,518	1,518
	RAND Journal of Economics	5	5,641	1,128.2
	Review of Economics and Statistics	2	286	143
	The Scandinavian Journal of Economics	1	0	0
Entrepreneurship journals: 2 (3%) articles: 3 (2%)	*Journal of Business Venturing*	1	287	287
	Small Business Economics	2	670	335
Interdisciplinary journals: 16 (26%) articles: 55 (28%)	*Administrative Science Quarterly*	7	35,605	5,086.4286
	Industrial and Corporate Change	1	188	188
	Innovation Policy and the Economy	1	26	26
	International Journal of Technology Management	1	27	27
	Journal of Product Innovation Management	8	2,078	259.75
	The Journal of Technology Transfer	2	26	8.6666667
	Technological and Economic Development of Economy	1	1	1
	Long Range Planning	1	2	2
	Managerial and Decision Economics	1	3	3
	R&D Management	2	0	0
	Research Policy	14	1	1
	Research Technology Management	2	372	186
	European Journal of Innovation Management	3	22	22
	International Journal of Innovation in Digital Economy	1	559	279.5
	International Journal of Strategic Information Technology and Applications	1	3,229	201.8125
	Technological Forecasting and Social Change	1	2,585	1,292.5
	Technovation	6	306	51
Management journals: 22 (36%) articles: 70 (36%)	*Academy of International Business*	1	899	899
	Academy of Management Executive (1993-2005)	1	6	6
	Academy of Management Journal	7	3,984	569.14286

(*continued*)

Table I.
Distribution of journals and articles across disciplines

Discipline	Journal name	No. of articles	Citations	Citations/ article
	Academy of Management Review	1	2,619	2,619
	California Management Review	1	668	668
	European Management Journal	2	311	155.5
	The Executive	1	63	63
	Global Business and Organizational Excellence	1	8	8
	Interfaces	1	425	425
	International Journal of Operations and Production Management	1	11	11
	Journal of Management	1	3	1.5
	Journal of Management Studies	20	751	751
	Journal of Workplace Learning	1	2,255	112.75
	Management Science	15	57	57
	Organization Science	6	7,489	499.26667
	Production & Operations Management	2	11,683	1,947.1667
	Sloan Management Review	1	0	0
	International Business Review	1	8	8
	Journal of Business Research	2	120	120
	Technology & Investment	1	5	5
	International Journal of Management Practice	1	959	479.5
	Journal of International Business Studies	2	0	0
Marketing journals: 3 (5%) articles: 7 (4%)	*Journal of Marketing*	2	262	131
	Journal of Marketing Research	4	1,159	289.75
	Marketing Science	1	10	10
Others journals: 2 (3%) articles: 2 (1%)	*American Journal of Sociology*	1	1,802	1,802
	IEEE Transactions on Engineering Management	1	27	27
Strategy journals: 3 (5%) articles: 33 (17%)	*Strategic Management Journal*	29	4	2
	Technology Analysis & Strategic Management	2	31,908	1,100.2759
	Journal of Management & Strategy	2	146	73

Table I.

Categorizing the literature into broad themes

The transformation of innovations into tangible products entails:

- *Discovery.* Recognizing a market for an innovation.
- *Development.* Developing and manufacturing it as a product.
- *Deployment.* Selling/distributing the product through distribution channels (Teece, 1986; Mitchell, 1989; Teece *et al.*, 1997; Ahuja, 2000a, b).

Thus, we initially classified the emerging literature into these three categories. After coding the articles into these themes, we found that three categories were not sufficient to classify all the 194 papers. To begin with, we found a significant number of papers (26) concentrated on the types of innovations, process vs product, radical vs incremental,

architectural vs component. Further, some papers linked types of innovations with sources (Jaffe *et al.*, 1993; Henderson and Cockburn, 1994; Christensen and Bower, 1996; Morgan and Berthon, 2008; Damanpour *et al.*, 2009; George *et al.*, 2012) and development (Jaffe *et al.*, 1993; Dahlin and Behrens, 2005; Golder *et al.*, 2008; Morgan and Berthon, 2008; Damanpour *et al.*, 2009; George *et al.*, 2012), thereby making the category impossible to ignore. About 20 articles concentrated on aspects related to market entry based on the capabilities of the firm and economic and technological feasibility. Most articles in this area were standalone articles, not linking with other themes. (Exceptions were (Kelm *et al.*, 1995; Morgan and Berthon, 2008; Kim *et al.*, 2011; Lo *et al.*, 2012), where feasibility was linked with sources of innovations, and deployment and development (Kim *et al.*, 2011; Lo *et al.*, 2012)). The reasons for the inclusion of market entry were:

- the articles ranged across disciplines: management, strategy and marketing;
- most of them came from top outlets such as *Academy of Management Journal*, *The Economic Journal*, *Journal of Marketing Research*, *Journal of Management Studies*, *Management Science*, *Organization Science*, *Research Technology Management*, *The Strategic Management Journal*, and *Technovation*; and
- market entry and feasibility analysis is paramount in determining the commercial potential of an innovation.

With 21 articles, innovation protection also emerged as a theme within the commercialization of innovations. While most of the articles concentrated on means of innovation protection, such as trademarks, patents and copyrights (Jaffe *et al.*, 1993; Grindley and Teece, 1997; Jaffe, 2000; Shane, 2002; Alcacer and Gittelman, 2004; Ziedonis, 2004; de Laat, 2005; Hall *et al.*, 2005; Lecocq and Demil, 2006), many linked protection with other themes such as innovation sources (Jaffe, 1986; Levin *et al.*, 1987; Levin, 1988; Jaffe *et al.*, 1993; Cassiman and Veugelers, 2002; Shane, 2002; Aldridge and Audretsch, 2010; Gambardella and McGahan, 2010; Datta *et al.*, 2011; Link *et al.*, 2011), innovation type (Jaffe *et al.*, 1993; Dahlin and Behrens, 2005; Anokhin *et al.*, 2011), development (Lowe, 1993; Garud *et al.*, 2002; Shane, 2002; Aldridge and Audretsch, 2010; Gambardella and McGahan, 2010; Anokhin *et al.*, 2011; Datta *et al.*, 2011), and deployment (Lowe, 1993; Grindley and Teece, 1997; Datta *et al.*, 2011).

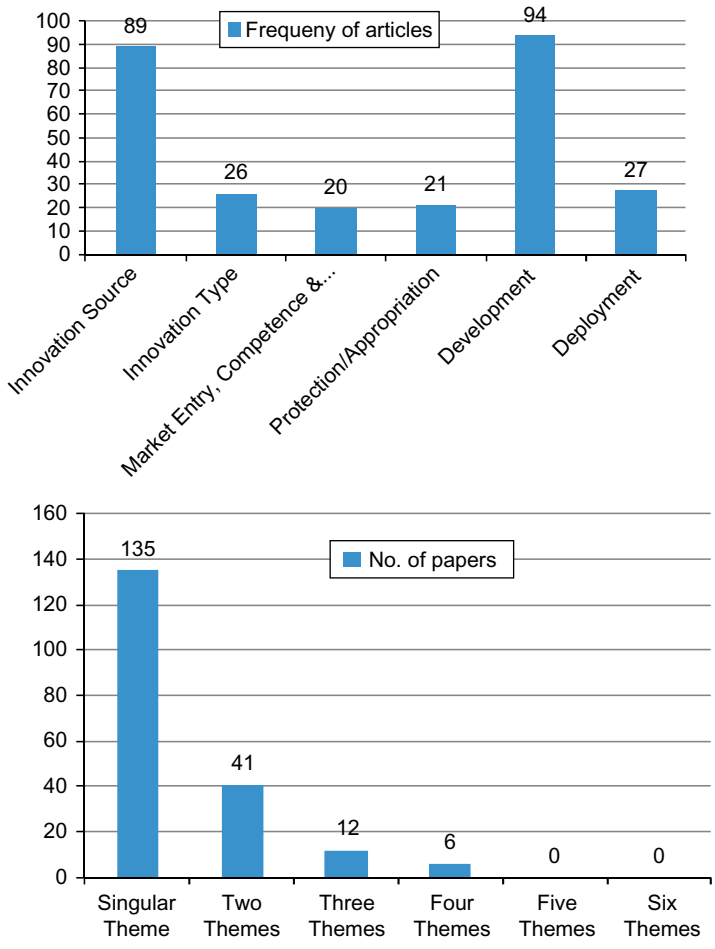
Three more themes had therefore emerged from our interpretation of the existing literature. Before committing ourselves to the six themes we also consulted two industry experts – an entrepreneur and an angel investor. Both of them agreed on the exhaustiveness of the six categories. Accordingly, we categorized the literature across these six themes:

(1) innovation source;
(2) innovation type;
(3) market entry: capabilities and feasibility;
(4) protection;
(5) development; and
(6) deployment.

