Commercialisation of new knowledge within universities: exploring performance disparities

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Abstract: This paper finds that vast disparities exist in new technology commercialisation outputs between a small percentage of high performing universities, and the remaining bulk of under-performers. Theoretical explanations for these findings are as follows. First, high performing universities attract resources, both human and financial, with a much stronger pull than lower performing universities. Second, this study confronts a gap in the literature with regard to the prominence of entrepreneurship within the innovation and technology development process. Third, this study brings new light to bear on the reliability and validity of evaluative tools (variables) currently accepted as indicators of innovation in the university technology transfer context.

Keywords: universities; technology transfer; technological intelligence; entrepreneurship; innovation; entrepreneurial capacity; commercialisation; performance; technology.

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1 Introduction

To better understand the practices and performance of universities in commercialising the Intellectual Property (IP) that they generate, this study examines a selection of data from a report published by the Association of University Technology Managers (AUTM Licensing Survey, 2003). We investigate three measures of output volume – disclosures, licenses and start-ups. These outputs are scrutinised in the context of a conceptual framework of innovation posited by the authors.

It is often argued that the continued growth of industrially developed countries is highly dependent upon competitive advantages generated by the public research system (Shane, 2004). Yet the knowledge produced within the university sector in and of itself has very little *economic* worth (Hindle, 2002). Newly discovered ideas and inventions must first be evaluated as to the potential market opportunity they offer and then recombined with traditional economic factors (such as financial capital) by 'human action', to bring about the production of new resources that have ever-greater social and economic value. This transformation of new knowledge into economic value is the essence of the innovation process and is contingent upon the energies of entrepreneurs (the human actors) who have the capacity to successfully bridge between the world of science (or any other new knowledge creating environment) and the market.

If the basic nature of innovation is as described above, it is not new knowledge (discovery, invention, patent, prototype etc.) or the science system per se that are influential in driving the economy, but 'innovation systems' that have the capacity to transform knowledge into the economic units that drive growth, such as new firms, and new products. Unfortunately, the process of creating such innovation systems *within* a university is not easy to define understand or analyse. The worlds of academic research and the market are often highly incongruent because the pursuit of science is not always driven by the same incentives that govern the economy. This presents a unique set of challenges to facilitating research commercialisation within universities. It is vitally important to develop better insights into how public research institutions can develop effective internal innovation systems.

In this context, the purpose of this study is to explore the phenomenon of knowledge transfer within universities. We adopt a performance perspective, and analyse the outputs derived from research through a framework that is developed around a conceptual understanding of the process of innovation. We are specifically interested in this set of questions:

- How well do individual universities transform knowledge into economic worth?
- Do current theories provide a sufficient understanding of emerging patterns evidenced in the data?
- How well does the concept of innovation as conceived and presented in this paper fit with emerging patterns of commercialisation performance?
- Can valuable insights be discovered from this exploration?
- Do commonly deployed output measures used in the evaluation of commercialisation performance provide reliable and valid measurements of innovation?

These questions lead to the examination of the numerous and diverse knowledge outputs produced by the university. They can include, but are not limited to: freely shared information of all types; research publications; human capital (in the form of students) *free* disclosure of IP and new products that arise from IP.

Unfortunately, discussion of the entire range of outputs produced by the institutions under investigation cannot be addressed within the scope of this paper. Focus is concentrated on outputs derived from research in the form of disclosures, licenses and startup companies.

This is exploratory research and does not begin with any formal hypothesis. However, the authors do entertain suspicions as to the nature of the patterns that may emerge from the data to be investigated. In particular, we observe that the complexities involved in two areas – knowledge transfer, and the outlets available for commercialisation – require years of investment and problem solving activity in order to build capacities and attract the resources necessary for successful commercialisation. This is evidenced by the recent growth in institutional policies and mechanisms that have developed around commercialisation, such as incubator programs, technology transfer departments and university created investment funds. Therefore, it is highly probable that disparities will exist between universities in terms of their output performance.

The paper is structured as follows. First, we provide a concise 'working' definition of innovation to highlight some of the key misuses and confusions of the term and to framework discussion of current modes and strategies for research commercialisation. Our second task is to outline some literature-derived suspicions concerning disparities in university performance outputs. Third, we articulate the methods employed to collect, sort analyse and present our findings. Fourth, following a discussion of the findings we introduce, post hoc, a model that can be used to explain the results of the test from the perspective of the innovation function. Fifth, implications of the research findings and their analysis are considered in conjunction with a brief discussion touching upon the limitations of the study. Finally we draw some conclusions and provide suggestions for further research.

