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MEASURING ENTREPRENEURIAL ACTIVITY AT KANSAS AND MISSOURI UNIVERSITIES

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Measuring Entrepreneurial Activity at Kansas and Missouri Universities*
Final Report to the Kauffman Foundation

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Executive Summary

The objectives of this study were to:

a. Develop a comprehensive database of all university-related spinoffs from five research universities in the states of Kansas and Missouri – Kansas State University, the University of Kansas system, the University of Missouri system, Washington University, and Saint Louis University (hereafter referenced collectively as K/M research universities);

b. Develop a database of entrepreneurship-related programs at these universities.

c. Construct a data profile for each university that will yield insight into its position in the national innovation system and the nature of the local startup ecosystem in which the university is embedded.

The key findings from the study are:

■ Washington University was the only K/M research university ranked in the top 50 of the Shanghai Jiaotong rankings during the 2007-2014 period. All other universities ranked outside top 200. Saint Louis University was not ranked.

■ At the level of specific subject fields, Washington University consistently ranked in the top 50 of the Shanghai Jiaotong rankings in the life sciences and between the top 50 and top 75 in medical sciences during the 2007-2014 period. It also was ranked in the top 200 in the physical sciences for 2012 and 2013. The University of Kansas was ranked between the top 150 and top 200 in medical sciences during 2012 to 2014 and was ranked in the top 200 for physical sciences for 2012 and 2013. The University of Missouri-Columbia was also ranked in the top 200 in physical sciences during 2012 and 2013. Kansas State University, which does not have a medical school, ranked in the Top 200 in the life sciences in 2012 and 2013. In contrast, in no year did any of these K/M universities receive a high ranking in engineering, with the exception of Washington University in 2007. Because of the importance of engineering for generating startups, this suggests that an improvement in the engineering departments, especially electrical engineering and computer science, could increase the number of university spinoffs.

■ Washington University was ranked 19th of all U.S. universities in R&D funding in 2011. The University of Kansas was ranked 71st, the University of Missouri was ranked 87th, and Kansas State University was ranked 114th.

■ R&D funding is primarily concentrated in the Life Sciences at K/M research universities. R&D funding for engineering is relatively small in comparison to other research universities.

■ Kansas & Missouri universities are relatively important sources of patents in each state. Missouri universities have had more patents. The University of Missouri-Columbia had the most patents of any K/M research university

■The SBIR program was found to be a fairly important funding source for university spinoffs at K/M research universities in the study. 35.2% of the spinoffs identified had received SBIR funds.

■ Firms in St. Louis received the most Small Business Innovation Research (SBIR) grants, followed by firms in Lawrence, Rolla & Manhattan, respectively.

■ More venture capital investments & venture capital deals were made in Missouri compared to Kansas. A small subset of investments were made in spinoffs from K/M research universities. Both Missouri and Kansas had a larger percentage of venture capital deals in biotechnology compared the national economy as a whole. Kansas also had a larger percentage of deals in information technology.

■ There was a total of $550 million of venture capital funds invested in spinoffs from K/M research

universities during the time period examined. The vast majority of this total (76.5%) was invested in spinoffs at Washington University. This was followed by 15.2% of this total invested in spinoffs from the University of Kansas system.

■ A total of 125 high-technology spinoffs K/M research universities were identified. This included 57 from Washington University, 33 from the University of Kansas system, 19 from the University of Missouri system, 10 from Kansas State University and 6 from Saint Louis University.

■ Only Washington University and the University of Kansas have consistently generated spinoffs over the last several decades. Spinoff generation at the other K/M research universities has been sporadic and/or was not a focus until the last decade. Still, the generation of spinoffs at all the K/M research universities has been below other larger research universities in the Midwest such as the University of Wisconsin-Madison.

■ The number of spinoffs at K/M research universities is strongly correlated with total R&D funding and research excellence as measured by ranking in the Shanghai Jiaotong index.

■ Despite the comparatively lower amount of R&D funding in Engineering at K/M research universities, more spinoffs were generated per R&D dollar in Computer Science & Electrical Engineering compared to the Biomedical Sciences. This is in keeping with national findings.

■ The University of Kansas was most efficient in generating spinoffs per R&D dollar.

■ Spinoffs at K/M research universities are predominantly formed by university faculty. Only at Washington University did students form a substantial number of spinoffs.

■ Spinoffs at K/M research universities were predominantly based on technology that was not licensed from the university. 56% of the spinoffs were based on unlicensed technology. Only in the University of Kansas system was the majority of spinoffs based on licensed technology.

■ The acquisition of spinoff firms by other companies was most frequent at Washington University, followed by the University of Kansas system and Kansas State University.

■ The vast majority of spinoffs are sited in locations where the university has a campus. Thus, the economic development benefits of spinoffs are accruing to the cities and states in which the universities are located. This pattern was the strongest among the K/M public research universities. Washington University had the most spinoffs located out of state. However, the acquisition of spinoffs did not appear to be a primary factor in the movement of these firms out of state.

■ The greatest number of spinoffs from K/M research universities are in the areas of medical technology (including instruments) and biotechnology (including support services). Over ½ of all spinoffs identified were related to these 2 technological areas. This is likely related to the major research emphasis on life & biomedical sciences at research universities in the region combined with the presence of medical schools. Kansas State University is the only university to deviate from this pattern with most spinoffs being in the Veterinary Medicine/Agriculture area.

■ All K/M research universities have active technology transfer offices overseeing university intellectual property and offer a wide range of program designed to educate, facilitate and promote entrepreneurship by faculty, students and other scientists on staff. The most common types of programs were in entrepreneurial education and entrepreneurial competitions. At this point in time, offering a larger number of entrepreneurial programs does not necessarily translate into the generation of a larger number of university spinoffs.

Measuring Entrepreneurial Activity at Kansas and Missouri Universities

U.S. research universities have a long history of spawning entrepreneurs that have created important new firms (Fini et al. 2011; Lockett et al., 2005; Rothaermel et al. 2007; Shane 2004), which, in some cases, formed the basis or were important contributors to the formation of new industrial clusters.[1] In recent years, there has been recognition that entrepreneurship can be a powerful driver of local development, as spinoff firms are very likely to be located in close proximity to the entrepreneurs' source location (Dahl and Sorenson 2012). Universities are particularly interesting organizations for those interested in local entrepreneurship, because the firms they spinoff are by-products of the institution's diverse activities and constituents (Kenney and Mowery, eds. 2014). In this report, we explore the records of Kansas and Missouri (K/M) universities in spinning-off licensed and unlicensed firms.

While this report limits itself to considering only technological-intensive spinoffs, we recognize that non-technology firms, such as Cushion Seats, Inc., a Kansas State University undergraduate student startup which grew to be a significant local firm, can also be significant contributors to entrepreneur-driven regional growth. However, they are not a direct outcome of university research and thus are not included in our study. Among university administrators and sub-national government policy-makers, interest in encouraging academic entrepreneurship has led to a proliferation of policy initiatives. For example, the interest in patenting and licensing the products of university researchers has expanded dramatically. Beginning in the 1970s university research centers designed to foster university-industry research collaboration were created, and the volume of industry-sponsored research conducted by U.S. universities continues to increase (Cohen et al., 1994; Berman 2011; Hunter et al. 2011). U.S. universities have also opened science/research

[1] For the case of San Diego in wireless, see Walshok and West (2014). For biotechnology, this regional clustering of startups close to universities has been recognized, since the inception of the industry (see, for example, Kenney 1986).

parks and business incubator facilities (for an early discussion of research parks, see Lugar 1991; for a summary of this research, see Hackett and Dilts 2004; Phan et al. 2005). More recently, universities have begun to make equity investments in newly formed companies (Bray and Lee 2000; Clarysse et al. 2007; Feldman et al. 2002; Shane 2004). Roughly contemporaneously, universities developed initiatives and degree programs designed to foster knowledge and training in entrepreneurship (Aldrich 2012; Kuratko 2005).

A key dimension and objective of these activities is that university spinoff firms can be a source for increased employment and, in some cases, the catalyst for creating a dynamic industrial cluster (for a discussion of how entrepreneurs can drive cluster formation, see Feldman et al. 2005). For the purposes of this research, a university spinoff firm is defined as an independent, de novo firm in a technology-based field with at least one founder who is affiliated with (employed by or enrolled in) a university. This conceptual definition will be discussed in further detail below. Taken as a whole, these changes have been touted as marking the rise of "entrepreneurial science" (Etzkowitz, 1989) and the "entrepreneurial university" in the U.S. (Rothaermel et al., 2007).

Universities have long been recognized as important sources of human capital and innovative ideas that entrepreneurs can transform into new firms (for an overview of this literature, see Rothaermel et al. 2007; Grimaldi 2011). Numerous studies have shown that research universities are important institutions in regions with high levels of technical entrepreneurship. There are regions in which university-related entrepreneurial firms have played a significant and, in some cases, critically important role in regional economic growth. Well-noted exemplars include the San Francisco Bay Area and Silicon Valley (see, for example, Saxenian 1994; Kenney 2000; Kenney and Goe 2004), San Diego (Casper 2007; Walshok and Shragge 2013), Greater Boston (see, for example, Hsu et al. 2007), and North Carolina's Research Triangle (see, for example, Link

and Scott 2003). Within these regions, local universities played vital roles role as both a source of university spinoffs and by supporting entrepreneurship through research, education and training, and outreach.

The bulk of research concerning university entrepreneurship has focused upon research universities located on the West and East Coasts. However, there is a smaller, but growing body of research that has focused on filling in the knowledge gaps about university entrepreneurship and spinoff activity at research universities located in the Midwest. For example, Kenney et al. (2009) found that over the last 25 years spinoffs from the University of Wisconsin made a significant contribution to economic growth in the Madison, Wisconsin region. Further, both Ann Arbor's University of Michigan and Urbana-Champaign's University of Illinois have been the source of a significant number of business startups (Kenney and Patton, 2011).

This research contributes to this growing knowledge base by examining entrepreneurial activities at research universities in a two-state area of the Midwest - Missouri and Kansas. Entrepreneurial activity, including the formation of university spinoffs, will be examined at seven research universities and medical schools within the two states: Kansas State University, University of Kansas, and the main campus of the University of Missouri in Columbia and its branch campuses in Kansas City, and St. Louis, Washington University, and Saint Louis University.

Of the cities and universities in K/M, Washington University and Saint Louis University have received the greatest attention. For example, Motoyama and Watkins (2014) found that Washington University, Saint Louis University and the University of Missouri-St. Louis were important support organizations in the social networks underlying the business startup ecosystem in the St. Louis, Missouri region. Possibly because of its historical legacy in chemicals and pharmaceuticals including Monsanto, Mallinckrodt, Anheuser-Busch, and Ralston-Purina, St.

Louis, in particular, has emphasized life sciences research. This industrial legacy may, in part, explain the emphasis at Washington University and in St. Louis on biotechnology as a field for entrepreneurial growth (Bayham et al. 2007; Bezold 2004).[2]

Interestingly, when comparing St. Louis to San Diego and Philadelphia, Walshok et al. (2013) concluded that, "the prevailing regional culture appears to be insular and hierarchical, with many initiatives, particularly in the life sciences and IT sectors, being driven by a few key individuals. St. Louis is adopting an innovation agenda to improve its regional economy, but until recently had been layering these efforts on top of existing social and business networks such as the important St. Louis Regional Chamber and Growth Association." They concluded that St. Louis suffered from a deficit of regional connective organizations. They attributed this deficit to a city whose hierarchy was not flexible and openly operated as "an old boy network of wealthy, established individuals who had clout and were at the top of the social hierarchy" (Walshok et al. 2013: 16).

Oddly enough, while not specifically part of our study and, despite the University of Kansas receiving far fewer research funds than Washington University, we had a distinct impression that Kansas City had a more entrepreneurial perspective. This is partially confirmed by Heike Mayer (2011: Chapter Six) who found that Kansas City was developing as a second-tier life science region, though it continued to have weaknesses in terms of local venture capital.

In the following report, we examine entrepreneurial contributions to the two states by the major K/M universities. The report is organized as follows: First, we provide a general description of the state of entrepreneurial activity in Kansas and Missouri (K/M). This is followed by a

[2] Interestingly, during the first biotechnology entrepreneurship wave in the late 1970s and 1980s, the local firms, Monsanto and Mallinkrodt, tied up the entire Washington University biological sciences faculty (Kenney 1986: 67-69). It is interesting to speculate regarding what would have happened, if the Washington University faculty had been given an opportunity to be more entrepreneurial.

statement of the research objectives and description of the research methodology used in the study. Next, the study findings will be presented. Finally, the implications of the study findings will be discussed.

1. General Environment in K/M for Academic Entrepreneurship

Entrepreneurship always occurs in a political-economic context or what might be termed regional innovation ecosystems. The character of the human, financial and knowledge assets can have a significant impact on opportunity recognition, a willingness to establish a new venture, and then the venture's ultimate success. This report was not meant to measure the quality of the regional ecosystems, but, as we will show, both states have only small amounts of venture capital and few entrepreneurial role models.

1a. Research Leadership

University startups are so important because they often develop new-to-the-world products. As one of the founders of the first venture capital firm, American Research and Development, Merrill Griswold, was quoted as saying in 1952:

> Some of our friends began to say, "Oh, Lord, not another longhair project. Why doesn't A.R. &D. back something commercial and make some money?" We learned our lesson. Now we realize that our best things are longhair. If they click we're not trying to do something that everyone else can do (Bello 1952).

As the above quote suggests, research leadership is a vital factor in academic entrepreneurship, as all studies conclude that research excellence is one of the primary determinants of university entrepreneurial activity (Grandi and Grimaldi, 2005; O'Shea et al., 2005; Powers and McDougall, 2005). Therefore, regardless of the number of entrepreneurship programs, the operation of the university technology licensing department, and the presence of incubators, accelerators, etc.; the two most significant determinants of successful university entrepreneurial activity are academic

excellence and research funding, which are, or course, highly correlated.

Probably the least biased measurement of research excellence is the Chinese Shanghai Jiaotong Academic Ranking of World Universities (ARWU). In the next few paragraphs, we explore the research rankings for these universities. The only K/M university that ranked highly in ARWU was Washington University.[3] Both the Saint Louis University and University of Missouri, Kansas City were not ranked at all (see Table 1).

Table 1: Shanghai Jiaotong Overall Academic Ranking for Missouri and Kansas Universities

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Washington University	22	28	28	28	28	29	29	30	31	31	32	32
U. MO, Columbia	201-300	202-301	203-300	201-300	203-304	201-302	201-302	201-300	201-300	201-300	201-300	201-300
Kansas State University	201-300	202-301	203-300	301-400	305-402	303-401	303-401	301-400	301-400	301-400	301-400	401-500
University of Kansas	201-300	202-301	203-300	201-300	203-304	201-302	201-302	201-300	151-200	201-300	201-300	201-300

Source: Shanghai Jiaotong AWRU, 2014

Of course, a university's general excellence may not be as important as excellence in specific fields. So, for example, excellence in research fields that are more easily commercializable may be more important than overall excellence. In Appendix Table A1, we report the AWRU Broad Subject Field rankings for the K/M universities. First and foremost, these data indicate the most commercializable subject fields that most frequently received high rankings among the K/M research universities included the life sciences, medical sciences and physical sciences. Washington University consistently ranked in the top 50 in the life sciences and somewhere between the top 50 and top 75 in medical sciences during the 2007-2014 period. It also was ranked

[3] All academic ranking systems can be criticized for their methodology. In the case of the AWRU, great emphasis is placed on Nobel prizes (20% of total index) and publication in journals such as *Nature* and *Science*. This favors the natural, biological, engineering, and medical sciences. This may, in part, explain Washington University's high ranking, but regardless the relative academic ranking of the other universities is an issue that should be of concern.

in the top 200 in the physical sciences for 2012 and 2013. The University of Kansas was ranked between the top 150 and top 200 in medical sciences during 2012-14 and was ranked in the top 200 for physical sciences for 2012 and 2013. The University of Missouri-Columbia was also ranked in the top 200 in physical sciences during 2012 and 2013. Kansas State University, which does not have a medical school, ranked in the Top 200 in the life sciences in 2012 and 2013. In contrast, in no year did any of these K/M universities receive a high ranking in engineering, with the exception of Washington University in 2007. While much attention has been given to the life sciences as a source of university spinoffs, engineering has been the source of most of the university spinoffs that could be considered transformative.[4] St. Louis University was not ranked in the top 200 in any of the subject fields evaluated. As indicators of research excellence, these rankings suggest that Washington University should be the most fecund source of startups, and that expecting large numbers of university spinoffs from the others might not be reasonable. However other factors can play a role.

1b. Research Funding

Because we confined our examination of the K/M universities to technology-based startups, R&D is an important factor in generating the knowledge upon which these spinoffs would be based. As shown in Table 2 below, Washington University receives far more research funding than its nearest K/M rival, the University of Kansas, which had less than 50 percent of research funding of Washington University. The University of Missouri, Columbia receives only one third of that of WU. The remaining institutions in our study receive still less R&D funding.

Table 2: Higher Education R&D Expenditures, Ranked by FY 2011 R&D Expenditures: FY 2004–11 (In Thousands)

[4] Akamai, Broadcom, Cadence, Digital Equipment Corporation, Google, Linkabyte (founders of which later founded Qualcomm),Quintiles, Netscape, SAS, Silicon Graphics, Sun Microsystems, Sybase, Synopsys, and Yahoo! were all university spinoffs. Dell, Facebook, and Microsoft were founded by undergraduates.