In terms of distribution of articles across themes, several articles corresponded to more than one theme. Thus, adding the articles belonging to a theme will produce a number higher than the total number of articles surveyed (194). The distribution of articles

across themes were innovation source (89), innovation type (26), market entry (20), protection (21), development (94), and deployment (27). Figure 1 (part I) summarizes this information. Out of the 194 articles, 135 corresponded to a single theme, only 41 articles corresponded to two themes, 12 articles to three themes, and only six articles addressed four themes. There were no articles that addressed five or more themes. Figure 1 (part II) summarizes this information. Table II shows how each article fared in terms of its presence across the six themes and the citation scores of each article.

In addition to distribution of articles and number of articles, we also looked at citations for each of the articles for impact. Figure 2 (part I) summarizes overall citations for each of the six themes. And, Figure 2 (part II) summarizes number of citations by number of articles across themes. Figure 2 (part I) is consistent with Figure 1 (part I), which shows that source and development got the maximum citations at 79,520 and 70,745, respectively.



Note: Some Articles belong to more than one theme

Figure 1.
Frequency of articles by themes (I) and across themes (II)

Table II.
Articles surveyed and corresponding themes on commercialization of innovations

Study	Journal	Citations	Themes Innovation source	Innovation type	Market entry, competence and feasibility	Protection/ appropriation	Development	Deployment
Lyles and Salk (2006)	*Academy of International Business*	899					Y	Y
Birley *et al.* (2001)	*Academy of Management Executive (1993-2005)*	6					Y	Y
Brass *et al.* (2004)	*Academy of Management Journal*	912					Y	Y
Garud *et al.* (2002)	*Academy of Management Journal*	518				Y	Y	
Katila (2002)	*Academy of Management Journal*	286	Y					
Katila and Ahuja (2002)	*Academy of Management Journal*	925	Y					
Kelm *et al.* (1995)	*Academy of Management Journal*	148	Y		Y			Y
Tallman and Li (1996)	*Academy of Management Journal*	630					Y	Y
Zahra (1996)	*Academy of Management Journal*	565					Y	
Brown and Eisenhardt (1995)	*Academy of Management Review*	2,619					Y	
Ahuja (2000a, b)	*Administrative Science Quarterly*	2,377					Y	
Cohen and Levinthal (1990)	*Administrative Science Quarterly*	17,918	Y				Y	
Gulati (1995)	*Administrative Science Quarterly*	1,726					Y	
Gulati and Singh (1998)	*Administrative Science Quarterly*	1,424					Y	
Hargadon and Sutton (1997)	*Administrative Science Quarterly*	1,360	Y					
Henderson and Clark (1990)	*Administrative Science Quarterly*	5,433		Y				
Powell *et al.* (1996)	*Administrative Science Quarterly*	5,367					Y	
Acs and Audretsch (1988)	*The American Economic Review*	1,492	Y					
Cassiman and Veugelers (2002)	*The American Economic Review*	730	Y			Y		
Jaffe (1986)	*The American Economic Review*	1,518	Y			Y		
Jensen and Thursby (2001)	*The American Economic Review*	1					Y	
Levin (1988)	*The American Economic Review*	234	Y			Y		
Gulati and Gargiulo (1999)	*American Journal of Sociology*	1,802					Y	
Levin *et al.* (1987)	*Brookings Papers on Economic Activity*	3,229	Y			Y		
Grindley and Teece (1997)	*California Management Review*	668				Y		Y
Mowery and Oxley (1995)	*Cambridge Journal of Economics*	414					Y	
Arthur (1989)	*The Economic Journal*	6,244			Y			
Trajtenberg *et al.* (1997)	*Economics of Innovation and New Technology*	449	Y					
Kutvonen (2011)	*European Journal of Innovation Management*	4	Y				Y	
McCoy *et al.* (2010)	*European Journal of Innovation Management*	4					Y	
Schroll and Mild (2011)	*European Journal of Innovation Management*	18	Y				Y	
Birkinshaw (1998)	*European Management Journal*	67					Y	
Kumar *et al.* (2000)	*European Management Journal*	244		Y				
Hitt *et al.* (1991)	*The Executive*	63	Y				Y	
Rohrbeck *et al.* (2009)	*Global Business and Organizational Excellence*	8					Y	
Di Benedetto *et al.* (2008)	*IEEE Transactions on Engineering Management*	27		Y			Y	Y
Link *et al.* (2007)	*Industrial and Corporate Change*	188	Y				Y	
Litan *et al.* (2007)	*Innovation Policy and the Economy*	26	Y				Y	
Teece (1988)	*Interfaces*	425					Y	Y
Birkinshaw *et al.* (2005)	*International Business Review*	120					Y	
Datta (2011)	*International Journal of Innovation in Digital Economy*	1	Y					
Hanninen *et al.* (2007)	*International Journal of Management Practice*	5			Y			

(*continued*)

Study	Journal	Citations	Innovation source	Innovation type	Themes Market entry, competence and feasibility	Protection/ appropriation	Development	Deployment
Ebers and Lieb (1989)	*International Journal of Operations and Production Management*	11	Y				Y	
Datta (2011)	*International Journal of Strategic Information Technology and Applications*	2	Y					
Soosay and Hyland (2008)	*International Journal of Technology Management*	27	Y				Y	
Aarikka-Stenroos and Sandberg (2012)	*Journal of Business Research*	2	Y				Y	Y
Frans (2012)	*Journal of Business Research*	1	Y				Y	Y
Mian (1997)	*Journal of Business Venturing*	287	Y				Y	
Teece (1996)	*Journal of Economic Behavior and Organization*	739					Y	Y
Dosi (1988)	*Journal of Economic Literature*	4,028		Y				
Griliches (1990)	*Journal of Economic Literature*	3,968				Y		
Ghoshal and Bartlett (1988)	*Journal of International Business Studies*	618					Y	
Zahra (2005)	*Journal of International Business Studies*	341					Y	
Barringer and Harrison (2000)	*Journal of Management*	751					Y	
Datta (2011)	*Journal of Management & Strategy*	3	Y				Y	Y
Datta (2011)	*Journal of Management & Strategy*	1	Y				Y	Y
Alexiev *et al.* (2010)	*Journal of Management Studies*	18	Y	Y				
Bock *et al.* (2012)	*Journal of Management Studies*	3	Y				Y	
Bradley *et al.* (2012)	*Journal of Management Studies*	7	Y				Y	Y
Ciabuschi *et al.* (2011)	*Journal of Management Studies*	8	Y					Y
Crossan and Apaydin (2010)	*Journal of Management Studies*	97	Y				Y	
Damanpour and Gopalakrishnan (2001)	*Journal of Management Studies*	347		Y				
Damanpour *et al.* (1989)	*Journal of Management Studies*	304		Y				
Damanpour *et al.* (2009)	*Journal of Management Studies*	104		Y			Y	
Drazin (1990)	*Journal of Management Studies*	63	Y					
George *et al.* (2012)	*Journal of Management Studies*	10	Y	Y			Y	Y
Grimpe and Kaiser (2010)	*Journal of Management Studies*	47	Y				Y	
Halme *et al.* (2012)	*Journal of Management Studies*	1	Y				Y	Y
Martínez-Sánchez *et al.* (2011)	*Journal of Management Studies*	2	Y					
Mascarenhas (1991)	*Journal of Management Studies*	8			Y			
Mellahi and Wilkinson (2010)	*Journal of Management Studies*	13	Y				Y	
Morgan and Berthon (2008)	*Journal of Management Studies*	46	Y	Y	Y		Y	
Salaman and Storey (2002)	*Journal of Management Studies*	62	Y		Y			
Simmonds (1986)	*Journal of Management Studies*	45						Y
Vaccaro *et al.* (2012)	*Journal of Management Studies*	17	Y				Y	
Wolfe (1994)	*Journal of Management Studies*	1,053	Y				Y	
Aboulnasr *et al.* (2008)	*Journal of Marketing*	28		Y				
Sorescu *et al.* (2003)	*Journal of Marketing*	234		Y				
Chandy *et al.* (2006)	*Journal of Marketing Research*	51	Y					
Chandy and Tellis (1998)	*Journal of Marketing Research*	648		Y				

(continued)

Table II.

Table II.

