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Innovation and US Engineering School Ranking

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ABSTRACT:

An association between the national ranking of a graduate school in engineering and innovation is investigated by product moment analysis and Spearman correlation coefficients. This paper combines school statistical data used in the national ranking with data normally associated with innovation, e.g., the college's number of patents, licenses and startups, to determine if there is some correlation between these factors and if so, to what extent there is a relationship. We determine the product moment and Spearman correlation coefficients between the ranking data and the innovation data from the top twenty five engineering schools in a recent USNWR ranking (2006). We find that disclosures of discoveries and inventions show a stronger relationship with innovation than ranking. Further, school ranking shows a more significant relationship with enrollment and research expenditures than with innovation parameters. We conclude that the subjectivity input into school ranking may not take into account a school's contribution to innovation and the creation of intellectual property, two attributes that are more closely aligned with the national priorities of business creation and economic development.

Keywords: Innovation, Engineering School Ranking, Economic Development.

1.INNOVATION & GLOBAL COMPETITIVENESS

Nations have made investments in scientific and engineering research for several reasons, the most important of which may be the creation of competitive advantage through innovation in one or more of the drivers of the modern world economy. Innovation can be realized in the technology of new material, process or integration of known components that results in an invention or discovery of economic value. Paraphrasing George Heilmeier, former CEO of Bellcore, innovation is technology measured in economic value. Although there may be some disagreement as to today's principal economic driver, some authors (Brownlie, 1992), (Thurow, 1999), (Larson, 2005) believe that technology and its realization in new knowledge or skills constitute the only sustainable advantage that a company or a country could have.

Innovation has been widely acknowledged as being a key factor to a country's global competitiveness, especially in today's knowledge economy. For that reason alone, there has been a surge of interest in determining how technology research contributes to innovation, especially when public funds are used to sponsor the research. Since innovation implies an economic value associated with the discovery or invention, U.S. graduate schools in engineering have been a major contributor to innovation in the country, if not the world. For it is in engineering schools that problem-solving is taught as a strategic mission, where economic value is linked to the methodology of resolution and in whose classes the urgency of time, money and effort are real constraints to success. Engineering students are often teamed up with medical professionals, chemists, biologists and other researchers in the physical and natural sciences to work on practical problems that lead to innovation. Graduate engineering schools are using the national ranking provided by the US News and World Report (USNWR) magazine as a marketing tool for attracting top quality students, faculty members and research grants. Although the national ranking by the magazine is determined by some factors such as peer opinion that are clearly subjective, there are other factors that are more deterministic that contribute to the ranking.

2. RANKING AN ENGINEERING SCHOOL

Engineering schools fiercely compete for excellent students by showing off their academic credentials for the last year, such as the number of: (a) faculty members who became fellows; (b) journal publications and books published; (c) grants and their aggregate expenditure; (d) graduate degrees awarded. Many of these credentials are also used to attract new faculty members, many of whom are often not much older than the student applicants. Recent cutbacks in foreign student availability, federally funded grants, and state subsidies to public universities have intensified this competition in recent years. Although these metrics listed above are quantitative, it is difficult to assimilate the multidimensional data and compare it to that of other schools. Indeed, one yearns for a single metric that aggregates that data and more and relates it globally among all schools. That is the appeal of the national ranking provided by US News and World Report (USNWR). With one number, the student or young faculty member knows where the school stands. A top ranked school often seizes on the opportunity and its ranking becomes a powerful recruiting tool.

However, of regional and national importance is the capacity of a graduate engineering school to create intellectual property and assist in economic development through technological innovation. Although general research in technology is undisputedly a beneficial outcome from an engineering school, the faster a discovery or an invention from that school can be commercialized, the better for its financial picture and for the region it serves. Innovation at a university is generally measured by "disclosures" from its faculty, namely the results of research leading to what appears a patentable and possibly licensable technology. From a percentage of disclosures come patent filings which add to the list of licensable technologies from the university's tech transfer office. A discovery or invention from a university does not become an innovation until its commercializability is manifested in a license agreement and significant royalties result from the agreement. From the 2007 edition of USNWR that ranked graduate schools (USNWR, 2006), we have listed the top twenty five engineering graduate schools from which their universities have made available innovation data such as patent licensing income, number of patents issued, number of start-ups, etc.(AUTM, 2004) Although this data is university-wide, engineering schools often contribute significantly to the university research revenue, an important factor in innovation. For the twenty five schools in this study, the engineering school's contribution ranged from a high of 63% at Carnegie Mellon to a low of 3% at Johns Hopkins. (average was 26%)