R&D Funding	National Ranking	2004	2005	2006	2007	2008	2009	2010	2011
Washington University	19	492,998	535,642	551,333	575,846	566,378	630,141	695,974	725,039
University of Kansas	71	194,440	208,285	214,768	219,535	227,433	236,544	267,961	302,668
U. MO, Columbia	87	227,592	234,334	231,170	244,429	251,894	253,527	238,500	**230,957**
Kansas State University	114	121,394	126,826	126,960	126,864	141,535	151,376	160,679	169,167
St. Louis U.	196	41,263	47,356	48,248	56,921	59,236	38,075	46,839	53,179
U. MO, Kansas City	234	35,208	34,282	27,572	30,944	28,892	28,657	30,163	32,769

Source: National Science Foundation, 2014

For the four leading R&D performers, we display the distribution of R&D funding in 2011 by fields (see Table 3). What is immediately apparent is the absolute dominance of the life sciences, particularly at Washington University, where it accounts for 89 percent of total R&D performance. This life science dominance is similar at Kansas State University, while at the University of Missouri-Columbia, leadership is evenly split between the life sciences and other, which is almost certainly agricultural research as it is a land grant university. We include the R&D expenditures for the University of Minnesota and the University of California, Davis, both of which are land grant universities with large research and teaching hospitals, as a point of comparison. What is clear is that these two comparison universities have significantly greater R&D expenditures in engineering and computer science than is the case at Washington University or the other Kansas and Missouri universities. Not surprisingly, there were few Kansas or Missouri university spinoffs in engineering and the computer sciences. While this report is unable to assess the impact of the relative lack of engineering R&D funding on university entrepreneurship in the two states, we believe it is worth noting, because the university spinoffs having the largest regional employment impacts are engineering firms such as Broadcom (UCLA), Cadence (UCB), Cisco (Stanford), Google (Stanford), Linkabit/Qualcomm (UCSD), Quintiles (UNC), SAS (North Carolina State), Sun Microsystems (Stanford and UCB), Synopsys (UCB), and Yahoo! (Stanford). Our K/M database did not find any

such large engineering-driven successes.[5] While biotechnology receives the greatest attention, nearly all of the firms are quite small.[6]

Table 3: K/M University R&D Expenditures by Scientific Field, 2011 (In Thousands)

	Overall Rank	Total	Envir.	Life	Math and CS	Phys	Psych	Social	NEC	Engin.	Other
Washington U.	19	725,039	11,474	644,264	5,532	15,998	7,804	1,362	1,056	19,914	17,635
University of Kansas	71	302,668	21,435	210,124	2,100	18,192	1,474	4,196	1,341	15,305	28,501
U. MO, Columbia	87	230,957	1,520	95,695	3,356	5,742	1,122	3,998	0	18,836	100,688
Kansas State U.	114	169,167	679	109,978	3,626	11,320	2,307	5,420	5,799	24,365	5,673
U. Minnesota	13	847,419	13,314	596,968	25,584	37,985	22,779	28,457	2,001	97,401	22,930
U. CA, Davis	22	707,896	27,710	507,389	13,215	29,308	4,210	23,258	6,248	86,855	9,703

Source: National Science Foundation, 2014

1c. Patenting

Patenting is yet another indicator of technological progress and potential for entrepreneurship.[7] The Kansas and Missouri universities were important patentees in their respective states. For example, from 2009 through 2013, the University of Kansas had been granted 62 patents (6.6% of all patents granted in the state), making it the 6th largest Kansas organizational patenting entity, while Kansas State University had received 20 patents (2% of all patents granted) making it the 18th largest patenting entity in the state. In the case of Missouri, two of the universities, the University of Missouri (which files as a system) and Washington University, were even more central to the state's innovation system. From 2009 through 2013, the University of Missouri received 121 patents (18% of all patents granted in the state), while Washington

[5] There is a large literature suggesting that prominent entrepreneurial successes can motivate involvement by yet more academics (Bercovitz and Feldman 2008). For a discussion on the role of different cultures on university spinoffs, see, for example, Kenney and Goe (2004).
[6] For example, Amgen Corporation, which was established in 1980 and is the most successful biotechnology firm in history had 19,000 employees in 2014, while Google, which was established in 1998 had 55,000 employees in 2015.
[7] Note, we are not claiming that patenting is necessary for technology-based university entrepreneurship; merely that it is a useful indicator of knowledge that might potentially be commercialized.

University received 112 patents (17% of all patents granted).[8]

These results show that in Missouri, in particular, university inventions make up a large portion of the state's overall patenting activity. While Washington University is the top university in terms of both academic ranking and R&D expenditures, the University of Missouri system is the top USPTO patentee. The two Kansas universities are far less important to the state's overall patenting activity than were the Missouri universities. However, Kansas had more patents granted than did Missouri during the period examined (946 patents in Kansas versus 671 in Missouri).

1d. Small Business Innovation Research Grants

Another general indicator of entrepreneurial activity is the number of Small Business Innovation Research/Small Business Technology Transfer (SBIRs) grants awarded in the state. Table 4 lists the number of SBIR awards and the number of unique firms to which the awards were made for the cities in which the K/M research universities operate campuses. St. Louis was the clear leader in terms of number of awards (509) and unique firms receiving them (119) from 1990 to 2014. The activity in the university towns of Lawrence, Manhattan, Columbia and Rolla stands out in terms of number of SBIR. Lawrence ranked 2nd in terms of the number of awards, followed by Rolla, Manhattan and Columbia. Rolla was particularly interesting because of the high number of awards for the relatively small number of firms (~10 awards per firm), while the other cities had roughly five awards per firm. Lawrence also ranked 2nd in the number of unique firms funded (34), followed by Kansas City and Columbia with 25 unique firms funded. Not surprisingly, the SBIRs are concentrated in the larger cities and in close proximity to the various universities with St. Louis

[8] To illustrate how important universities have become in state-level patenting. In California, the UC system is the tenth overall in patenting by an organization, while Stanford is 24th and Caltech is 29th.

having a far greater number of awards and firms than any other metro area

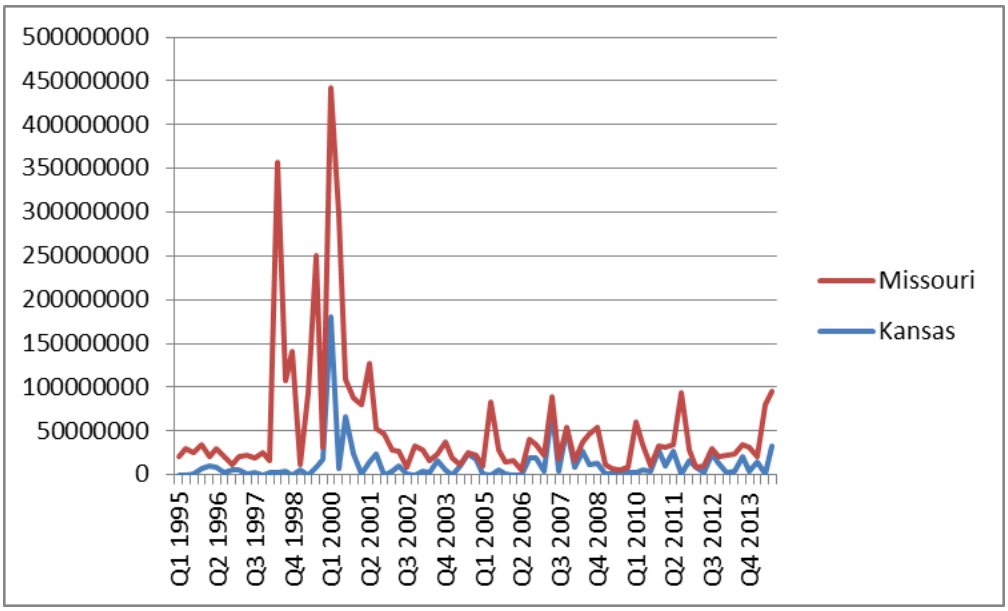
Table 4: Cumulative Number of K/M SBIR Awards and Unique K/M Firms Receiving SBIR Awards, 1990-2014

Kansas	Number of Awards	Number Of Unique Firms	Awards Per Unique Firm
Kansas City	68	25	2.72
Lawrence	163	34	4.79
Manhattan	105	16	6.56
Wichita	21	8	2.63
Other	52	16	3.25
Total	409	99	4.13
Missouri			
Columbia	79	25	3.16
Kansas City	45	19	2.37
Rolla	124	12	10.33
St. Louis	509	119	4.28
Other	33	18	1.83
Total	790	190	3.73

1.e Venture Capital Investment

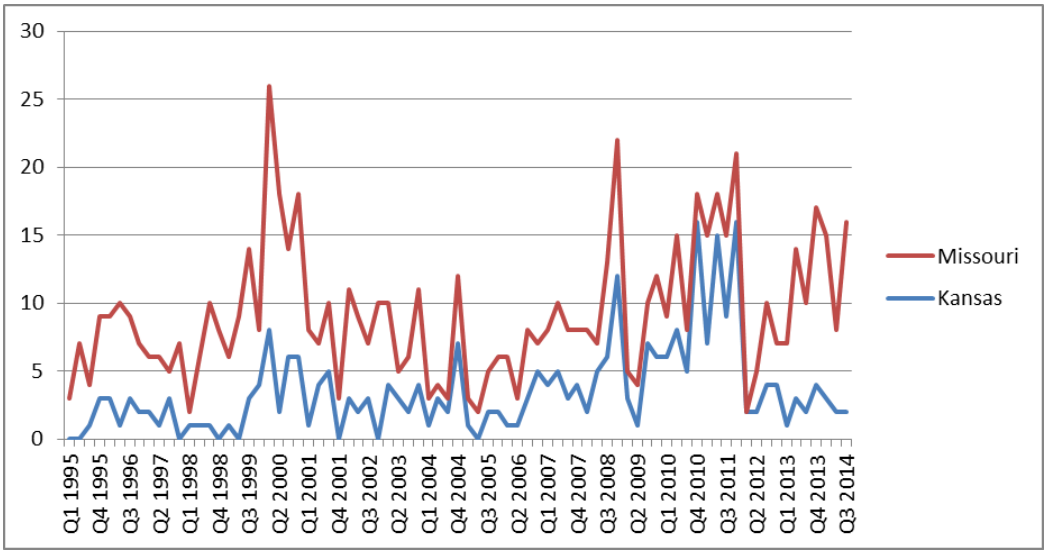
The final and most high-powered indicator of high-opportunity entrepreneurship is the amount of venture capital invested in each state. Missouri has attracted a far greater volume of investment and has had a significantly greater number of venture capital deals than Kansas (see Figures 1 & 2 below). The reasons for this are not clear, but it is a more populous and richer state. Further, St. Louis and Kansas City are more important financial centers. It is difficult to be certain how much of the greater flow of venture capital to Missouri can be attributed to spinoff businesses from Missouri research universities in general, and Washington University in particular.

Figure 1: Venture Capital Investment in Kansas and Missouri by Quarter, 1995-2014



Source: Thomson VentureXpert 2014.

Figure 2: Venture Capital Deals in Kansas and Missouri by Quarter, 1995-2014



Source: Thomson VentureXpert 2014.

The technology areas of venture capital investment can also reveal the fields of greatest entrepreneurial strength. Figures 3 through 5 indicate the number of venture capital deals for the U.S., Missouri, and Kansas during the 1995-2015 period, broken down into three categories: (a) biotechnology (biomedical and medical devices); (b) information technology; and (c) other. At the

national level, the preponderance of venture capital deals during the 1995-2015 period were in the information technology sector. Of the three categories, biotechnology ranked 3rd in number of deals to the "Other" category. In comparison, venture deals in the states of Missouri and Kansas were far more concentrated in biotechnology, particularly from 2002 onward. Thus, for venture capitalists, it is biotechnology that is the most important area for investment in K/M, which is in keeping with the strength of the local universities and in St. Louis and Kansas City with established firms. While a very small number, during a few years, information technology also provided a proportionately higher share of venture capital deals in Kansas.

Figure 3: Number of Venture Capital by Technology Sector for the U.S., 1995-2015

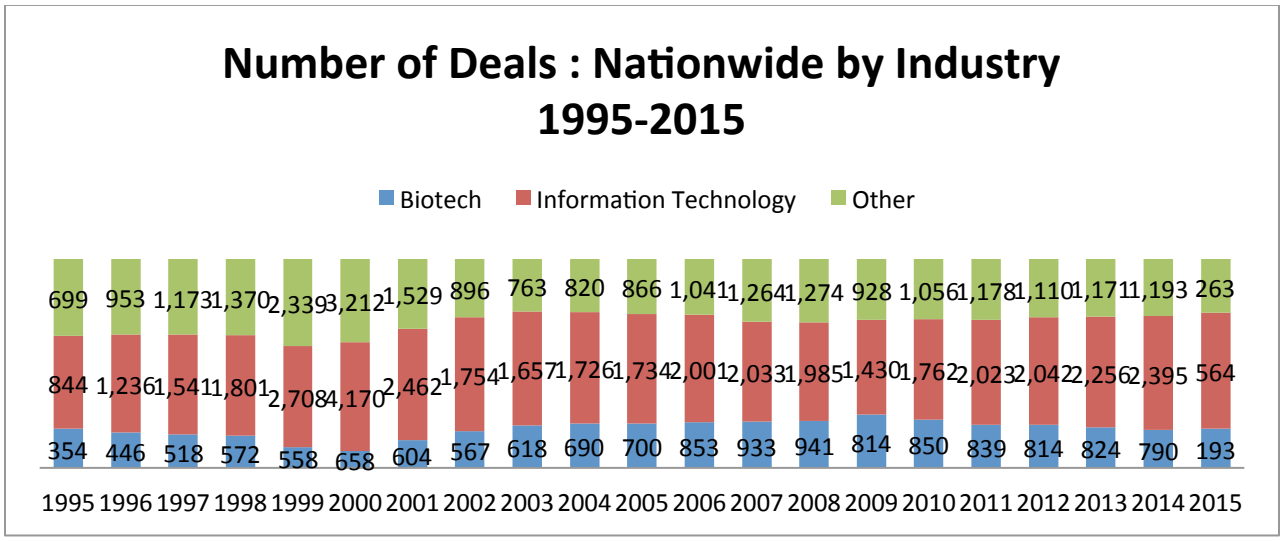


Figure 4: Number of Venture Capital by Technology Sector for Kansas, 1995-2015

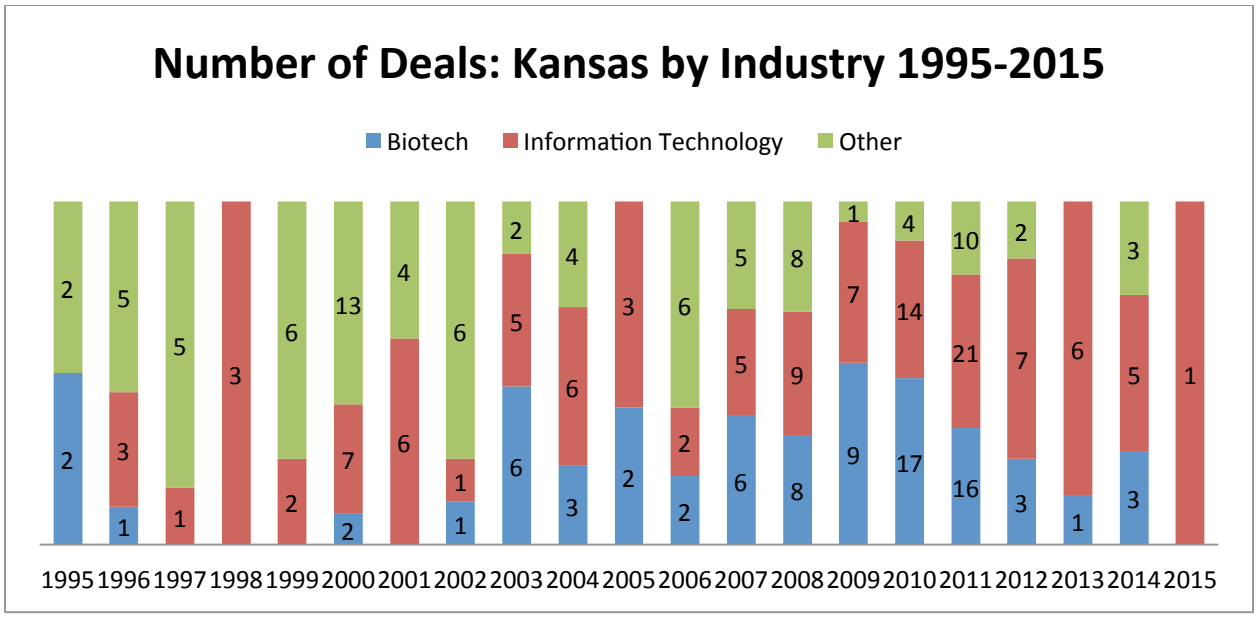
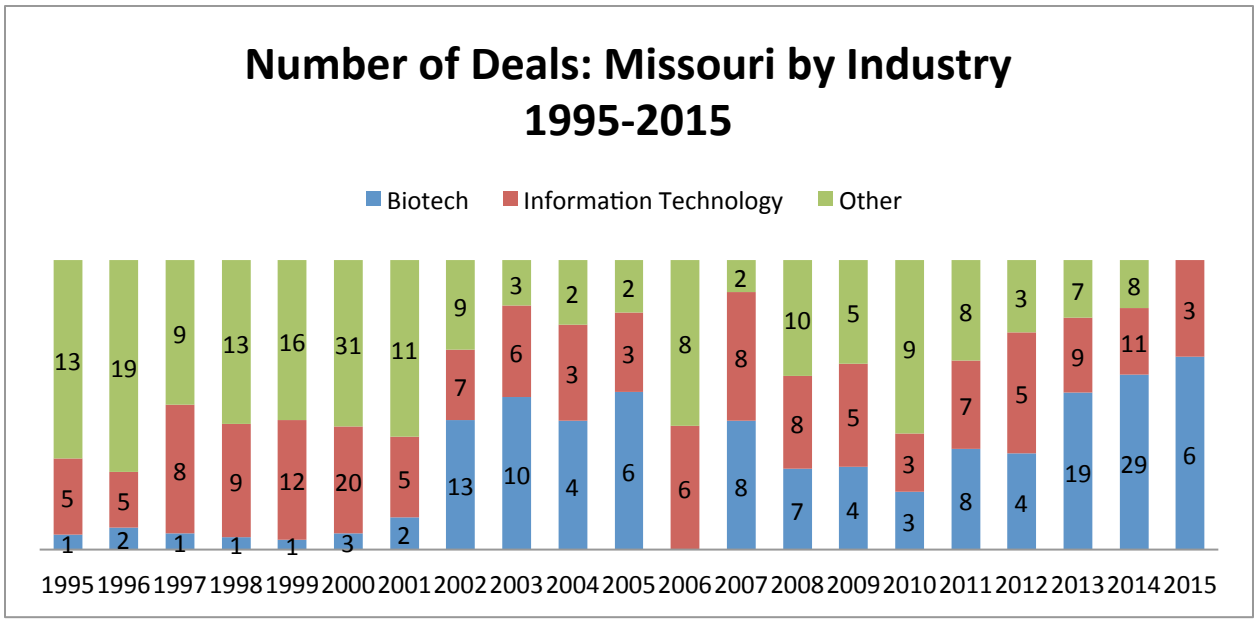


Figure 5: Number of Venture Capital by Technology Sector for Missouri, 1995-2015



2. Data Collection and Methodology

2a. Identifying & Classifying University Spinoffs

This study is based on a database of all technology-based spinoffs created by university affiliated personnel at the seven K/M research universities and medical schools: Kansas State University, University of Kansas, the main campus of the University of Missouri in Columbia and its branch campuses in Kansas City, and St. Louis, Washington University, and St. Louis University. Using the criteria described below, this study identified 125 technology-based spinoffs from these universities over the years 1968 through 2013.