2 Universities and innovation

2.1 A practical description of innovation and what it means for universities

The term 'innovation' is often used interchangeably in the literature with 'new technology', 'new ideas' or 'creative problem solving'. While these terms can and often are associated with innovation, they should only be regarded as potential knowledge sub-components and not used as if they were imbued with its full conceptual essence. A strong emphasis of 'novelty' or 'newness' is also a recurring theme in the literature. This newness belongs to the realm of discovery and opportunity as discussed by Shane and Venkataraman (2000). A discussion of whether or not 'novelty' is subjective or objective is beyond the scope of this paper. Transformation is another key theme that appears in the literature, and speaks to the necessity of human action for transferring the idea or invention into a commercially profitable or value-added form. The inventor and the entrepreneur do not necessarily share the same space and often discovery of the idea has little to do with the actual process of evaluating and exploiting the commercial opportunities that flow from its potential. Sustainability is another facet of innovation because economic actors must be cognisant of the vicissitudes of ever-changing environments that ultimately decide how long value lasts (Livingstone, 2000).

Our summary framework of innovation sees it as a process whose end result (value) is a product of the combination of new knowledge (inventions and ideas) with entrepreneurial action (the processes directed by human actors) to achieve new commercially oriented ends means relationships that provide measurable value to direct stakeholders, and spillover value to society through economic growth (Hindle, 2001, 2006). This concept of innovation holds that universities, whose primary function (as research institutions distinct from teaching institutions) is the production of knowledge, must strive to become more 'entrepreneurial' in order to help facilitate the innovation process. This is not a simple task, nor well-understood, though it is the subject of a growing body of academic literature (Etzkowitz, 2004; Clark, 2004; Shane, 2004). Further clarification of the 'entrepreneurial' university and the requisite capacities possessed by the institution are also vague.

To illustrate, an entrepreneurial university may be an institution that delivers only fine arts programs, but has the capacity to evaluate new opportunities for delivering its programs in a novel way that allows for a commercially marketable opportunity to be exploited, adding value to both students (better education, greater opportunity in employment/wages) and the institution (new streams of students who are willing to pay higher tuition fees -increased revenues- and higher prestige that attracts better scholars). Universities and research institutions that manage to create 'technology' innovation systems have done so using a variety of tools, mechanisms and pathways (Lockett and Wright, 2005). These models are not easily reproduced, success is often intermittent, and there is no overarching blueprint that guarantees positive outcomes.

One explanation for this observation stems from the nature of innovation itself: it is dynamic, non-linear and heterogeneous (Drucker, 1985). Entrepreneurship and creativity are also dynamic, non-linear and heterogeneous activities. Policies and processes that are designed to identify potential technologies to be transferred are often linear and non-heterogeneous (Frischmann, 2005; Nelson and Byers, 2005). This causes theoretical and functional challenges to fostering innovation within universities. Second, as entrepreneurship is a key ingredient for successful innovation, there is a requisite need for creating the capacity, and the environment that leads to promoting entrepreneurial activity, in order to properly facilitate the innovation process (Hindle, 2002). Emphasis must be placed on *both* knowing and doing (Ropke, 2000). Learning how to translate and reproduce this general knowledge for evaluating opportunity is often difficult due to it's being tacit and subjective. Skills' building is a less onerous educational task, but requires specific focus on experiential application and the combination of newly developed skills with the general ability to evaluate opportunity. Third, institutions are dissimilar. So, blanket incentive structures employed to promote innovation may suffer from this lack of homogeneity, or be completely misaligned within different environments (Clark, 1998). Finally, it is uncertain as to what 'positive outcomes' truly *are*. This leads to problems concerning the reliability and validity of evaluative methods. Output measures can distort goals and the true impact of university innovation systems may be unknown due to gaps in reporting, non-uniformity of evaluation tools, or simply due to the difficulty of measuring the entire depth and breadth of the innovation process's ultimate value (Bramwell and Wolfe, 2005).

Nonetheless, agreed indicators of innovation success do exist and these can provide a reasonably accepted measure of a university's capacity for commercialising knowledge, such as patents, licenses, and spinouts (AUTM Licensing Survey, 2005). What is less well accounted for in both applied measures and theory are the variables that make a university more 'entrepreneurial', with regard to knowledge transformation, and subsequently, capable of developing a more effective internal innovation system.

2.2 What do current methods of evaluation tell us?

The status of the study of university commercialisation is largely concerned with input/output contrasts. This is because of the bureaucratic nature and requirements of the governments and institutions involved in reporting and their associated need for 'public accountability' through mechanisms capable of showing the public and the taxpayer that they are getting 'value for money'.

As stated earlier, this study is different because it is not concerned at all with the various *inputs* involved with the commercialisation of IP despite our conceding that research dollars (a most significant input) do have predictive power in explaining performance with regard to outputs from scientific research. Ceteris paribus, we are interested in the output patterns described by non-inferential statistical data and what these patterns may suggest in light of our conceptual framework of innovation.

A review of the literature provides ample theoretical and empirical evidence that pertains to the reliability and validity of using output measures such as disclosures, licenses and startups for determining commercialisation performance. The institutional strategies that engage the opportunity, evaluation and exploitation components of innovation actively seek to license IP to newly formed or established companies through different arrangements that provide royalty revenues, equity or both (Chiaroni et al., 2005). Disclosures are distinct from licenses and startups as they can be construed as the 'discovery' element of the process and have the potential to be transformed into patented IP and then commercialised through other means. Thus, the relationship between disclosures and licenses and startup companies formed is suspected to be linear. Licenses and startups are outputs that can be:

- further developed (through investment or further inputs)
- measured in terms of strict output volumes for evaluating performance
- adequate variables for evaluating commercialisation intensity.