Study	Journal	Citations	Innovation source	Innovation type	Market entry, competence and feasibility	Protection/ appropriation	Development	Deployment
			Themes					
Eliashberg and Robertson (1988)	*Journal of Marketing Research*	201						Y
Shankar *et al.* (1998)	*Journal of Marketing Research*	259			Y			
Katz and Shapiro (1986)	*Journal of Political Economy*	2,240			Y			
Athaide *et al.* (1996)	*Journal of Product Innovation Management*	119		Y				
Cooper (1985)	*Journal of Product Innovation Management*	146	Y				Y	
Cooper and Kleinschmidt (1986)	*Journal of Product Innovation Management*	805	Y				Y	
Johne and Snelson (1988)	*Journal of Product Innovation Management*	245					Y	
Ragatz *et al.* (1997)	*Journal of Product Innovation Management*	580					Y	
Slater and Mohr (2006)	*Journal of Product Innovation Management*	129						Y
Spivey *et al.* (1997)	*Journal of Product Innovation Management*	39		Y				
Yoon and Lilien (1988)	*Journal of Product Innovation Management*	15	Y					
Bercovitz and Feldman (2006)	*Journal of Technology Transfer*	215	Y					
Wright *et al.* (2004)	*Journal of Technology Transfer*	166	Y					
Anselin *et al.* (1997)	*Journal of Urban Economics*	1,217	Y					
Elmuti *et al.* (2005)	*Journal of Workplace Learning*	57	Y					
Brouthers *et al.* (1995)	*Long Range Planning*	303					Y	
Gambardella and McGahan (2010)	*Long Range Planning*	69	Y			Y	Y	
Almeida and Kogut (1999)	*Management Science*	1,526	Y					
Cassiman and Ueda (2006)	*Management Science*	111					Y	
Clark (1989)	*Management Science*	729					Y	
Cohen *et al.* (2002a, b)	*Management Science*	1,247	Y					
Dutta and Weiss (1997)	*Management Science*	176					Y	
Griffin and Hauser (1992)	*Management Science*	503					Y	
Kulatilaka and Lin (2006)	*Management Science*	32					Y	
Lilien *et al.* (2002)	*Management Science*	465					Y	
Lilien and Yoon (1990)	*Management Science*	333			Y			
Ron and Levinthal (2001)	*Management Science*	350		Y				
Rosenkopf and Almeida (2003)	*Management Science*	604	Y					
Schilling and Phelps (2007)	*Management Science*	290	Y				Y	
Shane (2002)	*Management Science*	324	Y			Y	Y	
Urban *et al.* (1986)	*Management Science*	534			Y			
Ziedonis (2004)	*Management Science*	265				Y		
Shaw and Shaw (1984)	*Managerial and Decision Economics*	22			Y			
Golder *et al.* (2008)	*Marketing Science*	10		Y			Y	
Almeida *et al.* (2002)	*Organization Science*	306	Y				Y	
Conner and Prahalad (1996)	*Organization Science*	2,486			Y			
Hill (1992)	*Organization Science*	79				Y		
Kogut and Zander (1992)	*Organization Science*	7,959	Y					
Madhok and Tallman (1998)	*Organization Science*	657					Y	Y
Pennings and Harianto (1992)	*Organization Science*	196					Y	

(continued)

Table II.

Study	Journal	Citations	Innovation source	Innovation type	Themes: Market entry, competence and feasibility	Protection/ appropriation	Development	Deployment
Christensen (1992a)	*Production & Operations Management*	264		Y				
Christensen (1992b)	*Production & Operations Management*	91		Y				
Jaffe *et al.* (1993)	*The Quarterly Journal of Economics*	1,518	Y	Y		Y		
Rice *et al.* (2001)	*R&D Management*	99		Y				
Gans *et al.* (2002)	*R&D Management*	460					Y	
Hall *et al.* (2005)	*RAND Journal of Economics*	1,518				Y		
Henderson and Cockburn (1996)	*RAND Journal of Economics*	2,040	Y					
Katz and Shapiro (1985)	*RAND Journal of Economics*	490				Y		
Kortum and Lerner (2000)	*RAND Journal of Economics*	1,070	Y					
Wallsten (2000)	*RAND Journal of Economics*	523	Y					
Aldridge and Audretsch (2010)	*Research Policy*	12	Y			Y	Y	
Cohen *et al.* (2002a, b)	*Research Policy*	489	Y					
Dahlin and Behrens (2005)	*Research Policy*	149		Y		Y		
de Laat (2005)	*Research Policy*	76				Y		
Freeman (1991)	*Research Policy*	1,609	Y				Y	
Gans and Stern (2003)	*Research Policy*	514					Y	
Goldfarb and Henrekson (2003)	*Research Policy*	323	Y					
Hagedoorn (2002)	*Research Policy*	1,056	Y					
Iwasa and Odagiri (2004)	*Research Policy*	125	Y					
Jaffe (2000)	*Research Policy*	376					Y	
Link *et al.* (2011)	*Research Policy*	188	Y			Y		
Lynn *et al.* (1996)	*Research Policy*	167					Y	
Rothaermel and Thursby (2005)	*Research Policy*	159	Y					
Stuart and Sorenson (2003)	*Research Policy*	469	Y					
Teece (1986)	*Research Policy*	6,567	Y					
Veugelers (1997)	*Research Policy*	622	Y					
Cohen *et al.* (1998)	*Research Technology Management*	50					Y	
Prahalad (1993)	*Research Technology Management*	2,535			Y			
Alcacer and Gittelman (2004)	*Review of Economics and Statistics*	109				Y		
Henderson *et al.* (1998)	*Review of Economics and Statistics*	177	Y					
Griliches (1992)	*Scandinavian Journal of Economics*	2,170				Y		
Kwak (2002)	*Sloan Management Review*	8					Y	
Almeida and Kogut (1997)	*Small Business Economics*	453	Y					
Lockett *et al.* (2003)	*Small Business Economics*	217					Y	
Aaker and Day (1986)	*Strategic Management Journal*	223			Y			
Agarwal (2006)	*Strategic Management Journal*	152	Y					
Ahuja (2000a, b)	*Strategic Management Journal*	911					Y	
Ahuja and Katila (2001)	*Strategic Management Journal*	909	Y				Y	
Ahuja and Lampert (2001)	*Strategic Management Journal*	850	Y					

(*continued*)

Table II.

Study	Journal	Citations	Themes Innovation source	Innovation type	Market entry, competence and feasibility	Protection/ appropriation	Development	Deployment
Anand and Khanna (2000)	*Strategic Management Journal*	1,333					Y	
Butler (1988)	*Strategic Management Journal*	88					Y	
Christensen and Bower (1996)	*Strategic Management Journal*	1,384	Y	Y			Y	
Danneels (2002)	*Strategic Management Journal*	891		Y				
Dyer and Nobeoka (2000)	*Strategic Management Journal*	2,342	Y					
Gulati (1998)	*Strategic Management Journal*	3,403					Y	
Gulati *et al.* (2000)	*Strategic Management Journal*	2,958					Y	
Hagedoorn (1993)	*Strategic Management Journal*	1,773					Y	
Henderson and Cockburn (1994)	*Strategic Management Journal*	2,040	Y	Y				
Kogut (1988)	*Strategic Management Journal*	3,083					Y	
Koka and Prescott (2002)	*Strategic Management Journal*	557					Y	
Lane and Lubatkin (1998)	*Strategic Management Journal*	2,858	Y					
Lecocq and Demil (2006)	*Strategic Management Journal*	17				Y		
Lieberman and Montgomery (1988)	*Strategic Management Journal*	2,371			Y			
Makadok (1998)	*Strategic Management Journal*	256			Y			
Mowery *et al.* (1996)	*Strategic Management Journal*	2,282					Y	
Narayanan *et al.* (2000)	*Strategic Management Journal*	70	Y					
Nerkar and Roberts (2004)	*Strategic Management Journal*	199						Y
Nerkar and Shane (2007)	*Strategic Management Journal*	62					Y	
Penner-Hahn and Shaver (2005)	*Strategic Management Journal*	169	Y					
Shamsie *et al.* (2004)	*Strategic Management Journal*	83			Y			
Song *et al.* (2005)	*Strategic Management Journal*	242			Y			
Zahra and Nielsen (2002)	*Strategic Management Journal*	341					Y	
Zhang and Li (2009)	*Strategic Management Journal*	61						Y
Lowe (1993)	*Technology Analysis & Strategic Management*	65	Y			Y	Y	Y
Salamenkaita and Salo (2002)	*Technology Analysis & Strategic Management*	81	Y					
Datta *et al.* (2011)	*Technology & Investment*	0	Y			Y	Y	Y
Kim *et al.* (2011)	*Technological and Economic Development of Economy*	1	Y		Y		Y	Y
Anokhin *et al.* (2011)	*Technological Forecasting and Social Change*	3		Y		Y		
Autio (1994)	*Technovation*	58	Y					
Carayannis *et al.* (1998)	*Technovation*	213					Y	
Chen and Guan (2011)	*Technovation*	3					Y	
Guan and Chen (2010)	*Technovation*	32	Y				Y	
Lo *et al.* (2012)	*Technovation*	2	Y		Y		Y	Y
Numprasertchai and Igel (2005)	*Technovation*	64	Y					