There are a variety of classification schemes that may be used to identify university research spinoffs (see, for example, Carayannis et al., 1998; Pirnay et al., 2003). Fini et al. (2010) classify spinoffs on the basis of whether they were established from patented technology and whether the technology is owned by the inventor's university. Nicoloau and Birley (2003) separate firms into three types: orthodox -- firms whose technology and inventor's spinoff from the university; hybrid -- firms whose technology is licensed but the inventor remains a university employee while having a relationship with the firm; and spinoffs -- firms with which the inventor has no connection. In contrast, Wright et al. (2007) identify three ideal types of university spinoffs based on their market goals: venture capital-backed spin-offs, prospector spinoffs (based on technology with less immediate market potential), and lifestyle spinoffs (these are established by academic personnel with more of a consultancy orientation).

Most U.S. studies of university spinoffs, with the exception of Fini et al. (2010), utilize available secondary data that are most easily procured -- that is, data collected and aggregated by the Association of University Technology Managers (AUTM). While the AUTM data may be easily obtained from on-line sources, these data are almost entirely confined to university spinoffs resulting from the licensing of faculty inventions disclosed to their university Technology Licensing

Office (TLO). An important limitation is that AUTM does not collect data on other types of university-spawned firms such as firms spun off by faculty or research personnel that did not go through the university TLO or firms established by students. In the United States, these types of university spinoffs may represent a largely unmeasured, but significant number of university spinoffs (Fini et al. 2010; Kenney and Patton 2011). While academic classification schemes often include student spinoffs as a category, most studies do not identify or collect data on them. This is likely due to time and resource constraints and because a more rigorous data collection methodology would be required to identify and collect data on them. A second limitation of AUTM-based analyses is that the firms are often reported anonymously, thereby making it difficult to study firm and founder characteristics. The research methodology described below is designed to overcome these limitations and develop a database including all types of technology-based university spinoffs as well as founder and firm characteristics.

In the database collected for this study, which is an attempt to produce a census and not a sample, only de novo, high technology university spinoffs were included. To be considered a high-technology university spinoff a firm had to fulfill three criteria. The firm had to be founded by university personnel, it had to be de novo, and it had to be technology-based. The first criterion is that the firm must have been founded by at least one individual affiliated with (employed by or enrolled in) the target university. This affiliation must have existed within one year prior to the establishment of the spinoff, if not at the time of establishment (this criteria is used to capture firms that might be started by a university-affiliated individual that left the university to establish a firm). At the time of the firm's founding, the status of the founders' relationship with the university was determined from the founder's biography, which was usually found through Internet searches.

Firms founded by individuals that were more than one year away from their separation from

the university were not classified as university spinoffs and not included in the database.[9] Firms whose establishment was based on a university technology license were also excluded if no firm founder was affiliated with the university.[10] Another important reason for excluding such "license-only" firms is that our previous research (Kenney and Patton 2011) has found that such firms are often established as the result of a number of licenses from a variety of organizations (with some not being universities or from multiple universities, thereby making attribution difficult). In these cases, establishing a causal linkage between the establishment of a firm and a particular university is problematic. Finally, firms whose only linkage was that they were established by alumni were excluded.

The second criterion is that the spinoff firm must be *de novo*, i.e., the spinoff must be a new, independent firm established by, at least, one individual affiliated with the focal university as noted above. The third criterion for inclusion in the database is that spinoff firms must be technology-based, or be engaged in a high-technology industry. This would include, for example, spinoffs that write software algorithms for larger firms. It would also include spinoffs that produce other software products and internet firms that are large enough to have a significant web presence or have received venture capital – a decision that does lead to population censoring. Our justification for this is that many firms such as those winning business plan competitions never are actualized in an operational firm – moreover, the vast bulk of these have no economic impact. They are simply ephemeral.

In determining which firms are technology-based, and what type of technology category

[9] This is a somewhat arbitrary cut-off date, but the goal is to focus on university-derived spinoffs and not to include all alumni. The difficulty of using alumni entrepreneurship is that the further from graduation that the startup is formed the more difficult it is to directly attribute such a startup to their university education. Research on alumni entrepreneurship leads to the obvious result that students are more important for entrepreneurship than professorial entrepreneurship, whereby populations of graduates in aggregate produce more startups than professors, when the population of students is 100x larger than that of professors.

[10] These firm founders have been termed "surrogate" entrepreneurs (Franklin et al. 2001).

most accurately describes them, we relied on a consensus of classifications from other sources whenever possible. The reason for using a "consensus" classification is that alternative sources may describe a firm's industry and/or technology differently, so an informed decision must be made. To illustrate, a firm such as Amazon can be classified in the retail or Internet sector. In the case of Amazon, we would classify it as "internet" and include it in the database. In contrast, say a faculty member established a retail outlet or a brew pub, neither of these would be included. Sources used to classify a spinoff firm included any product descriptions on the firm's website, sources in the local business press, university technology transfer office, or a local business association. Each decision for inclusion was be made by one of the principal researchers.

In addition to the three criteria above, we also established criteria for the exclusion of firms based on firm size and significance. Very small spinoff firms that employ a few workers and engage in providing services or consulting were excluded from the database. However, we must add an important caveat here. The North Carolina State University spinoff, SAS, began as a consulting firm and likely would not have been included in its earliest stages. However, our retrospective analysis would include it in the technology-based spinoffs. The reasons for these exclusions are to ensure that the resulting database better captures high-potential entrepreneurship and excludes firms such as those Wright et al. (2007) identify as "life-style" firms.

A number of techniques and sources were used to assemble the spinoff firm database. First, all venture capital investments in the county within which the university is located were downloaded. Each firm was then inspected to identify the founders. Second, the university's websites, particularly the technology transfer office, business school, entrepreneurship programs, and engineering college websites were searched. Third, as part of analyzing the extant activities at each university to encourage entrepreneurship, we identified and conducted personal interviews

with local experts including personnel at the university TLO, local entrepreneurs, or personnel at university business parks or incubators. Fourth, where available, we consulted lists of entrepreneurial firms already compiled by other parties at each university for possible inclusion.

Once the population of spinoff firms was identified through these steps, data from the internet and other sources were collected on each firm to ensure that it conformed to our criteria. The list was then provided to local experts in the region to ascertain if there were missing firms. Data collection was terminated when no new firms were found.

All spinoffs were assigned to one of 27 firm industry classifications, and these were aggregated into three general categories (see Appendix Table A2). The category of biomedical sciences (BMS) includes all spinoffs involved in biotechnology and firms selling inputs to biotechnology firms, all firms involved in the provision of medical services and supplies, including medical instruments, and all veterinary and agricultural biology firms. Computer science and electrical engineering (CS&EE) includes all firms involved in electronic components, information technology, internet applications, semiconductors, software, and telecommunications, including wireless. Engineering and physical sciences (EPS) includes all spinoffs involved in engineering with the exception of electrical and biomedical engineering. It also includes firms involved in environmental applications, materials, nanotechnology, robotics, and scientific instruments.

2*b. The Identification & Classification of Entrepreneurial Programs*

A second objective of this research was to identify entrepreneurial programs at the K/M research universities that serve to facilitate entrepreneurship in general, including the formation of spinoff firms. Entrepreneurial programs were identified through the following steps: First, the university's websites were searched, particularly those for the business school, research

administration (including the technology transfer office), engineering college, and any other organizational unit providing programs related to entrepreneurship. Second, follow-up phone calls were then made to the organizational units to confirm the program identified. The entrepreneurial programs identified were then classified into one of eight types based on its primary purpose:

a. Entrepreneurial Education – specialized educational programs designed for students to develop knowledge and skills in entrepreneurship. This included internship programs that provided students with experience working with established entrepreneurs.
b. Business Networking – programs designed to allow students and faculty interested in entrepreneurship and/or private sector entrepreneurs to establish relationships and social networks. This type includes student clubs focusing on entrepreneurship.
c. Entrepreneurial Competitions – Competitions for funding for students and/or faculty engaging in entrepreneurship. This type included programs that provide seed funding for spinoffs in the early or conceptual stages of development, cash awards for business plans or product ideas, and educational funding (e.g. scholarships).
d. Capital/Funding – programs that provide financial capital to university spinoffs or other new business startups.
e. Incubators – university-operated facilities that provide space and services to assist university spinoffs or other new business startups.
f. Technology Transfer – programs that provide services related to managing intellectual property including patenting and licensing services.
g. Research on Entrepreneurship – programs designed to fund and/or conduct research to advance the knowledge base on entrepreneurship.

h. Recognition of Entrepreneurial Success – programs that provide recognition to graduates who had become successful entrepreneurs. Included under this type were annual awards programs and a museum of entrepreneurship.

3. Descriptive Statistics and Basic Results

We identified 125 high-technology spinoffs from the K/M research universities. Two of the seven universities examined, the two branch campuses of the University of Missouri in St. Louis and Kansas City were found to have produced very few spinoffs; and, in the interest of efficiency, these were analyzed as part of the entire University of Missouri system. Broken down by university, 57 spinoffs were identified at Washington University, 33 at the University of Kansas system, 19 at the University of Missouri system, 10 at Kansas State University, and 6 at Saint Louis University. The spinoff firms identified are listed in Appendix Table A3. As a point of reference for evaluating the number of spinoff firms identified, we used the University of Wisconsin, Madison (UWM) as an example of an entrepreneurial Midwestern university. How important has the UWM been to the state? Madison, the home of the UWM, is the only city in Wisconsin that has exhibited economic growth during the last twenty-five years and direct university spinoffs were a significant contributor to this growth (Kenney et al. 2009).

3a. University Spinoffs over Time

When considering the establishment of spinoffs over time, the records of K/M research universities were found to differ. Figure 6 compares the number of spinoffs established by year for the 5 K/M research universities and UW-Madison. This indicates that the generation of spinoffs from Kansas State, St. Louis University, and the University of Missouri was uneven over time (see Figure 6). Of the K/M research universities, only the University of Kansas and Washington

University have created spinoffs on a fairly consistently basis over the last two decades, although neither approach the University of Wisconsin in number or consistency.

Figure 6: Spinoffs by Year for K/M Research Universities, 1968-2013, and the University of Wisconsin, 1968-2009

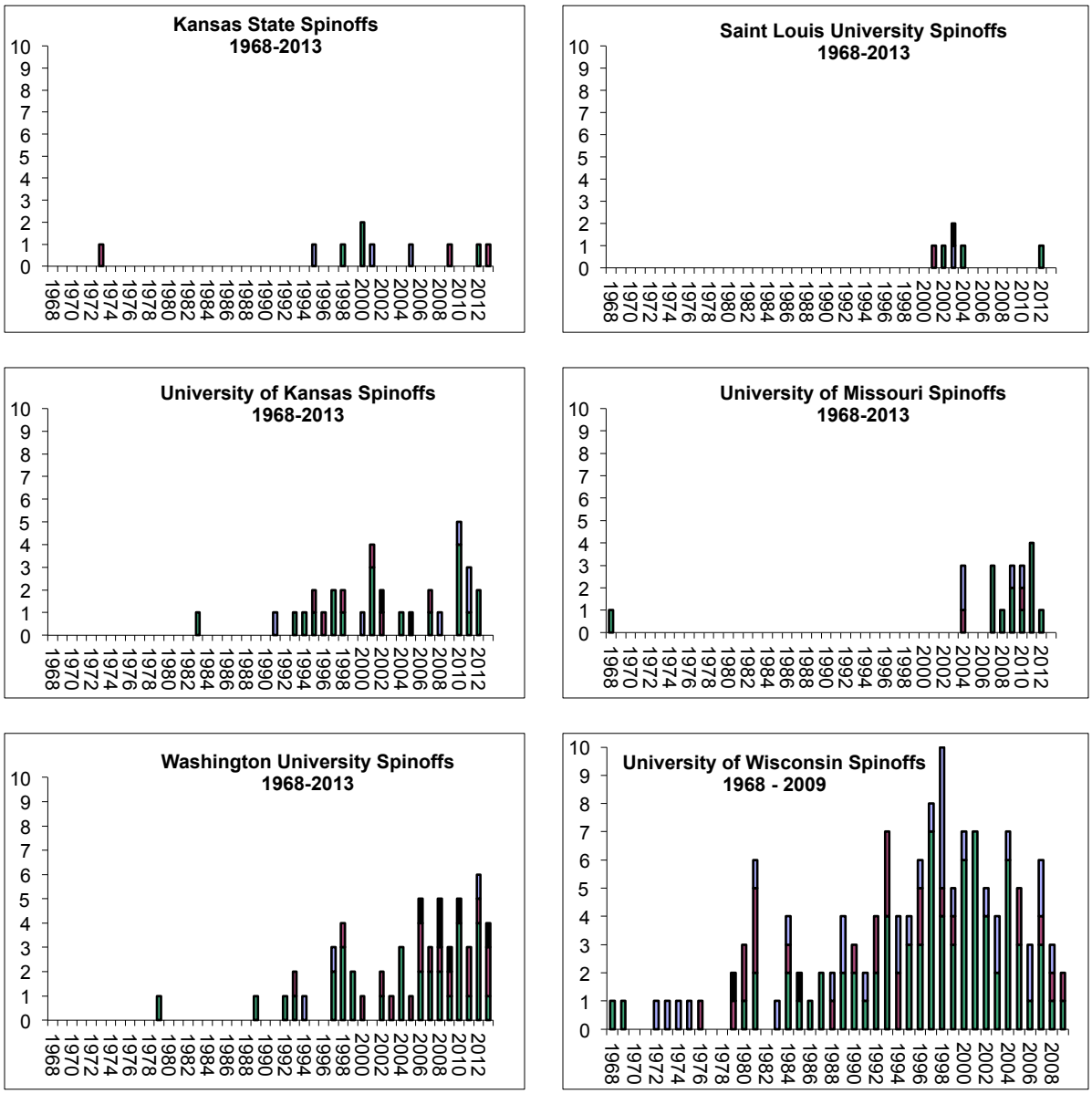


Figure 7 shows the cumulative formation of spinoffs over time for the K/M research universities. When taken as a group, K/M research universities have shown impressive growth in

spinoff generation – in keeping with what has been a national trend. Figure 8 shows the cumulative formation of spinoffs over time by university. Washington University has enjoyed steady growth in spinoffs since 1988 while the expansion of spinoffs at the University of Kanas began in 1990.

Figure 7: Cumulative K/M Spinoffs by Year and Field for all Universities Combined

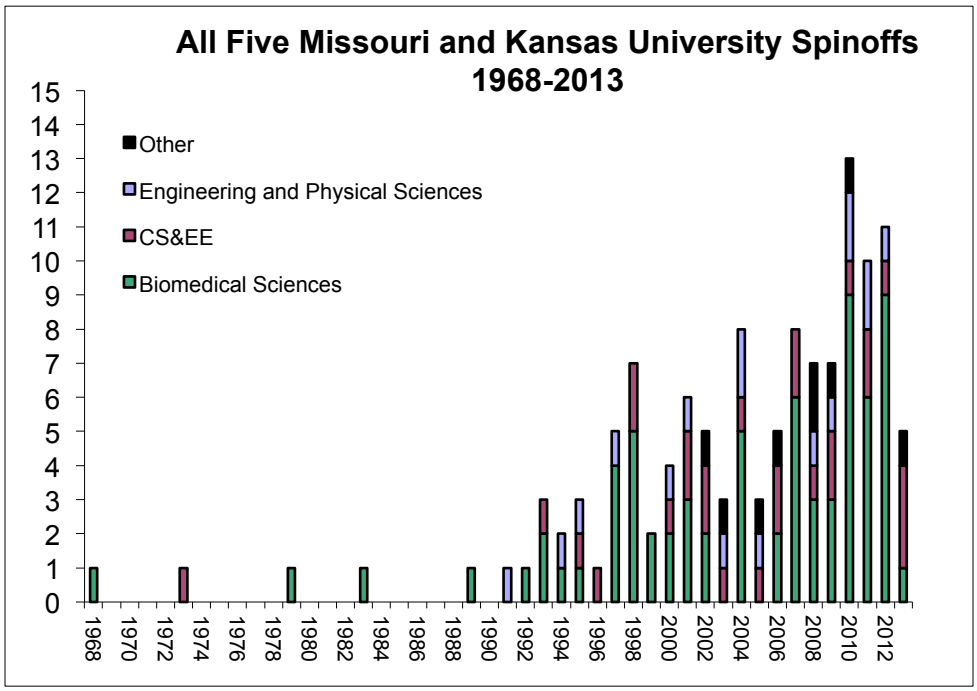
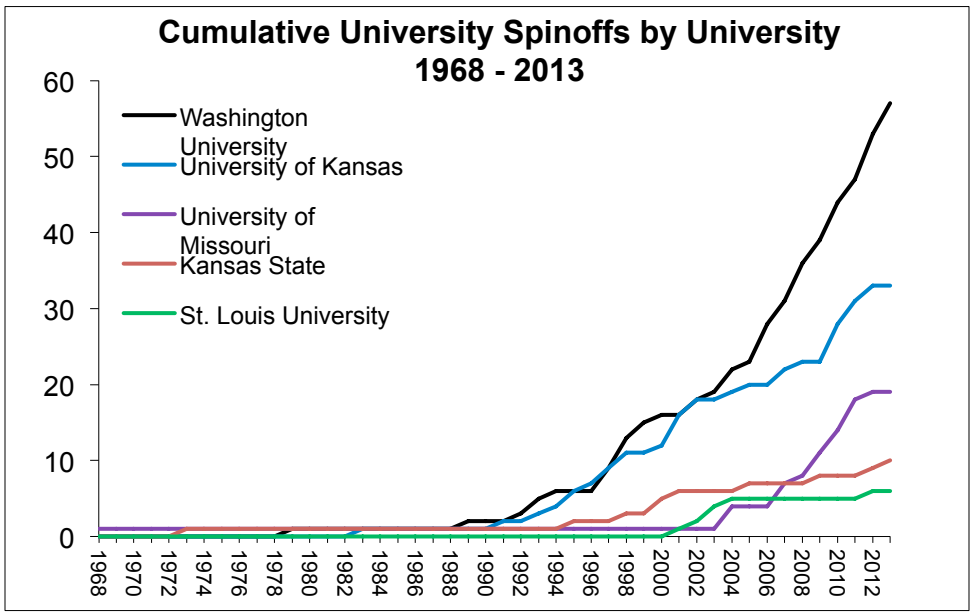