3. INNOVATION PROCESS

The university tech transfer process resulting in an innovation starts *first* with the identification stage whereby it is recognized that the technology in question does indeed have commercial value. The *second* stage is the determination of how much more work is required before a product or service can be derived from the technology. *Third*, a business concept needs to be developed by which the product or service can generate a sustainable business. *Fourth*, a management team needs to refine the business concept into a business plan which can be funded by professional investors. Finally, armed with a viable business plan, funding is sought to complete the commercialization (or tech transfer) process through a "start-up" company. Alternatively, the technology can be licensed to a third party by the university at any one of the stages after the identification phase. Of course, the more developed the technology, the higher royalty it can command.

4. UNIVERSITIES AND INNOVATION

Under the Bayh-Dole Act of 1980, universities have been given ownership of the intellectual property generated from research performed with funds from both federal and private sources. (Bayh-Dole, 1980) Although universities have been only modestly successful in tech transfer since Bayh-Dole, they still represent the largest number of organizations that specialize in research contract work that can lead to innovation.

An American university typically manages its intellectual property through a tech transfer (TT) office whose first job is to generate royalty income. The nature of licensing transactions usually requires proof of ownership and coverage of technology furnished through an instrument such as a US patent. The deeper and broader the "coverage" in the patent claims, the more valuable it can be for the licensee. (Salazar, 2005) However, if the technology is in a "raw" form that will require substantially more development and testing before it can be commercialized, the less valuable it can be for the licensee. A few universities have generated enviable income from their patents but most tech transfer offices are simply cost centers, namely having more expenses than income. The statistics, although skewed by the few successful universities, indicate that tech transfer at universities is worth supporting for economic development reasons. (AUTM, 1999) For example, start-up companies based around university intellectual property have helped the nation's effort to create new businesses which have led to regional and national economic growth. (Jamison & Jansen, 2001)(Nelson, 1996) Incentives presented to faculty and students to generate more IP have generally produced higher returns for universities. (Lach & Schankerman, 2003)

There have been numerous studies that indicate that universities can be made more efficient in tech transfer by collaborating more with industry. (Berneman, 2003)(Casey, 2004) Only about 7% of research funding at universities on average comes from commercial or industrial sources (Salazar & Kumar, 2004). Other countries have taken a different approach in promoting collaboration between industry and academia. (Garduno, 2004) A number of countries have adopted what is known as the "triple-helix" approach characterized by a fusing of goals and functions of the three main organizational types involved in research and development; namely, government, universities and industry.(Kaukonen & Nieminen, 1999) (Leydesdorff & Etzkowitz, 1998) (Etzkowitz & Leydesdorff, 1998) In this case, government is the funding source but industry is welcomed as a major player in the creation of intellectual property in academic settings.

5. INNOVATION DATA

Tech transfer offices at US major universities are members of AUTM – Association of University Technology Managers – an organization that publishes annual results concerning the intellectual property being created from university research at members' institutions. Table 1 lists selected annual parameters available from twenty five top ranked (USNWR) universities who subscribe to AUTM services and report the following – total research expenditures, number of disclosures, patents filed, licenses executed, licensing revenue, patents issued and finally, the number of start-ups or spin-outs from university intellectual property. Table 1 also lists USNWR data for the year 2006 including the engineering school rank, acceptance rate of graduate students, total engineering enrollment, percentage of international students, engineering school research expenditures, total university research expenditures. The following data is for the year 2004 and was filed with AUTM: no. of disclosures, patents filed, license executed, licensing revenue, patents issues and no. of startups. (Note: the AUTM data includes both UI-Urbana/UI-Chicago data.)