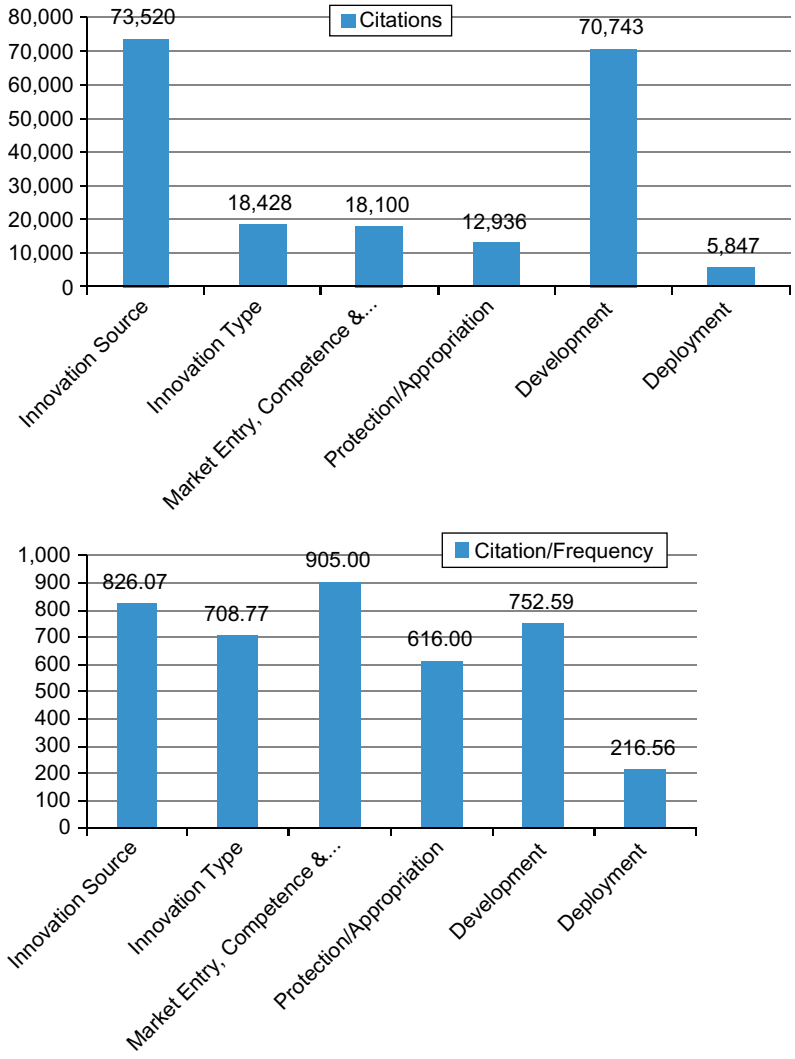


Figure 2.
(I) Frequency of citations by themes and (II) frequency of citations/no. of articles by themes

Central themes in commercialization of innovation

For an easier assimilation of the six themes that lead to the commercialization of innovations, as depicted in the articles and journals we examined, we created Figure 3. It shows how the six themes fit into the main activities of discovery, development, and deployment that broadly describe the process of innovation-commercialization. We need to caution the reader here about what may appear to be linearity among the themes in terms of sources of innovation leading to types of innovation, which in turn lead to market entry, and so forth. We cannot and do not claim linearity in the order of these activities. Depending on the scope of an innovation, a manager of a project can simply start from deployment of a prototype, seek customer feedback, and develop

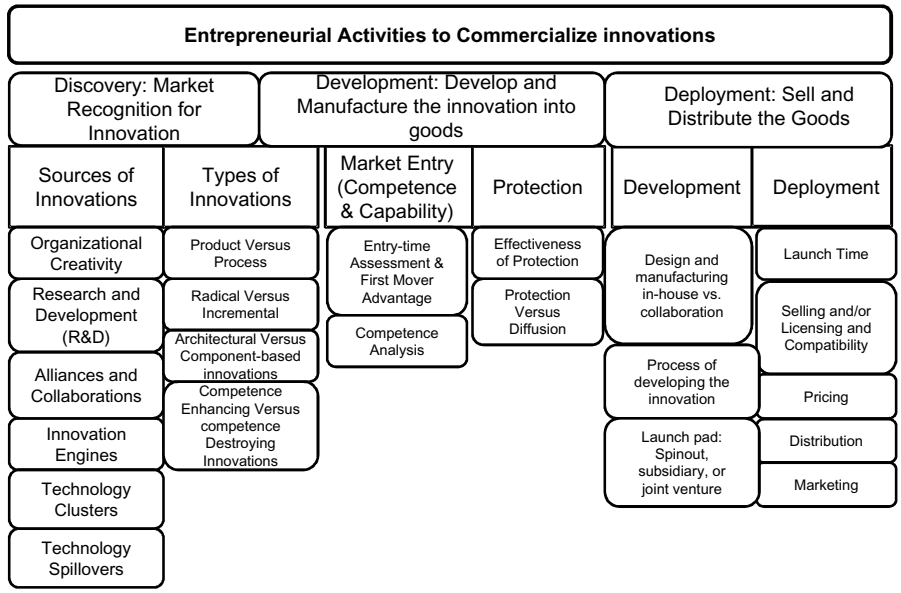


Figure 3.
Entrepreneurial steps to commercialization of innovations: themes from the extant literature

the innovation. Conversely, and for example, if the product is a therapeutic drug it is more likely that a more-linear process involving all six stages will be used.

All commentaries in the following sections are committed to the themes we identified rather than the order in which they take place. Below we describe the literature by the themes that emerged.

Innovation source

Innovation can originate within or outside the boundaries of the firm. The literature has identified sources of innovations as:

- organizational creativity;
- research and development;
- alliances and collaborations,
- innovation engines;
- technology clusters; and
- technology spillovers.

Organizational creativity. The creativity of the organization is a function of creative individuals and a variety of social processes and contextual factors that shape the way individuals interact and behave (Woodman *et al.*, 1993; Schilling and Phelps, 2007). To maximize creativity and idea generation processes that subsequently translate ideas into products, firms have routines and incentives in place (Schilling, 2006). Firms with the highest conversion ability are those that first focus on a moderate number of ideas in areas of market importance and in which they have expertise, and, second, that deliberate for a moderate length of time on promising ideas (Roberts, 2001; Chandy *et al.*, 2006).

Research and development. Firms' R&D intensity has been shown to have a positive correlation with sales from new products, sales growth rate, and profitability (Roberts, 2001). Thus, as a source of ideas for innovation, the R&D function, whether internally funded or externally contracted, is key (Acs and Audretsch, 1988; Levin, 1988; Kelm *et al.*, 1995; Veugelers, 1997; Lane and Lubatkin, 1998; Kortum and Lerner, 2000; Wallsten, 2000; Cassiman and Veugelers, 2002; Hagedoorn, 2002; Katila, 2002; Iwasa and Odagiri, 2004; Penner-Hahn and Shaver, 2005).

Alliances and collaborations. Recognition of an opportunity to commercialize an innovation is more likely to happen at the confluence of diverse entities (Anderson, 2008). Alliances and collaborations can help bring entities closer (Seppanen and Skates, 2001) through knowledge sharing and transferring. For instance, networks with customers, suppliers, complementors, and competitors are valuable sources of new product ideas (Cooper and Kleinschmidt, 1986; Yoon and Lilien, 1988). Also, external sources of information complements in-house R&D thereby increasing a firm's absorptive capacity (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Zahra and George, 2002; Chen, 2004). These sources include new ventures, licensing arrangements, sourcing agreements, research associations, and government-sponsored joint-research programs, as well as informal networks (Allen, 1977; Freeman, 1991; Hargadon and Sutton, 1997, 2000; Ahuja and Lampert, 2001; Burt, 1992). Such networks are especially important in high-technology sectors where it is unlikely that an individual firm will possess all the capabilities necessary to commercialize an innovation (Hagedoorn, 2002).

Innovations engines: universities and government. Universities and government agencies were freed to innovate with a view toward commercialization with the passing of the Bayh-Dole and the Stevenson-Widler Acts in 1980. Consequently, universities and firms will now often collaborate to develop innovations that can be commercialized (Trajtenberg *et al.*, 1997; Carayannis *et al.*, 1998; Jensen and Thursby, 2001; Goldfarb and Henrekson, 2003; Wright *et al.*, 2004; Numprasertchai and Igel, 2005; Rothaermel and Thursby, 2005; Bercovitz and Feldman, 2006). To increase the degree to which universities take a proactive role in commercialization of innovation, many have launched or significantly grown their technology transfer offices (Autio, 1994; Mowery and Oxley, 1995; Cohen *et al.*, 2002a, b; Colyvas *et al.*, 2002; Shane, 2002; Lockett *et al.*, 2003; Wright *et al.*, 2004; Agarwal, 2006; Bercovitz and Feldman, 2006). Similarly, numerous governments agencies also invest in research through their own laboratories, form and manage incubators, and offer grants for other public or private research entities (Wallsten, 2000; Cohen *et al.*, 2002a, b; Salamenkaita and Salo, 2002).