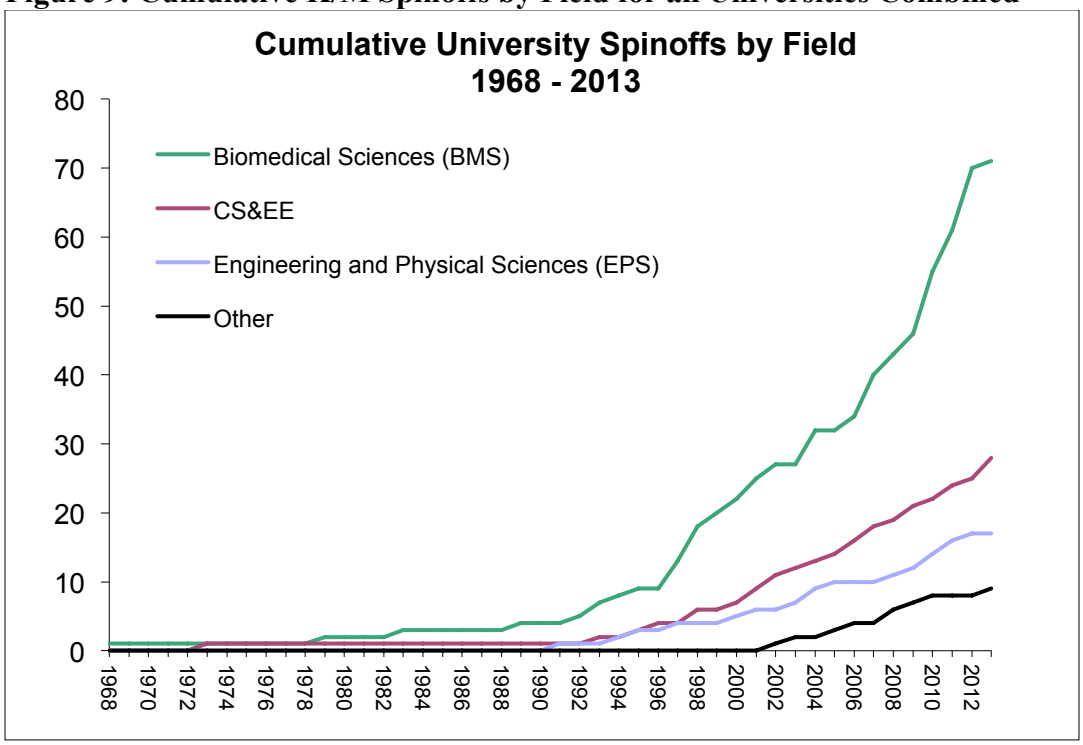
Figure 8: Cumulative K/M Spinoffs by University, 1968-2013



Also, beginning in 2002 the total for Washington University and the University of Kansas began to diverge dramatically. The growth of spinoffs from the University of Missouri has largely occurred since 2003. The majority of spinoffs from Kansas State were formed after 1998 while those at Saint Louis University were formed after 2000.

Figure 9 displays the cumulative total of spinoffs by broad academic field. The number of spinoffs in the biomedical sciences was found to be substantially larger than the number in computer science & electrical engineering, other engineering fields and the physical sciences, and other academic. This is a reflection of the relative academic emphasis of these universities in the life sciences.

Figure 9: Cumulative K/M Spinoffs by Field for all Universities Combined



3b. University Ranking by Academic Standing and R&D Funding

The five universities can be ranked according to three of the characteristics described above: spinoffs, academic ranking, and R&D expenditures. Given the frequently made observation that the academic status of universities and their departments are important in terms of numbers of spinoffs (see, for example, Di Gregorio and Shane 2003; O'Shea et al. 2005; Zucker et al. 1998), we would expect that these characteristics would be correlated. Table 5 compares the number of spinoffs from K/M research universities with their national rank in total R&D funding in 2011 and their 2014 Shanghai Jiao Tong ranking. These data shows that the

Table 5: Spinoffs, R&D, and Academic Rank

University	1968-2013 Spinoffs	2011 R&D National Rank	2014 Shanghai Jiao Tong Rank
Washington University	57	19	32
University of Kansas	33	71	201-300
University of Missouri	19	87	201-300
Kansas State University	10	114	401-500
St. Louis University	6	196	Not ranked

number of spinoffs a university produces is directly correlated to these two measures. The rank order correlation between number of spinoffs and national rank of total 2011 R&D funding is perfect.

All the K/M research universities are oriented towards the life sciences, both in the proportion of R&D funding they received and in the type of spinoffs they have produced. Table 6 shows that every one of the research universities in Missouri and Kansas has produced the greatest proportion of their spinoffs in the biomedical sciences. Over half of all of these spinoffs, 56.8%, have been in this field. The University of Missouri, in particular, has been most successful in

biomedical spinoffs as they make up two thirds of the university's total.

Table 6: Spinoffs by Discipline Category: 1968 through 2013

Discipline Category	Washington University	Univ. of Missouri	Univ. of Kansas	Kansas State	St. Louis University	All Five Universities
Biomedical Sciences	32 (56.1%)	13 (68.4%)	19 (57.6%)	4 (40.0%)	3 (50.0%)	71 (56.8%)
CS & EE	16 (28.1%)	2 (10.5%)	6 (18.2%)	3 (30.0%)	1 (16.7%)	28 (22.4%)
Engineering & Physical Sci	3 (5.2%)	4 (21.1%)	6 (18.2%)	3 (30.0%)	1 (16.7%)	17 (13.6%)
Other	6 (10.5%)	0	2 (6.1%)	0	1 (16.7%)	9 (7.2%)
Total	57	19	33	10	6	125

Discipline category percentage of total spinoffs for each column shown in parentheses.
Source: Authors' data

3*c. R&D Funding and Spinoff Performance*

In previous work on university spinoffs it has been found that not only that the number of spinoffs and total R&D expenditures are correlated, but that the number of spinoffs relative to R&D expenditures varies greatly by field of inquiry (Kenney and Patton 2011). The R&D funding for all universities can be divided into categories that are comparable to the spinoff categories (see Appendix Table Two). Because R&D data varies from year to year, the R&D funding for the four-year period 2005 through 2008 was used as a measure of R&D input by discipline to the universities. These data are shown in Table 7.

The most striking result in this table is the overwhelming importance of biomedical sciences R&D. Biomedical R&D accounts for over 92 percent of all R&D for Washington University, and 84% of all funding for these universities as a group. CS&EE accounts for only 2.1% of the total, with engineering and physical sciences (EPS) accounting for just under 11 percent of the total. As was shown in Table 3 with respect to UC Davis and the University of Minnesota, this heavy

Table 7: Total R&D (in Thousands of Dollars) from All Sources: Years 2005 through 2008 by Discipline

Discipline Category	Washington University	Univ of Missouri	Univ of Kansas	Kansas State University	St Louis University	All Five Universities
Biomedical Sciences	2,045,014 (92.3%)	720,564 (79.2%)	582,530 (73.2%)	335,925 (69.5%)	198,477 (96.2%)	3,882,510 (84.2%)
CS & EE	34,346 (1.5%)	28,271 (3.1%)	20,087 (2.5%)	12,876 (2.7%)	0	95,579 (2.1%)
Engineering & Physical Sci	109,326 (4.9%)	115,231 (12.7%)	150,763 (19.0%)	116,237 (24.0%)	7,286 (3.5%)	498,843 (10.8%)
Other	27,431 (1.2%)	45,185 (5.0%)	42,170 (5.3%)	18,562 (3.8%)	491 (0.2%)	133,839 (2.9%)
Total	2216116	909,251	795,550	483,600	206,254	4,610,771

Discipline category percentage of total R&D for each column shown in parentheses.
Source: National Science Foundation

emphasis in the life sciences is not typical among other comparable universities.

To obtain a clearer view of the relationship between R&D funding and spinoffs for these universities it is necessary to control for the distribution of R&D funding across disciplines. Tables 6 and 7 can be combined to create ratios of spinoffs to R&D funding, allowing for comparisons across disciplines and universities. The uneven distribution of spinoffs over time (see Figure 1) for most of these universities suggests that all spinoffs over time should be used as the measure of spinoff output, not just the number of spinoffs in a single year. Table 8 presents these ratios.

Table 8: Ratio of Spinoffs (1968-2013) / R&D in millions of dollars (2005-2008) by Discipline

	Washington University	Univ of Missouri	Univ of Kansas	Kansas State	St Louis University	All Five Universities
Biomedical Sciences	0.016	0.018	0.033	0.012	0.015	0.018
CS & EE	0.446	0.071	0.299	0.233		0.293
Engineering & Physical Sci	0.027	0.035	0.040	0.026	0.137	0.034
Other	0.219		0.047		2.037	0.067
Total	0.026	0.021	0.041	0.021	0.029	0.027

These ratios represent the ratio of total university spinoffs between 1968 through 2013 inclusive, divided by total university R&D in millions of dollars from all sources between 2005

through 2008 inclusive, by discipline category. Their interpretation is limited since the time frame used in the numerator is longer than that used in the denominator (this was because the NSF data were only available for these years). As a result, the ratio overestimates the number of spinoffs per research dollar. However, this measure does allow a broad comparison across disciplines and universities as an indicative measure of spinoff output relative to R&D input.

By comparing the ratios of all five universities by discipline we see that the ratio of spinoffs to R&D is 16 times greater for CS&EE than biomedical sciences (0.293 / 0.018), and that the ratio of CS&EE R&D to engineering and physical sciences (EPS) R&D per spinoff is 8.6. These ratios suggest that CS&EE spinoffs from universities occur at a much higher rate per dollar of R&D than do biomedical spinoffs or EPS spinoffs. These results generally agree with an earlier work comparing five U.S universities and the University of Waterloo in Canada (Kenney and Patton 2011).[11]

As an indicator of spinoff efficiency at each university, Table 9 below displays the ratios of spinoffs/R&D by discipline for each university compared to average ratio for all five universities. Given the small number of spinoffs in several of these cells these results should be interpreted very cautiously. Nevertheless, the University of Kansas performs above the group in every category except "Other." Washington University and St. Louis University perform at the average group level, while Kansas State University and the University of Missouri were less successful in terms of spinoffs per dollar of R&D, something that may likely be attributable to the difficulty in translating agricultural research into firm spinoffs. This suggests that, at least, in an earlier period, the University of Kansas was an active source of startups, but that this may have slowed recently,[12]

[11] The five American universities were the University of Wisconsin, University of Michigan, University of Illinois, UC Santa Barbara, and UC Davis (Kenney and Patton 2011). In this study the ratio of spinoffs per dollar of R&D of CS&EE to biomedical sciences was around 9, and the ratio of CS&EE to EPS was 4.5.

[12] Whether this is attributable to the massive state cuts for Kansas universities is not known.

while Washington University seems to be a steady source.

Table 9: Ratio of Spinoffs / R&D by Discipline for Each University Compared to the Average Ratio for the Group

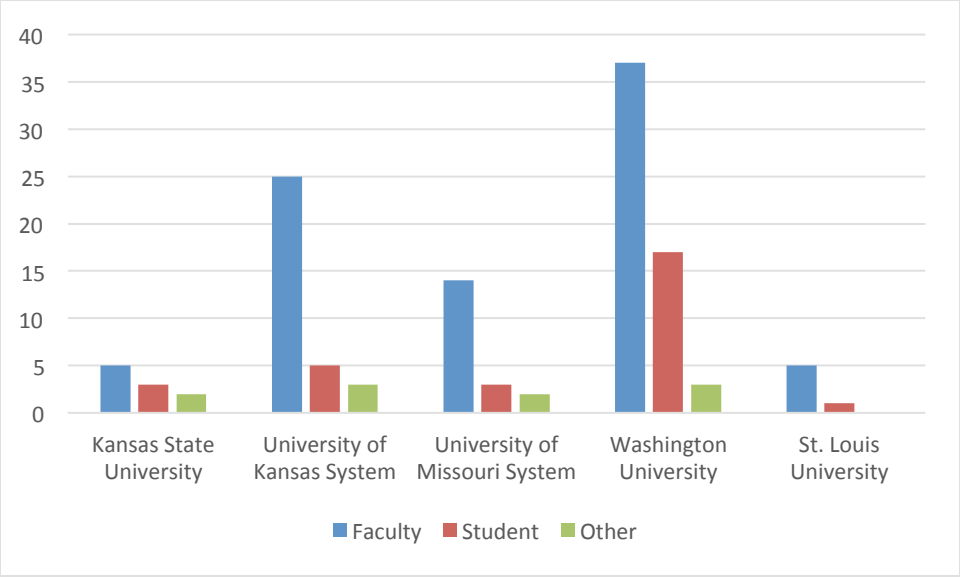
University	Biomedical Sciences	CS & EE	EPS	Other	Total
Washington University	0.86	1.59	0.81	3.25	0.95
University of Kansas	1.78	1.02	1.17	0.71	1.53
University of Missouri	0.99	0.24	1.02	NA	0.77
Kansas State	0.65	0.80	0.76	NA	0.76
St. Louis University	0.83	NA	4.03	30.29	1.07

3d. University Status of Founder/Entrepreneur

Data were collected on the founder(s) responsible for establishing each spinoff. The nature of the relationship of each firm founder to the university was determined from their biography. Each founder was classified by this relationship as being one of six types; faculty, graduate student, undergraduate student, university staff, post doc, or unaffiliated with the university. On this basis the founder type of each spinoff was determined to be one of three types; Faculty, Student, or Other.[13] The results are displayed in Figure 10. These data indicate that the vast majority of spinoffs are founded by faculty employed at the K/M research universities, followed by students who formed companies within a year after graduation. At Washington University, 17 of 57 spinoffs identified were founded by students while fewer than 5 spinoffs were founded by students at the other K/M research universities.

Figure 10: Number of Spinoffs by University Status of Founder(s)

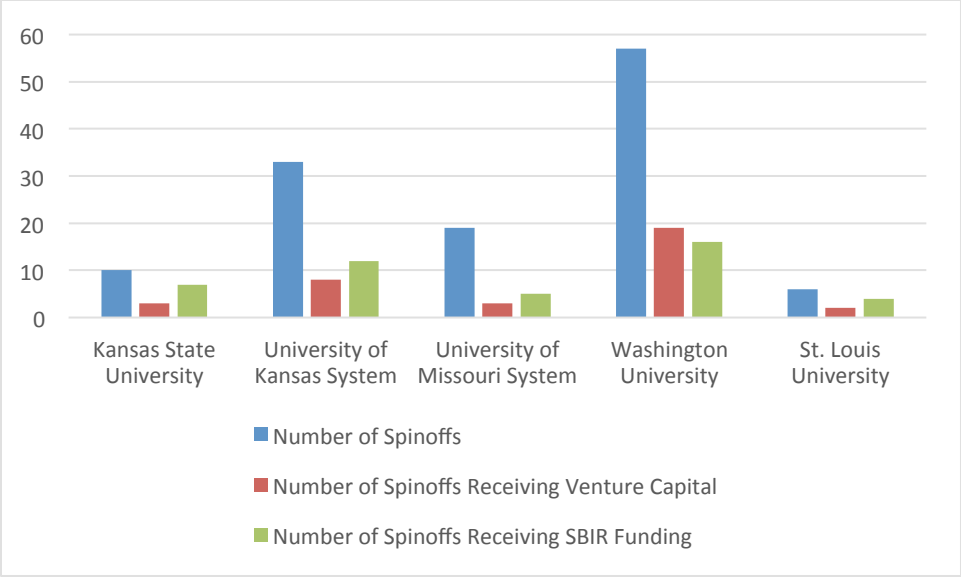
[13] Faculty: At least one of the founders was a faculty member of the university.
Student: At least one of the founders was a graduate student or undergraduate student, and none of the founders was a faculty member,
Other: At least one of the founders was affiliated with the university as a staff member,,post doc, or researcher, and none of the founders was a faculty member or student.



3e. Sources of Funding for Spinoffs

As noted above, venture capital firms and the Federal SBIR program represent important sources of funding for technology-based business startups in the two-state region, including university spinoffs. Figure 11 displays the number of startups at the Kansas and Missouri research universities that received funding from venture capitalists or the SBIR program. A total of 35 spinoffs received venture capital funding at the K/M research universities in the study. Broken down by university, venture capital was most frequently received by Washington University spinoffs, where 19 of the 57 (33.3% or 1 of every 3) spinoffs received venture capital (VC) financing. This was followed by the University of Kansas system where 8 of the 33 spinoffs (21.2%) received VC funding. In comparison, only 3 spinoffs at Kansas State, 3 at the University of Missouri system, and 2 spinoffs at St. Louis University received VC financing.

Figure 11: Number of Spinoffs Receiving Venture Capital and SBIR Funding by University



Data for the total amount of VC funds invested in these spinoffs were obtained, except for 1 spinoff from the University of Kansas system. These data indicate that a total of $549.59 million dollars in venture capital funds was invested in spinoffs from the K/M research universities with an average VC investment of $16.2 million per spinoff receiving these funds. Broken down by university, spinoffs at Washington University received a total of $420.3 million of venture capital funds invested in these ventures. Spinoffs from the University of Kansas system received a total of at least $83.8 million VC funds invested in these ventures. In comparison, a total of $22.1 million in VC funds was received by spinoffs at St. Louis University compared to $11.75 million by spinoffs at Kansas State and $11.63 million by spinoffs in the University of Missouri system. These data indicate that average VC investment per spinoff receiving it was $22.12 million at Washington University, $11.97 million at the University of Kansas system, $11.06 million at Saint Louis University, $3.92 at Kansas State University, and $3.87 million at the University of Missouri system.

Table 4 above lists the SBIR awards and number of unique firms receiving them in the Kansas and Missouri cities that serve as locations for the universities in this study. A subset of

these firms were university spinoffs. Figure 11 indicates that 16 of the spinoffs from Washington University had received SBIR funds, followed by 12 from the University of Kansas System, 7 from Kansas State, 5 from the University of Missouri system, and 4 from St. Louis University. The SBIR program appears to have played an important role in supporting spinoffs from these universities.