	Rank	Acc. Rate	Enroll	% intl	E. Res $M	Res. $M	Disc.	Pat. F	Lic exec	Lic $M	Pat. Iss	Startups
MIT	1	25.3	2708	40.4	224.8	1027.0	515	287	134	25.8	159	20
Stanford	2	35.7	2501	49.9	142.7	693.5	350	428	89	47.3	87	9
Ga Tech	4	33.8	2964	54.4	202.2	446.7	277	273	35	2.3	41	15
UI-Urbana*	5	19.9	2446	48.2	195.8	813.7	262	108	88	5.8	59	16
Purdue	6	36.5	1815	62.4	211.6	394.5	208	123	87	4.1	29	3
UM-Ann	6	42.2	2126	50.6	157.4	752.5	285	149	73	10.6	74	13
Carnegie	8	24.8	1376	55.5	142.3	225.0	95	50	21	4.6	52	4
USC	9	48.5	2195	75.1	157.4	421.0	127	88	61	3.2	29	7
Calif IT	10	10.9	577	48.1	51.2	388.9	549	416	45	9.9	142	14
Cornell	11	22.4	1234	48.7	112.2	537.7	225	89	80	7.2	53	6
UT-Austin	13	28.5	1605	55.0	106.9	343.9	87	41	23	5.0	36	5
U Maryld -CP	15	24	1395	64.8	145.3	288.0	109	40	41	0.9	22	5
UW-Mad	15	21.1	1249	49.6	123.2	764.0	405	163	203	47.7	93	2
Penn State	19	34.1	1410	61.8	121.0	607.0	167	125	23	1.9	46	4
Harvard	21	12.8	290	45.5	33.1	591.0	160	73	50	16.7	35	4
JohnsHop	21	18.3	691	50.6	53.2	1595.0	367	402	100	6.3	89	5
Northwest	21	25.1	995	40.6	78.2	355.0	137	139	21	1.5	18	1
U Wash	21	34.5	1130	35.2	91.8	834.0	233	104	70	22.8	38	7
U Florida	26	53.6	2041	50.4	92.1	428.0	278	233	64	37.4	53	8
U Minn	28	40.3	1155	55.4	63.1	515.0	224	83	100	46.6	38	3
Rice	29	21.6	521	49.3	33.1	70.0	55	125	4	0.1	18	3
Duke	30	26.6	511	44.0	55.4	492.0	127	38	51	3.8	32	10
VaTech	30	26.7	1817	35.0	56.1	129.0	120	93	24	2.7	27	6
Penn	32	31.4	1036	54.0	47.1	654.0	392	536	87	8.6	45	6
NC St	33	25.6	1377	54.2	93.0	293.0	176	112	72	4.8	46	4

Table 1: Top 25 Engineering Schools with AUTM Tech Transfer Data
(Note: Top 25 means the 25 highest ranked schools that report AUTM data)

6. RELATIONSHIP OF FACTORS THROUGH CORRELATION

The data in Table 1 was used to determine both the product moment (PM) and the Spearman correlation coefficients between the engineering school ranking and 11 other parameters. The PM correlation coefficient matrix is shown in Table 2 while the Spearman coefficient matrix is shown in Table 3. The highest PM correlation between school ranking were two parameters – students enrolled (-0.62) and engineering research expenditures (-0.81). The negative signs indicate that the ranking is high, i.e. a low number, when either of the two parameters increases. One possible inference from this relationship is that the more students there are in the program and the more research dollars are available in the program, the more publicity the program will receive on the outside. Hence, it is possible that more people will talk about the program if more activities and more students are involved in the program. Both of these parametric PM correlations are larger in magnitude than the innovation parameters – patents issued (-0.46) and startups (-0.53). Although large engineering schools get higher USNWR rankings, there is only a moderate PM correlation of school rank to the innovation parameters.

Disclosures, not school rank, is indeed, the driver for many innovation parameters, having high PM correlation with patents issued (0.88), patent filed (0.78), licenses executed (0.65), start-ups (0.55). All of these values are significant at probability of 0.01. Interestingly, besides disclosures the parameter of start-ups has relative high correlation with students enrolled (0.56) and patents issued (0.61), both relationships significant at probability of less than 1%.