Technology clusters. Clusters encompass an array of industries that are linked together in a geographical proximity through relationships among suppliers, buyers, and producers of complements (von Hippel, 1987; Dyer and Nobeoka, 2000; Schilling and Phelps, 2007). A cluster of firms with high innovation-productivity can lead to new firms starting up in the immediate vicinity and attract other firms in that area (Stuart and Sorenson, 2003), which explains the attractiveness of Silicon Valley for technology firms (Saxenian, 1990; Saxenian, 1996; Almeida and Kogut, 1999; Cohen and Fields, 1999).

Technology spillover. Technology spillover is defined as a positive externality from R&D resulting from the spread of knowledge across organization and regional boundaries (Cohen and Levinthal, 1990; Schilling, 2006) and is a function of patenting, copyrights, and trademarks (Cohen *et al.*, 2002a, b) in addition to the mobility of knowledge workers

(Almeida and Kogut, 1999). It has a significant influence on innovation activities (Jaffe, 1986; Jaffe *et al.*, 1993; Henderson *et al.*, 1998) and increases a firm's absorptive capacity (Cohen and Levinthal, 1990).

Innovation type

Various studies have posited different taxonomies for innovations. Four more-prominent and distinct dimensions of innovation types are:

(1) product vs process innovations;

(2) radical vs incremental innovations;

(3) architectural vs component innovations; and

(4) competence-enhancing vs competence-destroying innovations.

Product vs process innovations. Product innovations are embodied in the outputs of an organization (Cooper and Kleinschmidt, 1986; Spivey *et al.*, 1997; Danneels, 2002; Burgelman *et al.*, 2006; Schilling, 2006). Process innovations, on the other hand, are innovations oriented toward improving the effectiveness and efficiencies of production, like reducing defect rates or improving supply-chain mechanisms (Davenport, 1993; Burgelman *et al.*, 2006; Schilling, 2006; Klein *et al.*, 2007; Tarafdar and Gordon, 2007). While product innovations are distinct from process innovations, the latter often helps in the attainment of the former (Burgelman *et al.*, 2006; Schilling, 2006).

Radical vs incremental innovations. Radical innovations are those that are new and totally different from prior innovations (Dahlin and Behrens, 2005; Golder *et al.*, 2008), resulting in radically new products, services, or delivery systems (Burgelman *et al.*, 2006). Radicalness is a function of newness and is characterized as:

- novel from past innovations and unique from present innovations; or
- having an impact on future innovations; or
- both (Dahlin and Behrens, 2005).

The most radical innovations are the ones that are new to the world and are extraordinarily different from existing products and services. Incremental innovations involve adaptations, refinements to existing products, services, or delivery systems (Burgelman *et al.*, 2006). Sometimes radical innovations are followed by a series of incremental innovations. For example, through the introduction of the Windows-based software architecture and its subsequent mainstream penetration of the personal computer market, microsoft changed the way personal computers were adopted and adapted. It was by definition radical, and one could make the same argument for the windows-based user interface from the early Apple computers or from the prototypes at XEROX PARC that the Apple interface was partly based on. However, successive releases of the Windows operating systems can be seen as incremental innovation.

Architectural vs component-based innovations. An innovation is architectural when it changes the overall design of a system or the way components interact with each other (Christensen, 1992b; Henderson and Cockburn, 1994). An innovation is component-based or modular when it does not significantly affect the overall configuration of the system within which it is embedded (Christensen, 1992a; Henderson and Cockburn, 1994). In studying the disk-drive industry, Christensen (1992b) found that architectural innovations frequently redefine the functionality of related products and address

fundamental product-performance needs. Such innovations have the power to change industry structure, and can often drive market innovation in that they can be aggressively deployed in emerging or remote markets, thus exhibiting an attacker's advantage. Christensen (1992a) also studied component innovations from the perspective of the disk drive industry and found that improvement in individual components benefited the firm but did not necessarily have profound influence on the broader industry.

Competence-enhancing vs competence-destroying innovations. An innovation is competence enhancing from the perspective of a firm if it builds on the firm's existing knowledge base. For example, as a firm deploys each successive generation of the Windows operating system (i.e. 3.1, 95, 98, 2000, ME, XP, Vista, Windows 7), it builds not only on the technology underlying the previous operating system generation but also on its own, growing knowledge base. On the other hand, an innovation is competence destroying from the perspective of a firm if the innovation does not build on its existing competencies and instead drives new competencies. For example, the plasma screen TV supplanted the cathode ray tube (CRT).

Market entry: capabilities and feasibility

Literature on market-entry assessment concentrates on three main activities – entry-time assessment, first-mover advantage, and competency analysis. The overlap between the first two means they can be discussed together.

Entry-time assessment and first-mover advantage. Research on entry timing has shown that it is a function of the margin of advantage offered by the new innovation, the state of enabling technologies, the state of complements, the state of customer expectations, threat of competitive entry, whether the industry faces increasing returns, and a firm's resources (Shaw and Shaw, 1984; Aaker and Day, 1986; Arthur, 1989; Lilien and Yoon, 1990; Makadok, 1998; Schilling, 1998; Shankar *et al.*, 1998; Shamsie *et al.*, 2004). Core to the discussion of entry timing is the assessment of first-mover advantage. Advantages include:

- brand loyalty and a reputation for technological leadership, preemptively capturing scarce resources, and exploiting buyer switching costs (Urban *et al.*, 1986; Lieberman and Montgomery, 1988); and
- benefits from increasing returns due to learning-curve effects and network externalities (Katz and Shapiro, 1986; Urban *et al.*, 1986).

Some of the disadvantages include:

- high failure rates because of considerable R&D expenses and consumer ambiguity;
- late movers can capitalize on the R&D and marketing efforts of the first movers, producing technology at lower costs and that corrects mistakes by first movers (Lieberman and Montgomery, 1988; Shankar *et al.*, 1998); and
- first movers may also face poorly-developed infrastructure in the form of suppliers, distribution channels, and availability of complementary goods (Shaw and Shaw, 1984; Lilien and Yoon, 1990; Makadok, 1998; Shankar *et al.*, 1998; Shamsie *et al.*, 2004).

All of these magnify the challenge of launching new products or services.

Competency analysis. Core competencies are integrated combinations of abilities that distinguish a firm in the market place (Hamel and Prahalad, 1989; Prahalad and

Hamel, 1989; Prahalad, 1993). The combination of resources and embedded skills that constitute competencies can require harmonizing multiple technologies across business units and can be difficult for other firms to imitate (Reed and DeFillipi, 1990; Barney, 1991). While it can be argued that competencies and capabilities are different – competencies are skill and asset interactions whereas capabilities are organizational routines (Reed and DeFillipi, 1990; Barney, 1991) – they often are used interchangeably. To avoid confusion, from this point forward in our discussions we will use the single term capability.

Protection

Like most intellectual property, innovation needs protection against duplication. Research on protection has concentrated on types of protection and its effectiveness as well as arguments as to diffusion versus protection.

Effectiveness of protection. The degree to which a firm can capture rents from its innovations is known as appropriability (Levin *et al.*, 1987; Levin, 1988; Cohen and Levinthal, 1989; Cohen and Levinthal, 1990), which, among other things, is a function of how quickly competitors can imitate the innovation. The three primary forms of legal mechanism to protect innovations are: patents, trademarks, and copyrights (Jaffe *et al.*, 1993; Grindley and Teece, 1997; Jaffe, 2000; Shane, 2002; Alcacer and Gittelman, 2004; Ziedonis, 2004; de Laat, 2005; Hall *et al.*, 2005; Lecocq and Demil, 2006). Mechanisms for protecting innovations are more effective in some industries than they are in others (Levin *et al.*, 1987; Levin, 1988; Griliches, 1990; Griliches, 1992; Lowe, 1993). In industries such as electronics and software, patents provide relatively little protection as rival firms can often work around the patent without infringing upon it (Burgelman *et al.*, 2006; Schilling, 2006). In the biotechnology industry one typically finds that a process has created a new product (e.g. monoclonal antibodies) and it is the process that is protected, not the product itself. In such cases a firm must can reveal its products without revealing the underlying technology (Pisano and Teece, 2007). Some firms are extremely good at reverse engineering a commercialized product to understand the functionality of the components and the overall architecture. If the process is key to protecting intellectual property, reverse engineering becomes more difficult. However, the utility of process protection, and the utility of trade secrets, is diminished with the mobility of knowledge workers (Schilling and Phelps, 2007).