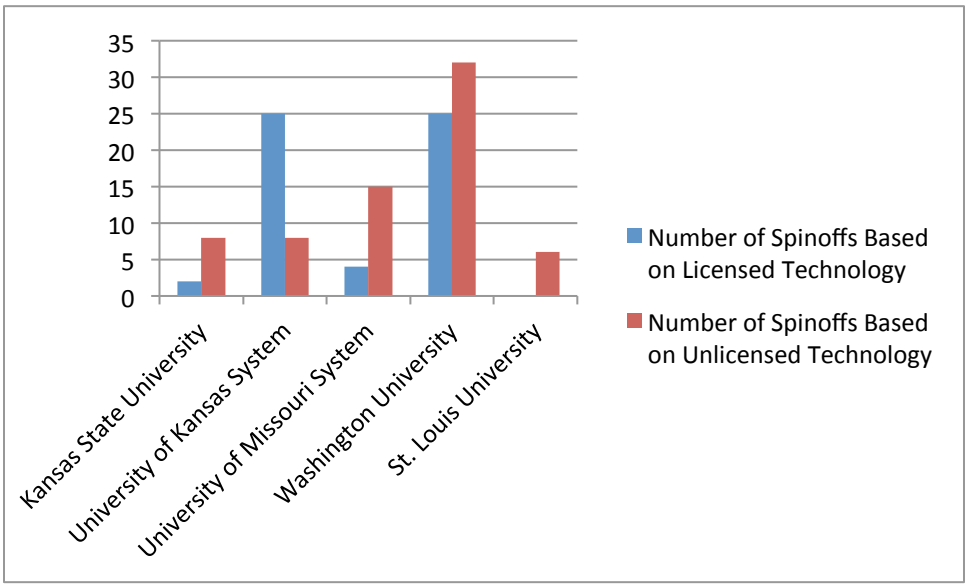
3f. The Role of Licensed Technology in University Spinoffs

As discussed above, the research universities in this study represent important sources of inventions in their respective states. Technology licensing by universities has become increasingly important to these institutions as they have attempted to expand their economic returns from academic research. In the case of public universities, this has occurred in conjunction with declining financial support from state governments. University spinoffs identified in this study were examined as to whether or not they were based on technology licensed from their respective universities. The list of spinoffs identified from each university was submitted to its respective technology licensing office for comment, which included a request to identify which spinoffs were based on technology licensed from the university. All universities in the study responded to this request with the exception of Saint Louis University. Figure 12 portrays the number of spinoffs from each K/M university that were based on licensed versus unlicensed technology.

These data indicate that the majority of spinoffs (55.2%) identified in the study were based on technology that was not licensed from a university. However, this percentage varied by university. Only at the University of Kansas system was the majority of spinoffs based on licensed technology. Here 25 of the 33 spinoffs (75.8%) were based on licensed technology. This was followed by Washington University, where 25 of the 57 (43.8%) of the spinoffs identified were based on licensed technology. Less than 20% of the spinoffs at each of the remaining universities

were based on licensed technology. In sum, with the exception of the University of Kansas system, spinoffs at the K/M research universities are more commonly formed using unlicensed technology.

Figure 12: Number of Spinoffs Based on Licensed Versus Unlicensed Technology by University*



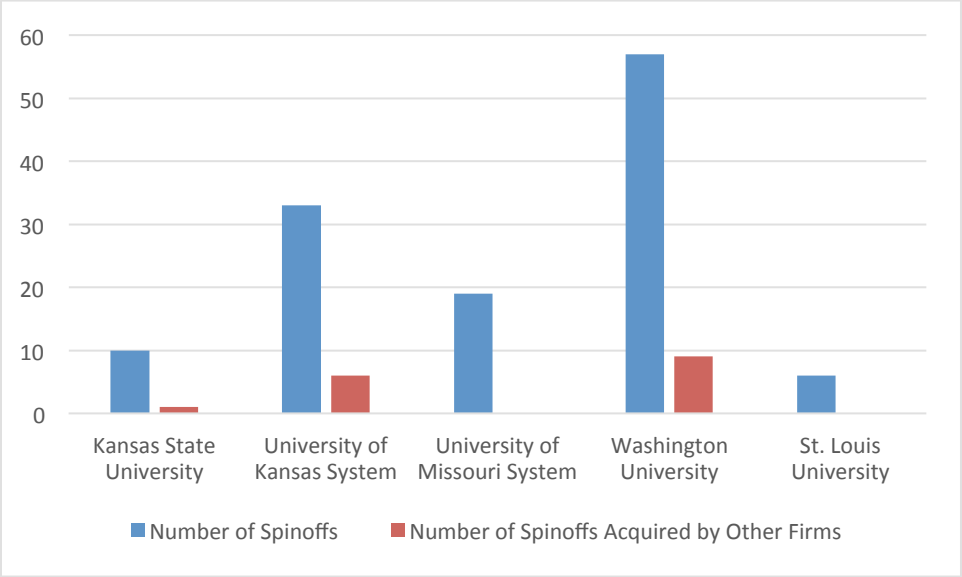
* We did not receive any information for St. Louis University regarding licensing status.

3g. Acquisition of University Spinoffs

One indicator that a university spinoff has either achieved some success in developing a market for its product and/or has shown strong potential for doing so is the acquisition of the spinoff by another established firm. Acquisition typically produces substantial economic returns for the owners of the spinoff. Data on whether the spinoffs identified at K/M research universities had been acquired by other firms were also collected. These results are portrayed in Figure 13. These results show that spinoffs had been acquired by other firms at three of the universities: Washington University, the University of Kansas system, and Kansas State University. At Washington University, 9 of the 57 (15.8%) spinoffs identified had been acquired by another firm

as of April, 2015 as compared to 6 of the 33 (18.2%) spinoffs from the University of Kansas system. One of the 10 spinoffs identified from Kansas State had been acquired while no spinoffs from the University of Missouri system and St. Louis University had been acquired. One caveat is that these data only include cases where the acquisition was publicized, either by the university, firm s involved, or the local business media. Acquisition deals that were not publicized are not included in these figures.

Figure 13: Number of Spinoffs from K/M Research Universities Acquired by Other Firms



3h. Geographic Location of Spinoffs

An important policy issue concerning the funding of public research universities has been whether the economic development effects that result, with spinoffs being one such effect, accrue to the state and/or the region in which the university is located. In other words, do university spinoffs

locate in the state and/or region in which the university is located, thereby providing new jobs, increasing spending, contributing to multiplier effects in the local economy and enhancing tax revenue? Or, do these effects leak out and accrue outside the state and/or region? This is an important issue, particularly in less developed states and/or regions which may lack the local presence of resources required to facilitate relevant forms of technology-based economic development (e.g. venture capital firms, legal expertise, labor with required knowledge or skills). Data on the location of spinoffs were collected with the results presented below.

Table 9: Location of Spinoffs from Kansas State University

Within Manhattan Metropolitan Area	8	80%
Outside Metropolitan Area, but Within Kansas	2	20%
Located in Another State	0	0

Kansas State University is a public university located in Manhattan, Kansas, which is a small metropolitan area consisting of 3 counties. The university also has branch campuses located in Salina, KS and Olathe, KS, a suburb of Kansas City. Eight of the 10 spinoffs identified at Kansas State were located in the Manhattan metropolitan area. The remaining 2 spinoffs were located in other metropolitan areas of Kansas.

Table 10: Location of Spinoffs from University of Kansas System

Within Metropolitan Areas of University Campuses	31	89%
Lawrence Metropolitan Area	(18)	55%

Kansas City Metropolitan Area	(13)	34%
Outside Metropolitan Areas, but Within Kansas	0	0
Located in Another State Excluding Missouri	2	11%

The University of Kansas is a public university, with the main campus located in Lawrence, KS, a metropolitan area consisting of a single county. It is located adjacent to the Kansas City metropolitan area, which consists of a 15 county area that extends across the borders of both Missouri and Kansas. The campus of The University of Kansas School of Medicine is located in Kansas City, KS. The university also operates three other campuses located in Overland Park, KS (a suburb of Kansas City), Wichita, KS and Salina, KS. The data in Table 10 indicate that of the 33 spinoffs identified as being affiliated with the university, 31 were found to be located in metropolitan areas in which the university has a campus. Broken down further, 18 of the spinoffs were located in the Lawrence, KS metropolitan area, while 13 were located in the Kansas City metropolitan area. While not displayed in the table, of the 13 spinoffs located in the Kansas City metropolitan area, 12 were located in Kansas while 1 was located in Missouri. Two of the spinoffs were located in states other than Kansas and Missouri.

Table 11: Location of Spinoffs from University of Missouri System

Within Metropolitan Areas of University Campuses	18	95%
Columbia Metropolitan Area	(14)	74%
Kansas City Metropolitan Area	(2)	5.5%
St. Louis Metropolitan Area	(2)	5.5%
Outside Metropolitan Areas, but Within Missouri	1	5%
Located in Another State	0	0

The University of Missouri is a public university with the main campus located in the Columbia, MO metropolitan area, which consists of a 3-county area in the central region of the state. The university operates three other campuses in Kansas City, MO (UMKC), St. Louis, MO (UMSL) and Rolla, MO (UM-Rolla). The data in Table 11 indicate that of the 19 spinoffs identified as being affiliated with the university, 18 were located within the metropolitan areas in which the university has a campus. Broken down by location, 14 were located in the Columbia metropolitan area, 2 were located in the Kansas City metropolitan area, and 2 were located in the St. Louis metropolitan area. While both the Kansas City and St. Louis metropolitan areas extend into another state, the spinoffs in these metropolitan areas were all located in Missouri, as was the one remaining spinoff that was not located in any of the metropolitan areas in which the university has a campus.

Table 12: Location of Spinoffs from Washington University

Within St. Louis Metropolitan Area	43	75%

Outside Metropolitan Area, but Within Missouri	0	0
Located in Another State	14	25%

Washington University is a private university located in the St. Louis metropolitan area, which consists of a 15 county area that extends across the Missouri and Illinois borders. The data in Table 12 indicate that 43 of the 57 (75.4%) spinoffs identified as affiliated with the university were located in the St. Louis metropolitan area. Of the remaining 14 spinoffs, all were located outside the state of Missouri. Interestingly, only 2 of these 14 firms had been acquired. This suggests that the majority of these firms had located out-of-state as a result of other factors. Further, the vast majority of the spinoffs from Washington University that had been acquired (7/9) maintained their location in the St. Louis metropolitan area.

Table 13: Location of Spinoffs from Saint Louis University

Within St. Louis Metropolitan Area	6	100%
Outside Metropolitan Area, but Within Missouri	0	0
Located in Another State	0	0

As indicated by its name, Saint Louis University is also located in the St. Louis metropolitan area. The institution is also a private university. The data in Table 13 indicate that all 6 of the spinoffs identified as affiliated with the university were located in the St. Louis metropolitan area and in Missouri.

In summary, these findings indicate that the economic development benefits from spinoffs from the K/M research universities predominantly accrue to the states and metropolitan areas in which the universities are located. This is true for virtually all of the spinoffs from the public research universities and predominantly true for the two private research universities.

3i. Spinoffs by Technological Area

One of the critical issues determining the success of a spinoff is whether a sufficient market can be developed for the product(s) being produced in conjunction with the funding stream that is available to operate the firm. Based on descriptions provided by the spinoffs, the primary product of each was classified into a set of technological areas. The number of spinoffs by technological area are displayed in Figures 14-19 below.

Figure 14: Number of Spinoffs by Technological Area for all K/M Research Universities

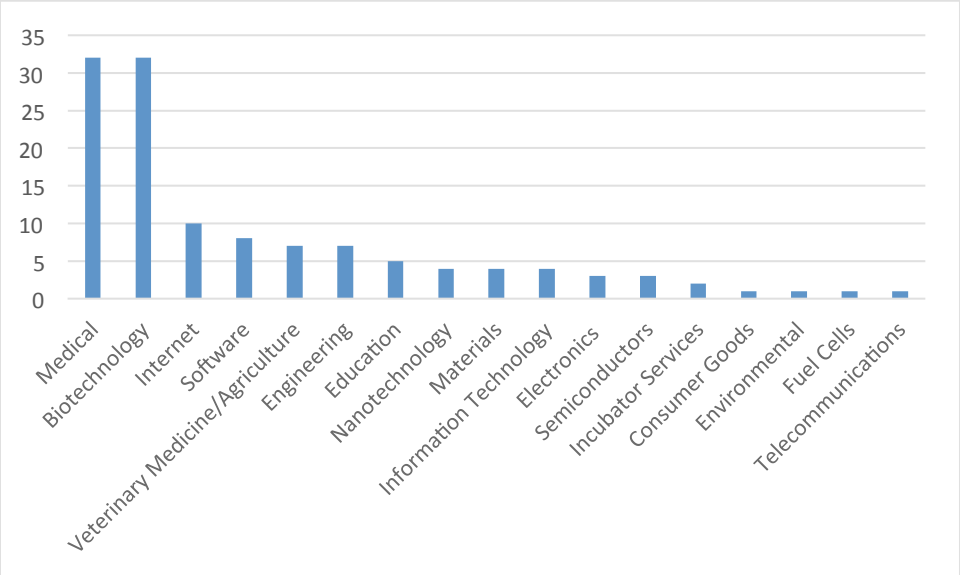


Figure 15: Number of Spinoffs by Technology Area for Kansas State University

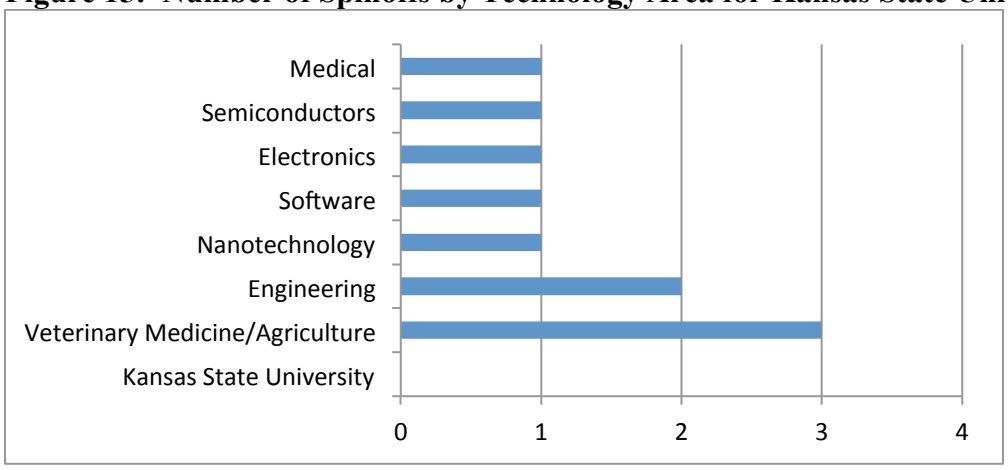


Figure 16: Number of Spinoffs by Technology Area for the University of Kansas System

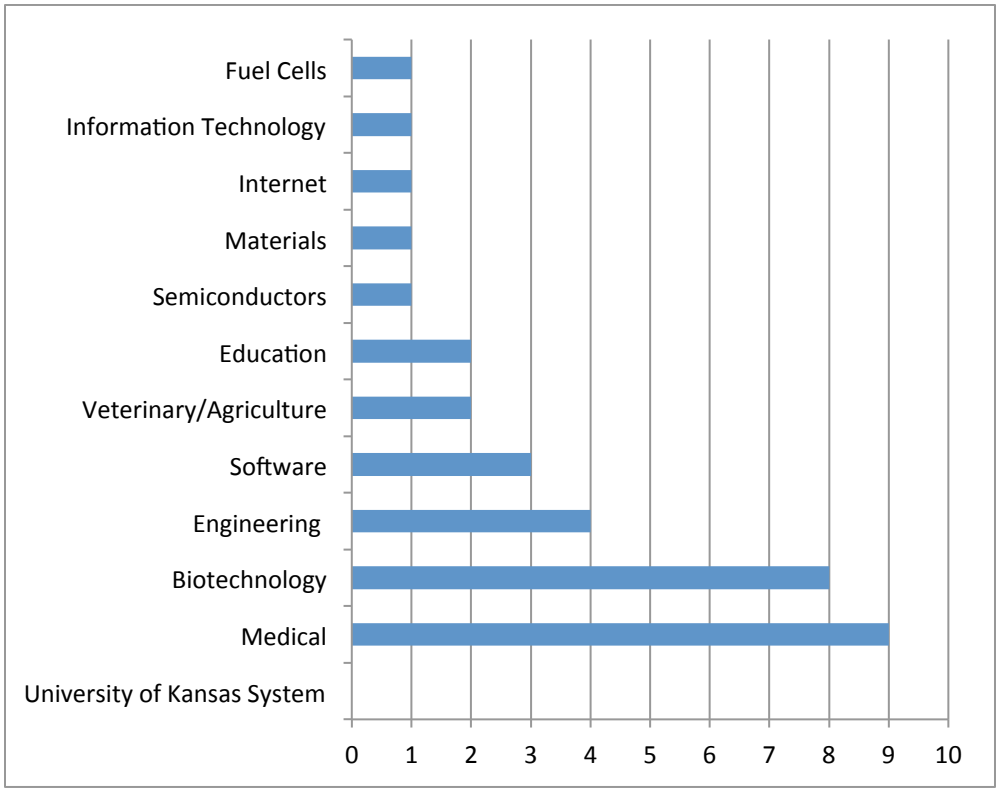


Figure 17: Number of Spinoffs by Technology Area for the University of Missouri System