	Rank	*Accept*	*Enroll*	*Intl*	*Res.exp*	*Tot res*	*Disc*	*Pat file*	*Lic ex*	*Lic inc*	*Pat iss*	*Start*
Rank	1.00											
Accept	-0.02	1.00										
Enroll	-0.62	0.51	1.00									
Intl	-0.21	0.37	0.18	1.00								
Res.exp	-0.81	0.29	0.83	0.32	1.00							
Tot res	-0.22	-0.10	0.07	-0.18	0.13	1.00						
Disc	-0.32	-0.14	0.18	-0.22	0.16	0.59	1.00					
Pat file	-0.10	-0.04	0.10	-0.09	-0.08	0.45	0.78	1.00				
Lic ex	-0.26	-0.05	0.20	-0.09	0.31	0.62	0.65	0.32	1.00			
Lic inc	0.07	0.29	0.06	-0.08	-0.08	0.19	0.31	0.10	0.34	1.00		
Pat iss	-0.46	-0.26	0.20	-0.23	0.23	0.53	0.88	0.57	0.57	0.22	1.00	
Start	-0.53	0.00	0.56	-0.22	0.48	0.30	0.55	0.33	0.19	-0.07	0.61	1

Table 2: Product Moment Correlation Matrix – Top 25 Engineering Schools

The Spearman or "rank" correlation coefficients are computed from Table 1 data that is transformed into ranking for all observations. For example, the engineering school that had the highest licensing income was assigned the number one rank, the second highest school was number two, and so on. Spearman coefficients are used for relationship detection when the observational data may be skewed or have large values that may distort the PM calculations. In the case of the Table 1 data, the Spearman coefficients are similar in value to the PM coefficients. For the USNWR rank, both enrollment (0.61) and research expenditures (0.78) are significant at the 1% level while patents issued (0.41) and start-ups (0.40) have lower values but are still significant at the 5% level. Under the Spearman coefficient method, the USNWR rank is still more strongly related to the same two characteristics: size of engineering school and its research expenditures. We conclude that although there is a moderate relationship between the USNWR rank and the school's innovation parameters of patents issued and start-ups, it is likely that the school's ranking is more determined by the school size and the aggregate research grants and contracts it is able to obtain.

	Rank	*accept rk*	*enroll rk*	*Intl rk*	*res.exp rk*	*tot res rk*	*Disc rk*	*pat file rk*	*lic ex rk*	*lic inc rk*	*pat iss rk*	*start rk*
Rank	1.00											
accept rk	-0.01	1.00										
enroll rk	0.61	-0.51	1.00									
Intl rk	0.16	-0.37	0.27	1.00								
res.exp rk	0.78	-0.34	0.84	0.38	1.00							
tot res rk	0.27	-0.02	0.11	-0.23	0.17	1.00						
Disc rk	0.29	0.02	0.17	-0.22	0.13	0.72	1.00					
pat file rk	0.16	-0.02	0.18	-0.15	0.02	0.40	0.78	1.00				
lic ex rk	0.19	-0.08	0.19	-0.03	0.24	0.74	0.72	0.35	1.00			
lic inc rk	0.14	-0.10	0.05	-0.24	-0.02	0.63	0.69	0.32	0.73	1.00		
pat iss rk	0.41	0.16	0.24	-0.12	0.23	0.63	0.81	0.56	0.61	0.69	1.00	
start rk	0.40	-0.13	0.47	-0.25	0.30	0.35	0.42	0.22	0.18	0.20	0.43	1.00

Table 3: Spearman Correlation Matrix – Top 25 Engineering Schools

7. CONCLUSIONS

The ranking of engineering graduate schools and some quantitative data used in computing the ranking along with the associated data concerning the creation of intellectual property at those schools has been used to determine both product moment and Spearman correlation coefficients between the two sets of data. From both sets of correlation coefficients computed from the data we are led to believe that national ranking is associated more with the size of engineering school determined by student enrollment and research budget than by the innovation parameters of patents issued and number of start-ups. We deduce that the subjective input of peer opinion to the school ranking also does not take into account the university's or the school's contribution to tech transfer, business creation and economic development. The innovation parameters of patents issued, licensing revenue and start-ups are all more closely aligned with number of disclosures rather than engineering school ranking. However, the AUTM data includes innovation parameters for the entire university and not just for the engineering school. Hence, there may be an inherent interfering factor, namely contributions to innovation parameters from schools other than engineering, which prevents higher correlation between AUTM data and the USNWR ranking. Further research may also determine whether on a per research dollar basis or on a per student basis whether the high correlations found here would still be significant.

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