Protection vs diffusion. The choice between protection and diffusion is not always obvious. Most firms neither use a wholly proprietary nor a wholly open strategy (Hill, 1997; Schilling, 2000). Protecting the innovation offers a means to earn rents from innovation, which can be re-invested to further develop the technology, and to produce complementary and compatible products. It also preserves the firm's architectural control, enabling it to direct the technology's development, determine its compatibility with other goods, and prevent multiple versions of the technology from being produced by competitors (Henderson and Clark, 1990). Technology diffusion on the other hand can encourage multiple firms to promote and distribute the technology, possibly accelerating its development. Diffusion in many cases is opposite of protection, and so a middle ground is controlling a standard through licensing or having a dominant design that ensures reaping monopolistic rents in the primary and other industries (Henderson and Clark, 1990; Shane, 2002; Burgelman *et al.*, 2006). It is useful when the firm:

- has inadequate resources to be the sole developer, producer, distributer and marketer of an innovation (Garud *et al.*, 2002);

- has competitors who may quickly develop their own, possibly better, version of the technology (Hill, 1992); or
- wants to ensure that its version of the technology becomes the dominant design (Hill, 1992).

Development

Three major aspects of developing an innovation are:

(1) design and manufacture: in-house or collaboration with other firms in the form of alliances or joint ventures;

(2) the process of developing the innovation; and

(3) deciding the launch form: product enhancement, new product development, wholly owned subsidiary, spin outs, or joint ventures.

Design and manufacturing in-house vs collaboration. The decision to collaborate is multidimensional and is dependent on factors such as:

- whether the firm or the collaborator has the required capabilities and resources;
- the degree to which collaboration would make proprietary technologies vulnerable to expropriation by a potential competitor;
- the importance a firm plays in controlling the development process for its innovations; and
- the degree to which a firm can access another firm's capabilities (Hitt *et al.*, 1991; Hagedoorn, 1993; Powell *et al.*, 1996; Ahuja, 2000a, b; Kwak, 2002; Zahra and Nielsen, 2002; Soosay and Hyland, 2008).

When a firm has the necessary capabilities to develop the product, and the managers are worried about protecting their proprietary technologies and retaining control over the development process, they typically choose to build and manufacture the innovation in-house. Often times, collaboration increases the duration from conceptualization through commercialization when too many firms are involved in the collaboration (Golder *et al.*, 2008).

Advantages of collaboration include sharing costs and risks of development, combining complimentary skills and resources (Freeman, 1991; Powell *et al.*, 1996; Ahuja, 2000a, b; Ahuja and Katila, 2001; Zahra and Nielsen, 2002; Brass *et al.*, 2004; Provan *et al.*, 2007), enabling transfer of knowledge between firms (Freeman, 1991; Gulati, 1995; Powell *et al.*, 1996; Gulati, 1998; Gulati and Gargiulo, 1999; Gulati *et al.*, 2000; Brass *et al.*, 2004; Cowan and Jonard, 2004; Provan *et al.*, 2007), and facilitating the creation of shared standards (Gulati, 1995; Powell *et al.*, 1996; Gulati, 1998; Gulati and Gargiulo, 1999; Gulati *et al.*, 2000; Brass *et al.*, 2004; Litan *et al.*, 2007; Provan *et al.*, 2007). Collaboration, when formed through networks, can take forms such as:

- strategic alliances (Barringer and Harrison, 2000; Provan *et al.*, 2007);
- joint ventures (Barringer and Harrison, 2000; Provan *et al.*, 2007);
- licensing (Barringer and Harrison, 2000; Shane, 2002; Provan *et al.*, 2007); and
- outsourcing (Barringer and Harrison, 2000; Provan *et al.*, 2007).

Process of developing the innovation. The literature on innovation commercialization, especially from the journals with a focus on new product development, has paid significant attention to the process of developing an innovation. Successful product development requires achievement of three objectives:

(a) maximizing fit with customer requirements;

(b) minimizing time to entry; and

(c) controlling development costs.

Some of means to achieve the three are:

- Parallel development-processes and coordination among marketing, manufacturing, and R&D, which provide the means to meet (a), (b) and (c) (Cohen and Levinthal, 1990; Griffin and Hauser, 1992; Clark and Wheelright, 1993).
- Championing, which ensures a project's momentum and improves its access to key resources (Howell and Higgins, 1990; Markham, 2000), thereby helping (b) and (c).
- Involving customers, which can help match development projects with their requirements (Cooper, 1985; Butler, 1988; Johne and Snelson, 1988; Brown and Eisenhardt, 1995; Cristiano *et al.*, 2001; Lilien *et al.*, 2002), thus helping with (a).
- Involving suppliers in product development, which helps in minimizing the cost of new product design and increases the likelihood that inputs are of appropriate quality and timely, thus helping with (b) and (c).
- Some process-optimizing methods, especially for addressing (b) and (c), are stage-gate processes that enable firms to get a blueprint of new-product-development process (Cooper, 1985; Cooper and Kleinschmidt, 1986; Cohen *et al.*, 1998), and CAD/CAM tools to reduce cycle times, improve product quality, and control development costs (Ebers and Lieb, 1989; Clark and Wheelright, 1993; Burgelman *et al.*, 2006; Schilling, 2006; Litan *et al.*, 2007).

Launch pad: spinout, subsidiary, or joint venture. An innovation can be launched in many forms. While a new product is typically launched solely by one firm, in some cases products are launched by means of spin-outs, a subsidiary, or through joint ventures. The decision between the choices is often a function of the scope of the innovation, and the risks associated with bringing it to market (Burgelman *et al.*, 2006):

- Spinouts are where a company "splits off" a section of itself as a separate business (Lowe, 1993; Zahra, 1996; Carayannis *et al.*, 1998; Lockett *et al.*, 2003; Cassiman and Ueda, 2006; Richards, 2009). The common definition of a spin out is when a division of a company or organization becomes an independent business. The spin-out company takes assets, intellectual property, technology, and existing products from the parent organization (Zahra, 1996; Lockett *et al.*, 2003; Richards, 2009). Spin outs are often created through university technology-transfer offices in conjunction with business incubators (Mian, 1997).
- A subsidiary is an entity that is controlled by a separate entity. The controlled entity is often in the form of a limited-liability company, but in some cases can be a government or state-owned enterprise. The controlling entity is called the

parent (or the parent company) (Ghoshal and Bartlett, 1988; Zahra, 1996; Birkinshaw, 1998; Frost, 2001; Birkinshaw *et al.*, 2005; Zahra, 2005). Two subsidiaries can be competitors in the same area. For example, Compaq, after being acquired by HP, became a subsidiary of HP but also competed against HP in the personal-computing space.

- A joint venture is a partnership that often requires significant equity investment and the creation of separate entities (Kogut, 1988; Pennings and Harianto, 1992; Dollinger *et al.*, 1997; Dutta and Weiss, 1997; Anand and Khanna, 2000; Lyles and Salk, 2006; Link *et al.*, 2007). They are created for pooling resources and capabilities, and sharing risks (Soosay and Hyland, 2008). Classic examples include AutoAlliance International, between Ford and Mazda, LG-Philips Components, between LG and Philips, and Sony Ericsson, between Sony and Ericsson.

Deployment

Research on commercialization of innovation specific to deployment of an innovation to a market has concentrated on launch timing, licensing and compatibility (whether or not to make the product compatible with older versions), selecting a pricing strategy, distribution, and marketing.

Launch timing. The literature identifies factors affecting launch timing as:

- business cycle and any seasonal effects (Eliashberg and Robertson, 1988; Corey *et al.*, 1989);
- availability of production capacity and complementary goods; and
- assessment of harvesting cash flows from existing product generations vs advantages of willingly cannibalizing existing products (Teece, 1988, 1996; Conner and Prahalad, 1996; Madhok and Tallman, 1998; Nerkar and Roberts, 2004; Song *et al.*, 2005).

Selling out, licensing and compatibility. The decision to sell out an innovation, or license an innovation is contingent not only upon the availability of the assets required for launch within the innovating firm and the ability to appropriate the income (Teece, 1988), but also upon issues related to compatibility (Teece, 1988, 1996; Grindley and Teece, 1997) and backward compatibility, which is when products of one technological generation can work with products of the previous technological generation (Lowe, 1993; Dhebar, 1996).

Pricing. Two of the common pricing techniques discussed in the literature are market skimming and penetration pricing (Shapiro and Jackson, 1978). With market skimming, firms usually ask a high price to signal significance or to quickly recoup development costs. When achieving maximum market share is the objective then penetration pricing is the more viable strategy. Honda used this strategy to market its hybrid car at $20,000, causing them to lose money for every sale, but it was based on the belief that the hybrid technology will be profitable in the long run and that increased sales will reduce costs through an accelerated experience-curve effect (Johng *et al.*, 2003).

Distribution. Firms can sell their products directly to end-users through their web sites, mail order, or can alternatively use intermediaries (Corey *et al.*, 1989). Intermediaries provide a number of valuable roles in the supply chain, such as breaking the bulk,

carrying inventory, logistics, selling services, and customer services (Zhang and Li, 2009). By forging relationships with distributors, and providing sales guarantees, firms can accelerate their distribution of innovations.