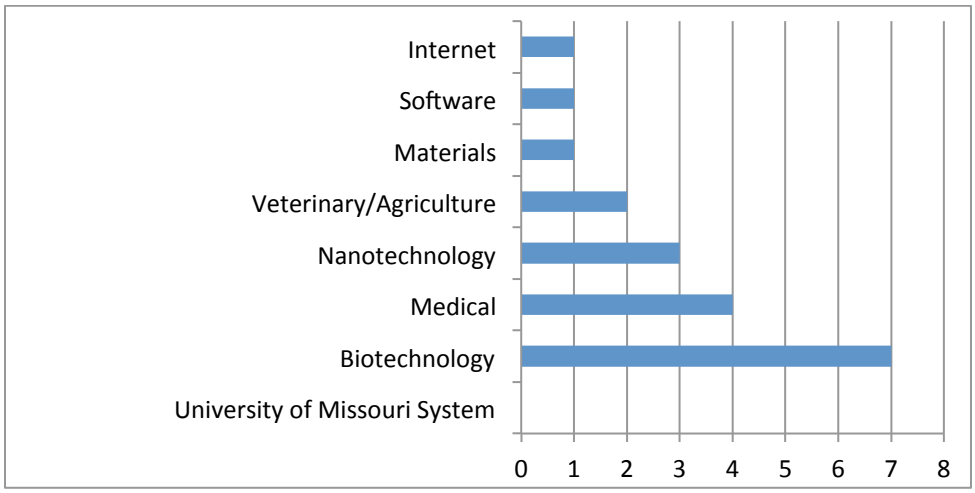


Figure 18: Number of Spinoffs by Technology Area for Washington University

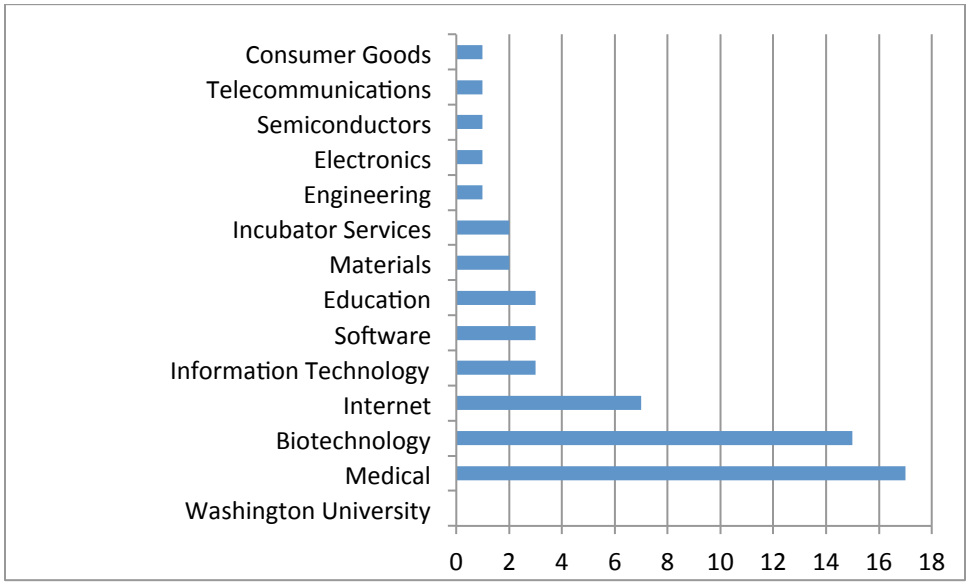
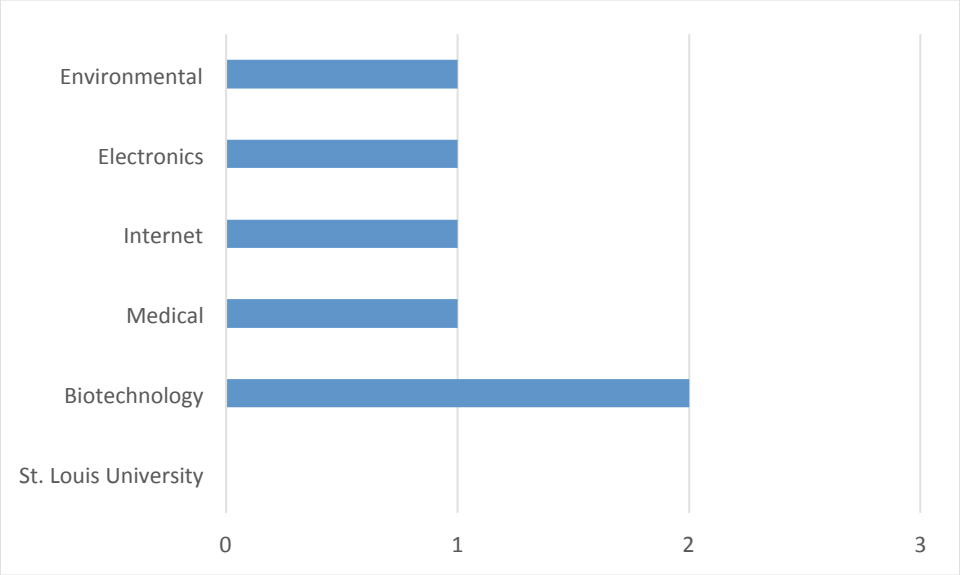


Figure 19: Number of Spinoffs by Technology Area for Saint Louis University



These data indicate that the most prevalent technological areas by far are medical technology (including instruments) and biotechnology (including support services). Spinoffs producing products in these technological areas are most prevalent at the two universities with the largest total number of spinoffs – Washington University and the University of Kansas system – as well as the University of Missouri system and Saint Louis University. The most prevalent technological area of spinoffs from Kansas State was in Veterinary Medicine/Agriculture. Other technological areas that were the focus of 5 or more spinoffs in the two state region included internet technology, software, engineering, veterinary medicine/agriculture and education, respectively.

4. Entrepreneurial Programs at K/M Research Universities

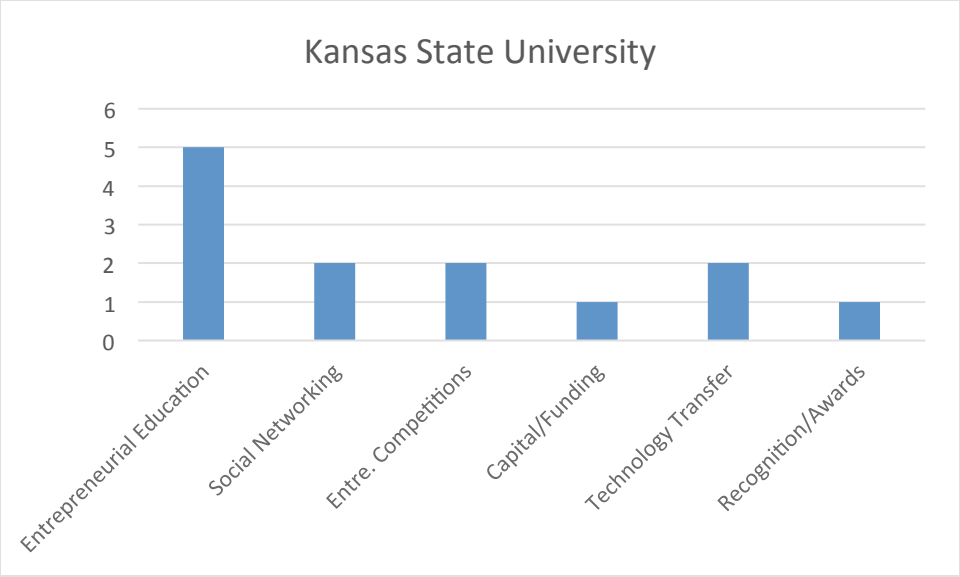
A total of 98 entrepreneurship-related programs were identified at the K/M research universities. These programs are listed in Appendix Table A4 and indicate that all K/M research

universities offer a range of programs and services designed to facilitate entrepreneurship. Broken down by type, 36 of the programs were in entrepreneurial education, 20 were entrepreneurial competitions, 14 were incubator facilities, 9 provided business networking, 8 provided technology transfer services, 6 provided capital/funding for business startups, 4 were awards/recognition programs for entrepreneurs, and 1 conducted research in entrepreneurship. The following discusses specific programs found at each of the K/M research universities.

4a. Entrepreneurship Programs at Kansas State University

A total of 13 programs related to entrepreneurship were identified at Kansas State University. Figure 20 lists these programs by type. The most frequent type of program was in entrepreneurial education. The College of Business Administration offers an undergraduate major and minor in entrepreneurship. The Advanced Manufacturing Institute offers the Technology Entrepreneurship Program, which is designed to educate graduate students in the commercialization of technology and formation of business startups. The College of Veterinary Medicine operates the Nanotechnology Technology Innovation Center, which assists faculty in the commercialization of nanotechnology. The College of Business Administration also offers several competitive programs. K-State Launch is a competitive program that provides cash awards for student business ideas. The Kansas Entrepreneurial Challenge and a statewide competition that provides cash awards for business ideas to entrepreneurs from Kansas High Schools and Kansas Board of Regents institutions. The College of Human Ecology annually presents the Entrepreneur Award to a graduate who has demonstrated success in entrepreneurship.

Figure 20: Entrepreneurial Programs by Type at Kansas State University



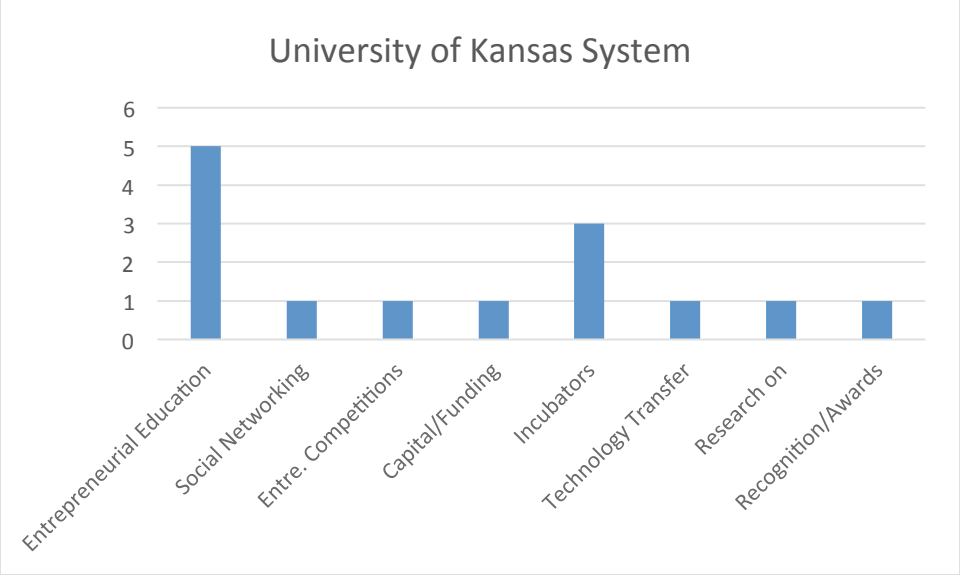
4b. Entrepreneurship Programs at the University of Kansas System

A total of 14 programs related to entrepreneurship were identified at the University of Kansas System. Figure 21 displays these programs by type. The most frequent type of entrepreneurial program concerned entrepreneurial education. The KU School of Business houses the KU Center for Entrepreneurship and offers a Concentration in Entrepreneurship to business majors. In addition, a Certificate of Entrepreneurship is offered to non-business majors. The KU Entrepreneurship Works for Kansas is a joint initiative of the KU Center for Entrepreneurship and the Institute for Policy & Social Research, whose purpose is to create and disseminate knowledge to facilitate entrepreneurship within the state. Both the School of Business and the School Engineering have student clubs that focus on promoting entrepreneurship.

The university operates 3 incubator programs – The Bioscience & Technology Business Center, which provides support services to bioscience and technology firms in northeast Kansas; The Catalyst, which provides support services to entrepreneurial efforts by students in the KU College of Business; and the Biotechnology Innovation and Optimization Center, which facilitates the commercialization of pharmaceutical and biomedical technology. The Institute for Advancing

Medical Innovation focuses on accelerating the transformation of basic medical research into innovative medical technology. Finally, the University of Kansas Innovation & Collaboration (KUIC) unit annually awards the Jim Baxendale Commercialization Award to recognize a KU researcher for excellence in entrepreneurship and commercialization.

Figure 21: Entrepreneurial Programs by Type at the University of Kansas System



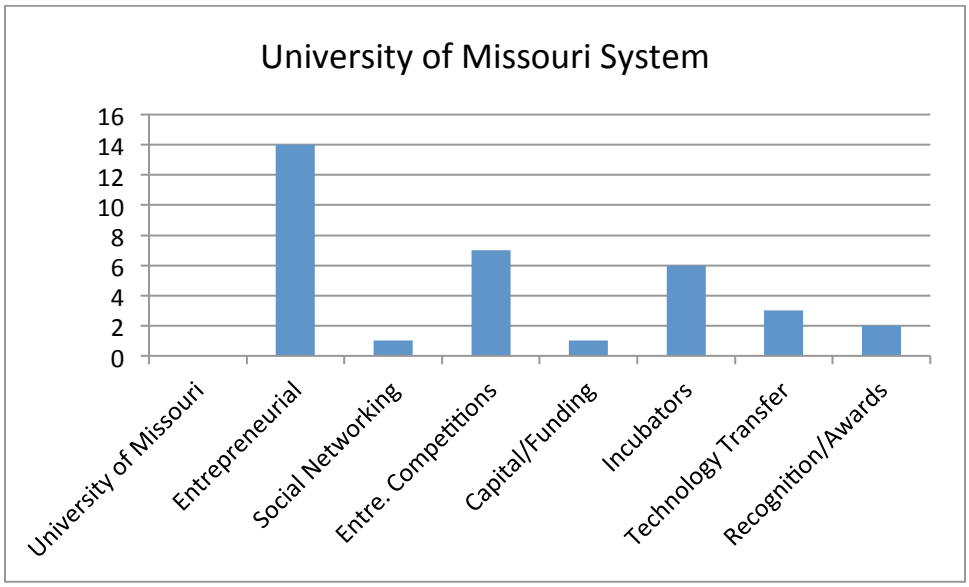
4c. Entrepreneurship Programs at the University of Missouri System

System-wide, the University of Missouri provides 34 programs related to entrepreneurship. Broken down, this includes 16 programs on the main campus in Columbia, 12 programs at UMKC, 3 programs at UM-St. Louis, and 3 programs that are system-wide in their operation. Figure 22 displays all of these programs by type. The most frequent type of program was in entrepreneurial education, followed by competitive entrepreneurial programs and incubators.

At the main UM campus in Columbia, a concentration in Entrepreneurship & Innovation Strategy is offered under the Management option in the Crosby MBA Program through the Robert J. Trulaske, Sr. College of Business. The Office of Undergraduate Studies offers an

undergraduate minor in Entrepreneurship for students in the Business School, the School of Agriculture, Food, and Natural Resources, and the School of Human Environmental Sciences.

Figure 22: Entrepreneurial Programs by Type at the University of Missouri System



The Entrepreneurial Alliance seeks to imbue students with further knowledge and skills in entrepreneurship and connections beyond what may be obtained through traditional coursework alone. The McQuinn Center for Entrepreneurial Leadership seeks to facilitate the entrepreneurial success of a new generation of farmers and ranchers. The BioDesign and Innovation Program and the Music Entrepreneurship Program seek to facilitate innovation and entrepreneurship in new medical technology and music, respectively. Incubator facilities operative on the main UM campus include the Missouri Innovation Center, the Life Science Incubator at Monsanto Place, and incubator facilities offered by the University of Missouri Research Reactor for firms that work with short-lived isotopes or produce radiopharmaceuticals.

At the UM campus in Kansas City (UMKC), the Henry W. Bloch School of Management offers an undergraduate concentration in entrepreneurship as part of the Bachelor of Business Administration major. A minor in entrepreneurship is also offered to non-business majors. The

school operates a Department of Global Entrepreneurship and Innovation, which consists of 7 full-time faculty, 1 adjunct faculty member, 1 instructor, and a Professor Emeritus. Housed within this department is the Regnier Institute for Entrepreneurship and Innovation, whose mission is to nurture entrepreneurship through education and research. Both MBA and Ph.D. degrees in Entrepreneurship are offered. In addition, an M.S. degree in Entrepreneurial Real Estate and an MBA degree with an emphasis in Entrepreneurship and Innovation with a concentration in Real Estate are also offered. The Entrepreneurship Scholars Program (E-Scholars) provides support, resources and mentoring to promising entrepreneurs needed to launch new business ventures.

Competitive awards programs for early stage ventures by students include the Regnier Venture Creation Challenge and the Roo Idea Jump Competition. Another program provides an annual scholarship to the student entrepreneur of the year. The Solo and Small Firm Incubator provides facilities for law firm startups by recent UMKC graduates of the School of Law. The Bloch School of Business also annually provides the Entrepreneur of the Year Awards to graduates who have become successful entrepreneurs. In addition, the school operates an Entrepreneur Hall of Fame to commemorate the success of its graduates.

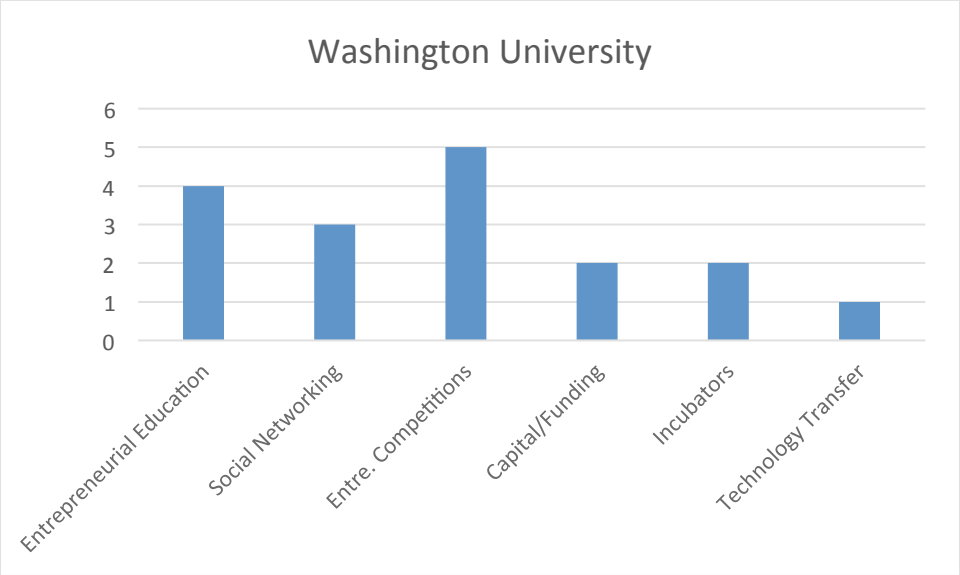
At the UM campus in St. Louis (UMSL), the School of Professional and Continuing Studies operates the Center for Entrepreneurship and Economic Education, whose mission is to contribute to the understanding of economics, personal finance, and entrepreneurship through education and outreach. UMSL is also a partner, along with Washington University, Saint Louis University and Missouri Botanical Garden, in the operation of the Cortex Innovation Community -- a district in St. Louis designed to attract and capture the benefits of university and regional corporate research through business development – and the Center for Emerging Technologies – an incubator facility operated within the district.

4d. Entrepreneurship Programs at Washington University

A total of 17 programs related to entrepreneurship were identified at Washington University. Figure 23 displays these programs by type. The most frequent type of program was entrepreneurial competitions, followed by entrepreneurial education and social networking, respectively.

The Olin Business School offers a major in Entrepreneurship as part of its BS degree in Business Administration. It also offers a second major in Entrepreneurship and a minor in Entrepreneurship for students in non-business majors. The full-time MBA program offers emphases in commercial entrepreneurship and social entrepreneurship. Washington University also operates the Skandalaris Center for Interdisciplinary Innovation and Entrepreneurship, whose mission is to provide "unique opportunities to learn and apply entrepreneurial skills through business plan competitions, intensive skills sessions, mentoring, [and] an internship program," among other initiatives.

Figure 23: Entrepreneurial Programs by Type at Washington University



The majority of the entrepreneurial competitions at the university are organized through the Skandalaris Center. This includes: (a) The YouthBridge Social Enterprise and Innovation Competition, which awards a student cash prize and provides grants and in-kind services to ventures that offer innovative approaches to address social problems or to enhance the sustainability and increase the capacity of mission-based organizations; (b) The Olin Cup competition, which awards seed capital for new companies; and (c) the Dutia and Grewal Global Impact Award, which provides a financial reward, mentorship, and other resources to "Washington University students, post-doctoral researchers or recent graduates who created scalable and sustainable ventures that have a large global impact."

Other competitive programs include the Discovery Competition, which provides cash awards to undergraduate engineering majors to turn their ideas into businesses, and the Bear Cub Fund, which provides competitive cash awards from the Office of the Vice Chancellor for Research to faculty to conduct "translational research," which will improve commercial licensing opportunities and/or investment potential. Washington University operates IDEA Labs, an incubator facility designed to support business startups in bioengineering, healthcare delivery, and clinical medicine. It is also affiliated with the aforementioned CORTEX Center for Emerging Technologies.

4e. Entrepreneurship Programs at Saint Louis University

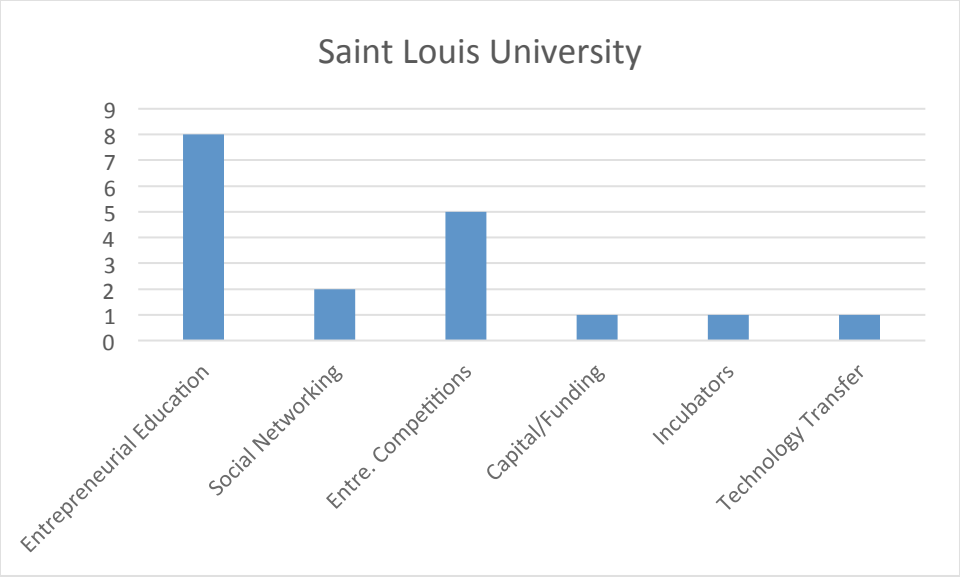
A total of 18 entrepreneurship-related programs were identified at Saint Louis University (SLU). Figure 23 displays these programs by type. The most frequent type of program was entrepreneurial education, followed by entrepreneurial competitions. SLU's John Cook School of Business offers an entrepreneurship concentration as part of the B.S. degree in Business Administration. Entrepreneurship is also offered as a "supporting area" in the curriculum for

students who select a different concentration area. The Cook School also operates the Center for Entrepreneurship, whose mission is "developing and delivering innovative programs to promote includes the Diamond in the Rough program, which provides training, mentoring and support to freshmen and sophomore students who own and run their own businesses and the Entrepreneurship Diplomate program, which provides workshops to promote entrepreneurial mindsets.

The Center for Entrepreneurship also offers a number of competitions, which include: (a) Idea to Product— students win cash awards for early stage ideas for products; (b) The Global Student Entrepreneur Awards – is a global level entrepreneurial competition in which SLU students may participate; (c) the Weekly Innovation Challenge – students win a cash prize for developing a solution to a business problem; (d) the Pure Idea Generator Challenge – students win a cash prize for developing a product idea that addresses a social problem or issue; (e) the "Real" Elevators Pitch program – students win cash awards for developing the best pitch for product ideas (for-profit and non-profit); (f) the Billiken Angel Network – a competitive program to allocate funds for businesses at any stage; and (g) the Bright Ideas Grant Program – provides cash grants to students for solutions to important social issues.

Programs in entrepreneurial education are also offered outside the business school. The Parks College of Engineering, Aviation and Technology provides a program in entrepreneurship and innovation as part of its curricula that receives funding from the Kern Family Foundation's Kern Entrepreneurship Education Network and the Coleman Foundation. This program includes the iScholars program -- a competitive program designed to promote an entrepreneurial mindset

Figure 23: Entrepreneurial Programs by Type at Saint Louis University



among engineering students – and the SPICE series, which brings in successful entrepreneurs as Health Sciences provides a concentration in Food Innovation and Entrepreneurship, which is designed to facilitate entrepreneurship in the culinary arts and dietetics.

4.f Summary

From our observation there does not appear to be a shortage of programs at these universities to encourage entrepreneurship. Programs appear to be operating in every part of the university that might conceivably be the home of potential entrepreneurs. While we believe it is unlikely, because of the criteria that we used in delineating spinoffs including the fact that we concentrated on technology-based entrepreneurial firms that were more than one- or two-person firms, it is possible that we missed some of the firms operating in these incubators and various programs.

5. Discussion & Conclusions

Before summarizing our key findings and drawing conclusions, it is important to begin with our caveats. We employed a rigorous search process to identify university spinoffs that met the

criteria to represent high potential entrepreneurship. We visited sites at these universities including incubators, technology licensing offices, entrepreneurship programs, and colleges of engineering and medicine searching for firms. We searched local newspapers and conducted internet searches on terms such as "Name of University", "Entrepreneur", "Founder", and "Startup." We also conducted a LinkedIn search for people that graduated from the K/M universities and "founder." This provided many "hits," but upon further examination, did not contribute toward identifying additional spinoffs beyond the other methods. Finally, with limited success, we sent our lists to various university officials asking for suggestions. Despite these steps, we recognize that our list of spinoffs is likely incomplete and that spinoff firms have been omitted. However, we also believe that the enumeration presented in this report is the best possible under the circumstances and given the difficulty of this objective.

It is also important also to emphasize that our database does not include spinoffs in non-technical fields. If the preponderance of entrepreneurship at the K/M research universities was/is not in high technology fields, then entrepreneurship at these universities is even more extensive than indicated by our database. The KSU stadium seat cushion startup mentioned earlier is an example of this possibility. As another example, we also identified a relatively successful cookie baking company spinoff from Washington University. However, our research did not discover a large number of such firms and we have little reason to believe that including non-technical spinoffs would change the results significantly.

This study identified 125 firms in high-technology fields that were de novo and met the criteria for employment size and affiliation with one of the K/M research universities. Overall, the research findings support a key finding from previous research that the number of university spinoffs is highly correlated with research excellence, particularly the employment of star scientists

by a university (Zucker and Darby 1996). By these terms, Washington University was the only K/M research university ranked in the top 50 of the Shanghai Jiaotong rankings, which heavily emphasizes the employment of Nobel prize winners and publication in highly prestigious journals such as *Nature* and *Science*. All the other K/M research universities in the study ranked outside the top 200 in these rankings. Using R&D funding as another indicator of research excellence, Washington University was in the top 20 of all U.S. universities in 2011, while KU and MU were in the top 100 and KSU was 114th. Supporting the finding of Zucker and Darby (1996), Washington University was found to have the largest number of spinoffs among the universities examined.

At the level of specialty fields, Life Science programs are the most highly ranked among the K/M research universities with Washington University being the overall leader, followed by Kansas State. Medical programs were also highly ranked fields at Washington University and the University of Kansas. As an indicator of research excellence in these areas, R&D funding at the K/M research is primarily concentrated in the Life Sciences as by classified by the National Science Foundation, which includes medical research. Accordingly, the greatest number of spinoffs from K/M research universities occurred in the biomedical sciences. Over 50 percent of the university spinoffs identified were in the areas of biotechnology (including support services) and medical technology (including instruments). In effect, the findings from this study suggest that the biomedical sciences are the comparative strength of the two-state region in terms of generating university spinoffs. Successful life science programs and medical schools have been central to the generation of spinoffs by research universities in the region, though the massive budget cuts to the Kansas university system may be stifling the continued generation of KU university spinoffs.

The importance of university spinoffs in these two areas are likely connected, either directly or indirectly, to broader economic development initiatives in two of primary locations in this study

– the St. Louis and Kansas City metropolitan areas. Bayham et al. (2007) discuss the initiatives and processes involved in the development of the St. Louis BioBelt as a high technology cluster in plant and life sciences. Each of the local research universities (Washington University, UM-St. Louis and Saint Louis University) contributed to this process. Mayer (2011) discusses the development of Kansas City as a life sciences region in which the University of Kansas has played a contributing role. In effect, the prevalence of university spinoffs in biotechnology and medical technology documented by this study can be viewed as representing one dimension of these broader developments.

While not strongly reflected in the spinoff data, another regional economic development initiative worthy of mention is the Kansas City Animal Health Corridor, an economic development region that stretches from Columbia, MO on one end through Kansas City to Manhattan, KS on the other end. While the numbers were small, spinoffs in veterinary medicine and agriculture were identified at Kansas State the University of Missouri-Columbia, which both have colleges of veterinary medicine, and the University of Kansas. This area was the most important source of spinoffs at Kansas State. Operated under the Department of Homeland Security, the National Bio and Agro-defense Facility (NBAF) – a national laboratory conducting research on animal diseases – is being relocated to Manhattan, KS in proximity to the Kansas State campus. It remains to be seen whether the presence of this lab will lead to more university spinoffs in related technological areas.

Previous research has indicated that engineering, in general, and electrical engineering & computer science, in particular, has been highly important in the generation of university spinoffs (see, for example, Agrawal and Henderson 2002; Kenney and Goe, 2004). An important finding from this study is that R&D funding in engineering is much lower at K/M research universities in comparison to other research universities and, in keeping with this fact, there are comparatively few

engineering spinoffs. We believe this has a significant negative impact upon university-derived entrepreneurship in K/M. However, the potential for engineering spinoffs can be seen in that more spinoffs were generated per R&D dollar in electrical engineering & computer science at K/M research universities compared to the biomedical sciences. Thus, improving the rate of engineering spinoffs could be addressed by policy that better balances support for the biological and medical sciences with support for engineering, especially electrical engineering and computer science.

When we consider other general criteria related to commercialization of research, the results are mixed, but may reflect the regional innovation ecosystems. In terms of patents, K/M universities are relatively important sources of patents for each state, but the numbers generated are still far below the larger, better-funded universities in the Midwest and on both coasts. Firms in St. Louis had by far the most SBIR grants, followed by firms in Lawrence, Rolla and Manhattan, respectively. Not surprisingly, these are all the locations of the universities we examined. In terms of venture capital, Missouri clearly received more investment than did Kansas, but neither state was significant in national terms. There was a total of $550 million of VC funds invested in the spinoffs from K/M research universities that were identified. However, $420.3 million of this total (76.5%) was invested in Washington University spinoffs. This was followed by $83.8 million (15.2%) invested in spinoffs from KU.

Washington University and the University of Kansas have performed better in spinoff generation than the other K/M research universities in several other respects as well. These two universities have not only generated the most spinoffs, but have consistently generated spinoffs over time. The other K/M research universities have either generated spinoffs sporadically and/or did not implement initiatives designed to generate them until the last decade. One surprising finding was that the University of Kansas was found to be the most productive in terms of

generating spinoffs per R&D dollar expenditure. These two universities also had the most spinoff firms acquired by other companies. While these two universities are the most successful in the region in terms of generating spinoffs, it is also important to examine their spinoff performance in a broader context. For example, as shown above, both universities significantly underperformed other larger Midwestern research universities such as UW-Madison in generating spinoffs.

It was found that high technology spinoffs at K/M research universities have predominantly been formed by university faculty. Only at Washington University did students form a substantial number of spinoffs. One possible explanation for this pattern is that student entrepreneurship at the other K/M research universities examined is concentrated in non-technical fields. Or, technology-based startups are formed by students after they are no longer affiliated with the university (1 year or more after graduation).

It was found that the majority of spinoffs identified were formed based on unlicensed technology. Only in the University of Kansas system were the majority of spinoffs based on technology licensed from the university. This, combined with the importance of university faculty in generating spinoffs, would suggest that with the exception of the KU system, K/M research universities are failing to capture a substantial share of the economic returns from commercializing faculty research, even though all employ a university ownership regime of faculty inventions. However, if the primary objective is to increase the revenue stream to the university, then it has been brought into question whether the university ownership regime is the most effective in promoting this goal. For example, Kenney and Patton (2011) found that a university that permitted inventor ownership generated more university spinoffs in comparison to five universities employing a university ownership regime. Kenney et al. (2014) found that at the University of California, successful spinoffs that were based on unlicensed technology and formed outside the purview of the

university technology licensing system can ultimately produce private donations to the university that are far larger in value than the revenue that could have been received from licensing. While the ownership of intellectual property developed by university faculty is an important issue, finding ways of further incentivizing entrepreneurship by faculty at the K/M research universities may increase the formation of spinoffs and increase the economic returns from research.

There has been significant political concern in the Midwest about the supposed fact that entrepreneurs and spinoffs are relocating out of state. Nonetheless, this research confirms what nearly all previous academic research has found -- namely startups begin and stay close to home and in these cases, in close proximity to the university from which they were spawned. In this respect, the economic development benefits of university spinoffs accrue to the cities and states in which the universities are located. This pattern was the strongest among the K/M public research universities, as Washington University had the greatest number of spinoffs that were located out of state. However, the acquisition of spinoffs was not a primary factor in the movement of these firms out of state.

It was found that all K/M research universities have well-developed systems for entrepreneurship. All K/M research universities have active technology transfer offices overseeing university intellectual property. Further, they offer a wide range of programs designed to educate, facilitate and promote entrepreneurship by faculty, students and other scientists on staff. These programs tend to extend across multiple colleges within the universities. The most common types of programs were in entrepreneurial education and entrepreneurial competitions. Considering these programs in relation to university spinoffs, a greater number of entrepreneurial programs did not necessarily translate into a greater number of university spinoffs. Of course, this does not take into account the quality of the programs, the personnel that run them, or the budgets and other resources

invested in them. The open question is whether these programs can ultimately help lead to a greater number of startup firms that become highly successful, whether or not such firms are university spinoffs as defined in this study?

In conclusion, the five Kansas and Missouri research universities examined in this study are all actively engaged in entrepreneurship as part of their current missions. Each university was found to have generated spinoff firms in technology fields with Washington University and the University of Kansas being the most successful. While the number of spinoffs generated by these universities is lower than other research universities located in the Midwest and on the coasts, this does not diminish the importance of the success that has been realized. Each university was found to be actively engaged in educating students about entrepreneurship and offering programs to facilitate and promote business formation by its constituents. In sum, entrepreneurship is a visible and important component in the mission of these institutions in promoting economic development.