Marketing. Research on commercialization of innovations that focused on marketing has acknowledged that technology and marketing capabilities both were found to be significant in bringing innovations to market (Di Benedetto *et al.*, 2008). Methods of marketing vary in attributes such as cost, reach, information content, and the ability to target particular segments (Moore, 1991; Mohr, 2001; Slater and Mohr, 2006). In addition, pre-announcements of technology, and a firm's reputation, often influence market perception associated with the innovation (Eliashberg and Robertson, 1988; Moore, 1991; Mohr, 2001; Slater and Mohr, 2006).

Moving commercialization of innovation research forward

We next build on the review done in the previous section to propose an agenda for future research on innovation commercialization. We utilize some key concepts such as radical innovations, industry boundaries, viability, future markets, and governance as a means to link the themes together.

Viability and governance: linking market entry, development and deployment

Our definition of commercialization of innovations has three attributes:

(1) recognizing a market for an innovation;

(2) developing and manufacturing it into a product; and

(3) selling/distributing the product.

Where the first one is addressed through the themes of sources of innovation, as well as types of innovation and protection, the last two are essentially addressed through market entry, development and deployment themes. The literature surrounding the development theme concentrates on whether an innovation should be developed in-house or with partners, or whether it will be licensed out. Essentially, it is a question of governance form dealing with ownership of innovation with three options: development and commercialization being in-house, commercializing the innovation with others either through an alliance or via licensing, or selling it to others for them to commercialize (Zahra, 1996). Usually, commercialization is thought of in terms of the first two forms, but electing to sell an innovation also allows the firm to secure a return and, arguably, also is a form of commercialization. The choice of which form to adopt is governed by:

- the amount of profit available from commercialization; and
- the distance between a firm's existing capabilities and those required for it to be able to commercialize the innovation.

In the following discussion, we build on Teece (1986) contention that regimes of appropriability also must be in place, and on the thesis that economic gain rests critically upon a firm's ability to create and transfer technology more quickly than it is imitated.

When the returns from an innovation are thought to be high and the firm already has the requisite capabilities that are required for commercialization then logically,

development will be through hierarchy (in-house). If the capabilities are not available internally, then sourcing them externally will reduce the firm's ability to earn rents from the innovation because suppliers of those resources will bid up prices, or they may turn into potential competitors. An alternative is to develop the capabilities internally. That requires an assessment of the effects on the current stock of knowledge and capabilities (Kogut and Zander, 1992, 1996) because long-term strategies of building new capabilities can require a tradeoff between current and future profitability. Such a choice is viable only when the firm's survival is not at stake and it has the necessary short-term cash flows to undertake learning initiatives and bear the associated risks (Kogut and Zander, 1992, 1996; Decarolis and Deeds, 1999). Conversely, too much reliance on exploiting current profitability may deter a firm from developing capabilities for the future (Stiglitz, 1987; Kogut and Zander, 1992). The decision of maintaining and developing some capabilities over others is influenced by the current knowledge of the firm and expectations from economic gain by exploring newer technologies and organizing principles into future market developments (Kogut and Zander, 1992). Thus, the promise of economic rents is usually sufficient to convince firms that developing new capabilities is a worthwhile activity (Kogut and Zander, 1992, 1996; Decarolis and Deeds, 1999). The most significant determinant of make or buy, and within firm or with suppliers, has been found to be the transaction costs associated with relying on outside suppliers (Monteverde and Teece, 1982; Walker and Weber, 1984; Kogut and Zander, 1992). It has been shown that volume and technological uncertainties, and the production capability of the buyer, reduce the advantage of buy over make, while supplier production-cost advantage, competitiveness of supplier market, and size of supplier market increases the advantage of buy over make (Walker and Weber, 1984). While boundaries of firms are influenced by transaction costs (Williamson, 1981, 1991, 2000), performance relies mostly on owned capabilities (Kogut and Zander, 1992).

An innovation can be contracted, licensed, or developed with alliances when the firm does not have the necessary capabilities required to bring it to market, when there are uncertain cash flows, and when imitators and competitors are better positioned (Teece, 1986). Specifically, when an innovation has the potential to earn high returns, but the firm does not have the capabilities to develop the assets necessary for bringing the innovation to market, the available options are to develop the innovation with partners or license it out (Friedman, 2006). It also means that when the firm has the requisite capabilities to develop the assets that are critical for commercialization but the innovation only has the potential for low returns, commercialization via partnership also is preferable. Choosing between alliances for joint development or licensing depends upon several factors beyond profit potential and capabilities. For example, the short-term profitability needs of the firm and high investment costs (Zahra, 1996; Makadok and Walker, 2000; Kalaignanam *et al.*, 2007), along with the existence of steep learning curves (Malerba, 1992), make a strong case for licensing.

Drawing on transaction-cost economics (Williamson, 1981, 1983, 1991, 1994, 1998), contracts with partners in developing an innovation may lead to a reduction of environmental uncertainty at the cost of behavioral uncertainty – opportunism. Such behavior occurs when an innovation, albeit novel, has uncertain market potential, or requires capabilities beyond those of the firm. A governance structure that leads to reduction of environmental uncertainty in this scenario may be more important than

a partner being opportunistic. Mutual gains from contracts and alliance will be a less risky form of governance than in-house development.

Additionally, licensing an innovation is an option when the licensor has superior, tacit knowledge that protects the ability to secure rents, when capabilities required for commercialization are beyond those possessed by the firm, or there is pressure for immediate survival. In the case of the lack of capabilities, if the innovating firm does not license its new technology, competitors may quickly develop their own, possibly better, versions of the technology. By licensing, the innovating firm may ensure that its version of the technology becomes the dominant design (Hill, 1992; Schilling, 1998; Schilling and Phelps, 2007), thus securing an industry-wide advantage. We have already stated that advantages of collaboration include sharing costs and risks of development, combining complementary skills and resources, enabling transfer of knowledge, and facilitation of creation of shared standards. A clear example of these advantages is in the commercialization of Microsoft's Windows software. Developing complementary assets needed for commercialization of the software required sets of capabilities that were distant from what Microsoft possessed, but the partnership with Intel resulted in the emergence of the industry standard Wintel and a win for both firms.

Last, when the potential to earn profits is low and the capabilities required to develop assets required to commercialize the innovation are not available internally or through partnerships, the most logical option is to sell the innovation to another firm. Given this low-return scenario, this would be the least risky option. That, of course, assumes that the sale would not result in the buyer becoming a future competitor.

The discussions thus far raise the question:

RQ1. How does the profit potential and distance between current and required capabilities, either singly or in combination, dictate the appropriate governance form for an innovation?

An innovation with low profit potential combined with the lack of capabilities necessary for commercialization will result in selling the innovation, assuming that selling it does not benefit competitors. An innovation with low profit potential combined with the capabilities necessary for commercialization will result in either developing the innovation with partners via alliances or licensing it out, assuming that the firm can use its capabilities for commercializing a more profitable innovation. However, the decision becomes much more complex when the innovation has higher profit potential. When the firm has the necessary capabilities, then the innovation likely will be developed in-house, assuming that the firm cannot use its capabilities for commercializing a more profitable innovation. If it does not have the capabilities then it can be commercialized using partnerships or, if the profit potential is sufficiently large, then it may be worthwhile spending the money to develop the necessary capabilities. Obviously, the decision is economic one. Thus, the key question becomes:

RQ2. How large does the marginal profit have to be before it is worthwhile developing capabilities in-house rather than using a partnership?

This question is far more complex than its obvious revenue versus the administrative and opportunism-transaction-cost implications insofar as there are the additional issues like complements and competitive rivalry to be taken into consideration.

Radical innovations and industrial boundaries: linking innovation sources with innovation types

While patents are means to protect innovations, they have long been considered proxies for the innovative outputs of organizations (Basberg, 1987; Grindley and Teece, 1997; Cohen *et al.*, 2002a, b; Katila, 2002; Dahlin and Behrens, 2005; Katila and Ahuja, 2005). Patent citation counts are considered to be good estimators of the technological importance of innovations (Narin *et al.*, 1987; Albert *et al.*, 1991). Highly cited patents are also considered an important indicator for radical innovations (Trajtenberg, 1990). Dahlin and Behrens (2005) used patent citations to assess radicalness of innovations. In their research, a patent is radical if it is:

- both unique and novel; or
- has an impact on future technologies; or
- both.

Radical innovations have a profound influence on industry competition and company survival. Using patent-citation rates as a measure of radicalness, Hall *et al.* (2005) showed that the commercial value of radical innovations is significantly higher than those that are incremental. While the commercialization of innovation is key to a firm's survival (Nerkar and Shane, 2007), the commercialization of radical innovations is central to firm longevity (Burgelman and Grove, 1996; Tushman and O'Reilly, 1996, 2002; O'Reilly and Tushman, 2004). Successful radical inventions tend to provide the opportunity for the inventing firm to gain a sustainable competitive-advantage and for the subsequent generation of economic rents (Achilladelis *et al.*, 1990; Harhoff *et al.*, 1999). It has been observed that dominant firms value radical innovations more so than non-dominant firms (Sorescu *et al.*, 2003), and a firm becomes long-lived when it can develop radical new products without hurting existing markets (Tushman and O'Reilly, 1996, 2002; O'Reilly and Tushman, 2004).