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Appendix Table A1: Performance of K/M Research Universities in Academic Ranking of World Universities by Subject Fields

Washington University

Subject	2007	2008	2009	2010	2011	2012	2013	2014
SCI	Na	na	na	na	na	101-150	151-200	na
ENG	77-106	na	na	na	na	na	na	na
LIFE	22	24	24	23	30	31	33	27
MED	51-75	52-75	39	39	50	51-75	51-75	42
SOC	30	33	31	33	35	35	32	30

Kansas State University

Subject	2007	2008	2009	2010	2011	2012	2013	2014
SCI	Na	na	na	na	na	na	na	na
ENG	Na	na	na	na	na	na	na	na
LIFE	Na	na	na	na	na	151-200	151-200	na
MED	Na	na	na	na	na	na	na	na
SOC	Na	na	na	na	na	na	na	na

University of Kansas

Subject	2007	2008	2009	2010	2011	2012	2013	2014
SCI	na	na	na	na	na	151-200	151-200	na
ENG	na	na	na	na	na	na	na	na
LIFE	na	na	na	na	na	na	na	na
MED	na	na	na	na	na	101-150	101-150	151-200
SOC	na	na	na	na	na	101-150	101-150	151-200

University of Missouri, Columbia

Subject	2007	2008	2009	2010	2011	2012	2013	2014
SCI	na	na	na	na	na	151-200	151-200	na
ENG	na	na	na	na	na	na	na	na
LIFE	na	na	na	na	na	na	na	na
MED	na	na	na	na	na	na	na	na
SOC	77-104	77-107	76-100	76-100	na	101-150	101-150	101-150

Source: Shanghai Jiaotong University, Academic Ranking of World Universities

Appendix Table A2: Classification Categories for Spinoffs

R&D Categories:	Spinoff Categories:
Biomedical Sciences (BMS)	BMS
Life Sciences	Biotechnology
Psychology	Biotechnology support
Biomedical Engineering	Medical
	Medical instruments
	Veterinary/Agriculture
CS & EE	CS & EE
Computer Sciences	Internet
Electrical Engineering	Information technology
	Software
	Electronics
	Semiconductors
	Telecommunications
	Wireless telecom
	Wireless applications
	Networking
	Fiber optics
Engineering and Physical Sciences (EPS)	EPS
Physical Sciences	Engineering
Mathematics	Environmental
Environmental Sciences	Materials
All Engineering subfields except	Robotics
biomedical and electrical	Scientific instruments
	Fuel cells
	Photovoltaics
	Alternative fuels
	Nanotechnology
Other	Other
Social Sciences	Education
	Consumer goods
	Incubator services

Appendix Table A3: Technology Spinoff Firms by University

Kansas State							
Firm N = 10	**Industry Classification**	**Industry Class**	**Licensed Tech**	**VC**	**SBIR**	**Founding Type**	**Founding Year**
Agrenew Inc.	Veterinary/Agriculture	BMS			1	Faculty	1998
ICE Corporation	Electronics	CS&EE			1	Student	1973
Nacelle Therapeutics Inc.	Medical	BMS			1	Faculty	2000
Nanoscale Materials	Materials	EPS		1	1	Other	1995
Nitride Solutions	Semiconductors	CS&EE		1	1	Student	2009
NutriJoy	Veterinary/Agriculture	BMS	1	1		Faculty	2000
PepGel LLC	Veterinary/Agriculture	BMS			1	Faculty	2012
ScavengeTech	Engineering	EPS	1			Other	2005
Thunderhead Engineering	Engineering	EPS			1	Other	2001
Virtutecture	Software	CS&EE				Student	2013
			2	3	7		
St. Louis University							
Firm N = 6	**Industry Classification**	**Industry Class**	**Licensed Tech**	**VC**	**SBIR**	**Founding Type**	**Founding Year**
Akermin	Environmental	EPS		1	1	Faculty	2003
Antegrin Therapeutics	Biotechnology	BMS		1	1	Faculty	2012
Auxagen, Inc.	Medical	BMS			1	Faculty	2004
e-Tab	Internet	CS&EE				Student	2001
VirRx, Inc.	Biotechnology	BMS			1	Faculty	2002
Vivid Sky	Other	Other				Faculty	2003
			0	2	4		
University of Kansas							
Firm N = 33	**Industry Classification**	**Industry Class**	**Licensed Tech**	**VC**	**SBIR**	**Founding Type**	**Found Year**
360 Energy Engineers	Engineering	EPS				Student	2010
Admunex	Biotechnology	BMS	1		1	Faculty	2001
Arcademics Inc.	Software	CS&EE	1		1	Faculty	2007
BioComp Systems	Software	CS&EE	1		1	Other	1996
Cadstone, Inc.	Semiconductors	CS&EE	1			Student	2001
Cancer Survivorship Train	Medical	BMS	1			Faculty	2011
Casing Solutions	Engineering	EPS	1			Faculty	2011
Computerized Assessments	Education	Other	1			Faculty	2005
CritiTech, Inc.	Biotechnology	BMS	1	1	1	Faculty	1997
CyDex, Inc.	Biotechnology	BMS	1	1		Faculty	1993
DARcorporation	Engineering	EPS	1			Faculty	1991
Echogen Bio	Medical	BMS	1	1		Faculty	2010
eLearning Creations, Inc.	Education	Other	1			Faculty	2002
Flint Hills Scientific, LLC	Medical	BMS	1		1	Faculty	1995

HylaPharm	Biotechnology	BMS	1			Faculty	2010
IBT Laboratories	Medical	BMS				Faculty	1983
ImmuPep, Inc	Biotechnology	BMS	1			Faculty	2001
Likarda	Veterinary/Agriculture	BMS	1			Student	2012
Mencuro Therapeutics	Medical	BMS			1	Faculty	2010
NetGames USA	Software	CS&EE				Faculty	1998
Orbis Biosciences	Materials	EPS			1	Faculty	2008
Orion Bioscience	Biotechnology	BMS	1		1	Student	2012
Phlogistix LLC	Biotechnology	BMS				Faculty	2010
ProFusion, LLC	Internet	CS&EE	1	1		Faculty	1995
ProQuest Pharmaceuticals	Biotechnology	BMS	1		1	Faculty	1997
Pulse Aerospace	Engineering	EPS				Student	2011
Savara Inc.	Medical	BMS	1	1		Faculty	2007
TerraMetrics Agriculture	Veterinary/Agriculture	BMS	1		1	Other	1998
TVAX Biomedical Inc	Medical	BMS	1	1		Faculty	2004
TVN Systems, Inc.	Fuel Cells	EPS	1		1	Faculty	2000
Veatros, LLC	Information technology	CS&EE	1	1		Faculty	2002
Vince and Associates	Medical	BMS		1		Other	2001
XenoTech, LLC	Medical	BMS	1	1	1	Faculty	1994
			25	9	12		
University of Missouri							
Firm N = 19	**Industry Classification**	**Industry Class**	**Licensed Tech**	**VC**	**SBIR**	**Founding Type**	**Found Year**
Acousys Biodevices	Medical	BMS				Other	2011
Analytical Bio-Chemistry	Veterinary/Agriculture	BMS		1		Faculty	1968
Benson Hill Biosystems*	Biotechnology	BMS		1		Faculty	2012
Comparative Clinical Pathology	Biotechnology support	BMS				Faculty	2008
Electrotap, LLC,	Software	CS&EE				Student	2004
Elemental Enzymes	Biotechnology	BMS				Student	2011
Emerge Medical Solutions	Medical	BMS				Faculty	2007
Equinosis	Veterinary/Agriculture	BMS	1		1	Faculty	2007
EternoGen	Biotechnology	BMS	1			Faculty	2009
HLB Horizons	Materials	EPS				Faculty	2010
Katalyst Surgical	Medical instruments	BMS				Other	2010
Modern Meadow	Medical	BMS		1		Faculty	2011
Nanopartical Biochem Inc.	Nanotechnology	EPS	1		1	Faculty	2004
Nanos Technologies	Nanotechnology	EPS				Faculty	2009
Nanova Biomaterials	Biotechnology	BMS			1	Faculty	2007
NEMS/MEMS Workshop	Nanotechnology	EPS			1	Faculty	2004
Pep Pro Analytics	Biotechnology support	BMS	1			Faculty	2011
Sapentia Development	Internet	CS&EE				Student	2010
Tensive Controls	Biotechnology	BMS			1	Faculty	2009
			4	3	5		

Washington University							
Firm N = 57	**Industry Classification**	**Industry Class**	**Licensed Tech**	**VC**	**SBIR**	**Founding Type**	**Found Year**
AcuPlaq LLC	Medical	BMS	1			Faculty	2012
Admission Spy	Internet	CS&EE				Student	2009
Aerosol Control Technologies	Engineering	EPS	1			Student	2012
AGEIA Technologies Inc.	Software	CS&EE		1		Faculty	2002
AP Materials, Inc.	Materials	EPS	1		1	Faculty	1997
Apath, LLC	Medical	BMS	1		1	Faculty	1997
ARTA Bioscience, Inc	Biotechnology	BMS			1	Faculty	2010
Automation Kit	Software	CS&EE				Student	2012
Auxeris Therapeutics	Biotechnology	BMS	1	1		Faculty	2002
Benson Hill Biosystems*	Biotechnology	BMS		1		Faculty	2012
Betaversity	Incubator services	Other				Student	2013
Blendics	Semiconductors	CS&EE			1	Faculty	2007
C2N Diagnostics, LLC	Biotechnology	BMS	1		1	Faculty	2007
Cephalogics, LLC	Medical	BMS	1			Faculty	2007
Confluence Discovery Tech	Biotechnology	BMS				Faculty	2010
Confluence Life Sciences	Biotechnology	BMS		1	1	Faculty	2010
Cytotherapeutics, Inc.	Biotechnology	BMS	1	1		Faculty	1989
DNA Polymerase Technology	Biotechnology	BMS			1	Faculty	1999
Exegy, Inc.	Information technology	CS&EE	1	1		Faculty	2003
Farmplicity	Internet	CS&EE				Student	2013
Global Velocity, Inc.	Information technology	CS&EE	1			Faculty	2000
Green Envelope	Internet	CS&EE				Student	2008
Growth Networks Inc.	Telecommunications	CS&EE	1	1		Faculty	1998
Igenica, Inc	Medical	BMS	1	1		Faculty	2009
Kereos, Inc.	Biotechnology	BMS	1	1		Faculty	1999
Lifeline Technologies	Biotechnology	BMS	1		1	Faculty	1998
LipoMatrix, Inc	Medical	BMS				Faculty	1992
LogYourRun	Internet	CS&EE				Student	2006
Medexceed Medical Corp	Medical instruments	BMS				Student	2008
Medros, LLC	Medical	BMS	1		1	Faculty	2006
Megan Health, Inc.	Biotechnology	BMS	1	1	1	Faculty	1993
Metamason Web Studio	Internet	CS&EE				Student	2005
MetaPhore Pharmaceuticals	Medical	BMS		1	1	Faculty	1998
Mindfull Games	Education	Other				Faculty	2006
Mission Center L3C	Incubator services	Other				Other	2010
MMBiosensing LLC	Medical instruments	BMS				Other	2013
MOgene	Biotechnology support	BMS			1	Faculty	2004
Nanopore Diagnostics, LLC	Medical	BMS		1		Other	2012
Neurolutions	Medical instruments	BMS	1	1		Faculty	2008
Observable Networks	Information technology	CS&EE		1	1	Faculty	2011

Off Campus Media	Internet	CS&EE				Student	2006
Orion Genomics, LLC	Biotechnology	BMS	1	1	1	Faculty	1998
Particle and Coating Tech	Materials	EPS	1			Faculty	1994
PharmaMonde, Inc.	Biotechnology	BMS	1			Faculty	2004
Radialogica	Medical	BMS				Faculty	2011
Restorative Therapies, Inc.	Medical instruments	BMS	1			Faculty	2004
Retectix, LLC	Medical	BMS	1			Student	2010
Schoology	Education	Other		1		Student	2009
Sketch-a-Song	Software	CS&EE				Student	2013
Sparo Labs	Medical instruments	BMS				Student	2012
STS Technologies, Inc.	Electronics	CS&EE	1			Faculty	1993
Symblia	Internet	CS&EE				Student	2011
Tripos, Inc.	Medical	BMS	1	1	1	Faculty	1979
Vasculox	Medical	BMS	1	1	1	Faculty	2006
Virtual Nerd	Education	Other				Student	2008
YurBuds	Consumer goods	Other		1		Student	2008
ZyStor Therapeutics, Inc.	Biotechnology	BMS		1		Faculty	1997
			25	20	16		

* Benson Hill Biosystems was founded by both University of Missouri and Washington University faculty.

Industry Classes:

BMS: Biomedical Sciences

CS&EE: Computer Science and Electrical Engineering

EPS: Engineering and Physical Sciences

Founding Type:

Faculty: At least one of the founders was a faculty member of the university.

Student: At least one of the founders was a graduate student or undergraduate student, and none of the founders was faculty.

Other: At least one of the founders was associated with the university as a staff member, post doc, or researcher.

Appendix Table A4: Entrepreneurship-Related Programs by University

Kansas State University

Kansas Entrepreneurship Challenge	Competition	College of Business Administration
K-State Launch	Competition	College of Business Administration
K-State Launch a Business	Educational/Competition	College of Business Administration
Venture Accelerator	Networking	K State Center for the Advancement of Entrepreneurship
Wildcat Venture Fund	Funding/Networking	Department of Finance
K-State Olathe Innovation Accelerator	Networking	K State Olathe
Entrepreneur Award	Award	College of Human Ecology
Technology Entrepreneurship Program	Education	Advanced Manufacturing Institute
KSU Research Foundation	Education/Technology Transfer	Office of Vice President for Research
Office of Corporate Engagement	Technology Transfer	Office of Vice President for Research
Major and Minor in Entrepreneurship	Education	The College of Business Administration
Bioprocessing and Industrial Value Added Program	Technology Transfer/Incubator	Grain Science and Industry
Nanotechnology Innovation Center (NICKS)	Education	College of Veterinary Medicine

University of Kansas System

University of Missouri System

University of Missouri-Columbia		

Bioscience and Technology Business Center	Incubator	Bioscience and Technology Business Center
RedTire	Network	KU School of Business
The Catalyst	Incubator	Bioscience and Technology Business Center /KU Center for Entrepreneurship
Venture Fund	Funding	University of Kansas Innovation and Collaboration
Global Entrepreneurship Week Competition	Competition	School of Business
The Biotechnology Innovation and Optimization Center	Incubator	The Biotechnology Innovation and Optimization Center/ KU Center for Research
Institute for Advancing Medical Innovation	Research	Institute for Advancing Medical Innovation
KU Center for Entrepreneurship	Education	KU School of Business
KU Entrepreneurship Works for KS Initiative	Education	KU Center for Entrepreneurship
E Club of KU	Education	School of Engineering
KU Innovation & Collaboration (KUIC)	Technology Transfer	KU Innovation & Collaboration (KUIC)
Jim Baxendale Commercialization Award	Award	KU Innovation & Collaboration (KUIC)
KU Small Business Development Center (KU-KSBDC)	Education	School of Business
KU Entrepreneurship Club	Education	School of Business

Entrepreneurship Alliance	Education	College of Business
Allen Angel Capital Education Program	Education	College of Business
Life Science Business Incubator at Monsanto Place	Incubator	Missouri Innovation Center
McQuinn Center for Entrepreneurial Leadership	Education	College of Agriculture, Food and Natural Resources
Missouri Innovation Center	Incubator	Office of Research and the Trulaske College of Business
Coulter Translational Paternership	Capital	Department of Bioengineering
Collaboration-Leadership-Innovation for Missouri Businesses	Education	University of Missouri- Student Org.
CLIMB Seed Grant Competition	Competition	CLIMB- Student Org.
BioDesign and Innovation Program	Education	School of Medicine
Music Entrepreneurship	Education	Department of Music
Minor in Entrepreneurship	Education	Office of Undergraduate Studies
Office of Technology Management and Industry Relations (OTMIR)	Technology Transfer	Office of Economic Development
MBA program for Management	Education	Robert J. Trulaske, Sr. College of Business
Entrepreneurial Program	Competition	MU Student Union
University of Missouri Research Reactor (MURR)	Incubator	University of Missouri Research Reactor (MURR)
Graduate Certificate in Life Sciences Innovation & Entrepreneurship	Education	Institute for Clinical and Translational Sciences
University of Missouri-Kansas City		
Roo Idea Jump Competition	Competition	Regnier Institute for Entrepreneurship and Innovation
Regnier Venture Creation Challenge	Competition	Regnier Institute for Entrepreneurship and Innovation
E-Scholars Program	Educational	Regnier Institute for Entrepreneurship and Innovation
Student Entrepreneur of the Year	Competition	Regnier Institute for Entrepreneurship and Innovation
Entrepreneur of the Year	Award	Henry W. Bloch School of Management
New Entrepreneur Hall of Fame	Museum	Henry W. Bloch School of Management
Master of Entrepreneurial Real Estate (M.E.R.E.)	Education	Henry W. Bloch School of Management
Regnier Institute for Entrepreneurship and Innovation at the Henry W. Bloch School of Management	Education	Henry W. Bloch School of Management
Entrepreneurs in Residence	Network	Regnier Institute for Entrepreneurship and Innovation
Solo & Small Firm Incubator	Incubator	UMKC School of Law
Office of Technology Commercialization	Technology Transfer	Office of Technology Commercialization
UMKC Innovation Center	Education	UMKC Innovation Center
University of Missouri-St. Louis		

CORTEX Center for Emerging Technologies	Incubator	
Center for Entrepreneurship & Economic Education	Education	School of Professional and Continuing Studies
Office of Research Administration	Technology Transfer	Office of Research Administration
University of Missouri Systemwide		
Student Entrepreneur of the Year	Competition	
Faculty Entrepreneur of the Year	Competition	
Research Parks and Incubators	Incubator	

Washington University

Discovery Competition	Competition	School of Engineering and Applied Sciences
YouthBridge Social Enterprise and Innovation Competition (SEIC)	Competition	Skandalaris Center for Entrepreneurial Studies and the YouthBridge Community Foundation
Olin Cup	Competition	Skandalaris Center for Entrepreneural Studies
IdeaBounce	Networking	Skandalaris Center for Entrepreneural Studies
Student Entrepreneurial Program	Education	Student Involvement and Leadership
BioEntrepreneurship Core	Networking	
Arch Grants	Funding	
Bear Cub Competition/Fund	Competition/Fund	Office of the VC of Research
Biogenerator	Funding	Office of Technology Management
CORTEX Center for Emerging Technologies	Incubator	
Skandalaris Center Internship Program	Internship/Education	The Skandalaris Center for Interdisciplinary Innovation and Entrepreneurship
The Hatchery (Business Planning for New Enterprises)	Education	The Skandalaris Center for Interdisciplinary Innovation and Entrepreneurship
Global Impact Awards	Competition	The Skandalaris Center for Interdisciplinary Innovation and Entrepreneurship
Office of Technology Management (OTM)	Technology Transfer	Office of Technology Management (OTM)
Entrepreneurship and Venture Capital Association	Club/Networking	Olin Business School
Olin Business School	Educational	Olin Business School
Idea Lab	Incubator	Office of Technology Management (OTM)

Saint Louis University

Idea to Product (I2P)	Competition	Center for Entrepreneurship
Global Student Entrepreneur Awards	Competition	Center for Entrepreneurship
Bright Ideas Grants	Scholarship/Competition	Center for Entrepreneurship
Weekly Innovation Challenge	Competition	Center for Entrepreneurship
Diamond in the Rough	Education	Center for Entrepreneurship
Entrepreneurship Diplomate	Education	Center for Entrepreneurship
Pure Idea Generator Challenge	Competition	Center for Entrepreneurship
Real Elevator Pitch Competition	Competition	Center for Entrepreneurship
iScholars Program	Education	Parks College of Engineering, Aviation and Technology
CORTEX Center for Emerging Technologies	Incubator	Innovation Hub
Office of Technology Management Home	Technology Transfer	Office of Technology Management Home
Entrepreneurship Concentration	Education	John Cook School of Business
Billiken Angel Network	Competition	
Collegiate Entrepreneurs Organization	Network	Center for Entrepreneurship
Saint Louis University Technology Transfer Endowment Fund	Capital	Center for Entrepreneurship
Mentor-In-Residence program	Network	Center for Entrepreneurship
Food Innovation and Entrepreneurship (FIE) curricular concentration	Educational	Doisy College of Health Sciences
Speakers Pioneering Innovation, Creativity and Entrepreneurship (SPICE)	Educational	Parks College of Engineering, Aviation & Technology