Using patent counts as a reasonable approximation of R&D and innovativeness (Trajtenberg, 1987; Trajtenberg *et al.*, 1997), Sorensen and Stuart (2000) observed that as firms grow and age, they start citing their own patents in their quest to seek future innovations. Thus, with age and size, firms tend to become more inward-looking for future innovations. Self-citation shows that the firm is looking at its old innovations and thus there likely will be overlap between technology classes of its past and current innovations, which allows it to exploit existing capabilities (Sorensen and Stuart, 2000).

Remaining within the firm's existing boundaries (i.e. within the focal–industry knowledge and existing technologies) results in little or no creation of knowledge required for the exploration that is necessary for creating novel, radical innovations (Fleming, 2001; Fleming and Sorenson, 2001). Rothaermel and Thursby (2005) found that firms are able to integrate complementary knowledge and technology by extending a firm's boundaries and tapping into innovations from outside the focal industry, which, in turn, enhances the firm's ability to create radical innovations. Integration of complementary technologies produces unique combinations through experimentation (March, 1991), and that increases the explorative ability of the firm beyond its current technology stock, resulting in novel innovations (Decarolis and Deeds, 1999; Rosenkopf and Nerkar, 2001; Hall *et al.*, 2005). Thus, to seek complementary technologies, firms have to look beyond their boundaries. That is not limited to innovations from firms from other industries but can also include universities and research laboratories, collectively

known as engines of innovations. Increasing the diversity of sources increases the relative novelty of knowledge a firm can access (Phelps, 2010). Given the necessary condition for radical innovation is access of dissimilar knowledge (Jansen *et al.*, 2006; Greve, 2007), the question emerges:

RQ3. How far and how much does a firm need to expand beyond the boundaries of its existing stock of knowledge in order to create radical innovations?

Radical innovations and governance: linking innovation types, market entry, and development

As far as we can determine, there is little or no research linking types of innovations with governance forms, especially launch forms. It has been argued that radicalness of innovation is important to determine whether the innovation will be commercialized by means of refinements of existing products or as a new product or a delivery system (Chandy and Tellis, 1998; Dahlin and Behrens, 2005; Chandy *et al.*, 2006). Product enhancements or refinements do not entail creating new forms of firms, rather just product enhancements, such as Windows Service pack, or possibly a new but very similar product, such as Windows 7 (which was significantly different, but by no means radically different, from Windows XP). As already explained, radical innovations, on the other hand, entail a technology that may be drastically different from the existing stock of the firm's capabilities. Bringing such an innovation to market may involve creation of not only a new product line but potentially a new venture to drive it. There are times when not only the technology class is different but, as discussed above, also the capabilities needed to bring the innovation into the market. Too much dissimilarity may result in licensing the technology, or developing that with partners in order to bring the product into market. But, also as discussed above, if the profit potential is large enough, the commercialization may done in-house. That raises the question of what would be the best way to achieve that - integration with existing in-house activities, a separate division, or a spinout? Thus, a significant extension to the research on commercialization would be an analysis of innovation types and governance forms. Specifically:

RQ4. Is radicalness sufficient to determine a change in a governance form and, if not, what are the boundary conditions?

Prima facie, the question appears straightforward, but it is worth noting, however, that firms create spinouts even if innovations are not drastically different to existing products. For instance, the engines of Scion and Lexus are not extremely different, yet they are produced by different spinouts from Toyota. Even though Scion and Lexus serve different market segments, both General Motors and Volkswagen, whose products also serve different segments, haves gone the other direction and consolidated engine manufacturing in-house with fewer engine variants.

Discussions and implications

Commercialization of innovations is a critical entrepreneurial activity that leads to economic development and growth, but remains under-researched and is therefore not as well understood as other aspects of innovation. We believe that the reasons for this are twofold. First, commercialization of innovation requires research expertise from a multitude of disciplines including management, strategy, entrepreneurship, economics, and marketing. Each of these disciplines has its own research agenda and set of

variables that often are unique and distinct from other fields of study, making a comprehensive view almost impossible. Second, most of the work has been focused on one specific area of commercialization of innovation, such as sources of innovation, protection of intellectual property, and so forth, and identification of common themes across these diverse disciplines seemed to be the most prudent next step with this work in order to help move the research agenda forward.

Our work makes contributions to both theory and practice. From a theoretical standpoint, this paper provides two primary offerings. First, we provided a comprehensive review of the literature on innovation and commercialization that resulted in the identification of six themes of entrepreneurial activities leading to commercialization of innovations. The six themes include: sources of innovations, types of innovation, market entry (which includes capabilities and feasibility), protection, development, and deployment. Our second contribution involves identifying new areas of innovation-commercialization research. As we noted, much of the research in management, strategy, entrepreneurship, economics, and marketing clusters around a small number of themes and, often, just a single theme. We linked the themes by asking research questions:

RQ1. How does profit potential and distance between current and required capabilities dictate governance form for innovation?

RQ2. How large does the marginal profit have to be before it is worthwhile developing capabilities in-house rather than using a partnership?

RQ3. How far and how much does a firm need to expand beyond the boundaries of its existing stock of knowledge in order to create radical innovations? And,

RQ4. Is radicalness sufficient to determine a change in a governance form and, if not, what are the boundary conditions?

We believe that this work is not only useful for future research, but it also provides some help for practitioners as well. First, and most fundamentally, our questions on commercialization and profit indicate that a careful assessment of the profit potential, *vis-à-vis* the firm's existing capabilities and the costs of developing new capabilities, can help reduce investments in innovations with little or no chance of financial success. In other words, financial success should not be confused with commercial success. This perspective helps force a separation between commitment to the newly developed technology and the ability to make money from it. Second, our framework highlights the need to consider the availability of partners and their capabilities before plunging into a decision to commercialize an innovation. This permits risk reduction insofar as it prevents a firm from disposing of a technology that could be developed with partners, it allows the firm to find better capabilities than those it possesses, and perhaps more cheaply, and it allows the firm to hand off development and commercialization, which then frees up time and resources for bringing other innovations to market. Third, the work identifies the need to carefully consider extending firm boundaries to include new sources of innovation – sources with product offerings whose technology base is different from the firm's current technology stock – that will be demanded in future markets. Lastly, when firms bring out products that are radically different from existing stock, we raised the question of governance form. In the absence of research that

provides rules of thumb for implementation, we can only offer what amounts to a platitude of ensuring a strategy-structure fit.

All research projects have certain inherent limitations, as does ours. Our first assumption that the fields of management, strategy, entrepreneurship, economics, and marketing are sufficient to capture all the themes associated with entrepreneurial activities surrounding commercialization of innovation may not be valid. Inclusion of journals from science and engineering might give a deeper and richer understanding to the process. Second, it would be worth investigating whether specific disciplines had bias towards certain themes. These kinds of observations would strengthen and enrich our findings and perhaps lead to more interdisciplinary research, which clearly is needed if we are to expand our knowledge in this area. Addressing some of these issues remained outside the scope of this work, but are certainly worthy of consideration in subsequent work.

Before the research agenda set forth in this work is pursued with any vigor, the framework presented in here needs validating. That means that the assumptions and boundary conditions associated with the framework need to be tested and confirmed as being realistic. All of that achieved, we recommend a two-step approach for future research. First, conduct detailed case-studies on how firms combine aspects of each stage to bring innovations to market. Such exemplars would test for the robustness, veracity, limits, assumptions and boundary conditions of the framework. Such specific case-studies help in giving a nuanced picture to the innovation-commercialization process. For instance, while Nokia may forge alliances with universities for contracted R&D to tap innovations, Merck could invest heavily in its own R&D, and use networks for distribution. Being a player in the GSM arena, Nokia is less dependent on cell phone service providers for market penetration than Samsung, but that means Nokia has to spend much more on branding than Samsung, whose alliance with Sprint brings co-branding opportunities. Thus, networks and alliances could come into play at different stages for different companies. Case studies can be used to look for firm-specific as well industry-specific characteristics. For example, some industries patent more than others (Levin *et al.*, 1987). Once that is achieved, then the themes presented here can be refined into constructs and then into variables. The second stage is to empirically test the refined model using large-scale data. We anticipate that both primary and secondary data will be used.

Finally, some firms are good at innovation, but the fact remains that firms live and die by their ability to successfully bring innovations to market. We have provided a theoretical framework to address the question of what are the key elements of the commercialization-innovation pathway. While the work clearly is of relevance to practice, our intent has been to generate a framework for scholars to extend existing research on the commercialization process, and thus create an even deeper understanding of this crucial business activity.

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