Based on a long list of anecdotal and theoretical evidence, the authors suspect that universities that perform better in licensing and startups will grow their performance faster than universities that do not perform well in these categories (Katz, 2006). As well, success of some universities breeds more success for them and raises barriers for others. This is a simple function of prestige. Investment follows success, and the excellence of research programs that attract star scientists, and the endogenous growth that comes with such success. Some of the most pertinent examples of this phenomenon can be found in the well documented histories of research institutions such as MIT, Stanford, UC Berkeley, and others that grew into commercialisation powerhouses (Saxenian, 1994; Link and Scott, 2005). The above examples are underpinned by basic economic and business theories that can be used to extrapolate an argument for higher performance outputs translating into competitive advantages (Friedman and Silberman, 2003; Barney, 1991). These in turn attract further inputs (research dollars from government and industry, human capital, etc.). This creates a virtuous circle that is powered from the activities of learning and doing (Stigler, 1976; Rosen, 1972). Therefore, it is reasonable to surmise that a gap between low performers and high performers will be substantial, and that this gap could be increasing over time. With all other inputs controlled, a key question arises. If disparities do exist between low performers and high performers, then what are the implications and/or theoretical explanations with respect to our concept of innovation?

3 Methods

This study explores technology transfer practices within public research universities using a simple conceptual model of innovation. This model hypothesizes that the value derived from innovation is a function of new knowledge created (technology) and entrepreneurial capacity. We use this model to help us interpret the data that is observed from university technology transfer proxy outputs.

Data collected from surveys conducted on licensing and commercialisation activities in North American universities by the Association of University and Technology Managers (2003) were used for this study. Three output variables – volume of *disclosures*, volume of *licenses*, and volume of *startups* – were examined.

Non-inferential statistical techniques were used to sort and manipulate the data into easily understandable table formats. First, we distributed university data on all three variables across stratified ordinal ranges that allow for examination of output patterns for universities performing in a specific bracket within the given year. The number of universities with outputs in the variable performance bracket is then summed across the entire range. Second, each variable category is sorted between high and low ranges for universities in order to determine aggregate outputs across North American university innovation systems. The high and low ranges are found by simply halving the ordinal ranges represented in the data.

Cumulative tests were then performed on licensing and start up variables over the 1991–2003 periods to determine if current trends matched the historical average. Identical methods were used to observe the data as used above for the 2003 data. Finally, revenue data was used to calculate the licensing revenue percentage between breakdowns of high performing universities and low performing universities. This method allows for an interpretation of the outputs being produced within high performing universities as compared to the outputs being produced in low performing universities on a ‘dollars revenue’ basis.

4 Findings

The first set of figures, presented in Table 1, shows disclosures reported by universities that responded to the AUTM survey, and represents a cross section of activity for 2003. The varying volumes of activity are displayed in size categories and distinguish Canadian and US universities.

Data displayed in Table 2 represent licensing activity.

Table 1 Invention disclosures received by US and Canadian Universities 2003

No. of disclosures	*1–10*	*11–25*	*26–50*	*51–75*	*76–100*	*101–200*	*201–300*	*301–400*	*401–500*	*500+*
Canadian Universities	11	9	7	2	2	4	–	–	–	–
US Universities	21	24	41	17	18	27	8	3	2	2
Total CAN/USA	32	38	48	19	20	31	8	3	2	2

Source: AUTM Licensing Survey (2003)

Table 2 Licenses/options executed by US and Canadian Universities 2003

No. of licenses	*0*	*1–9*	*10–19*	*20–29*	*30–39*	*40–49*	*50–59*	*60–69*	*70–79*	*80–89*	*90–99*	*100+*
US Universities	8	71	22	18	10	6	6	3	2	4	1	6
Canadian Universities	5	16	4	5	2	3	–	–	–	–	–	–
Total CAN/USA	13	87	26	23	12	9	6	3	2	4	1	7

Startup activity is displayed in Table 3 using the same style of presentation, with ranges adjusted according to weights for easier interpretation. Direct observation of these tables suggests that there is a cohort of universities in each output category that demonstrates extremely high levels of outputs reported.

Table 3 Startup companies formed by US and Canadian Universities 2003

No. of startups	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13+*
US Universities	50	46	21	6	13	3	4	3	1	2	1	0	2	3
Canadian Universities	19	7	1	4	3			1		1				1
Total CAN/USA	69	53	22	10	16	3	4	4	1	3	1	0	2	4

In order to present a clearer picture of the patterns emerging, the findings are re-sorted in Table 4 into a high – low dichotomy of universities that perform within prescribed ranges and represented in percentage terms. For each of the first three tables, an estimate of the total volume of each activity were obtained by multiplying the total number of universities by the midpoint of the range and then summed into the high-low categories in the third row of the table.

Finally, a calculation of the average number of reports per university is presented in the fourth column.

Table 4 Canada/US University commercialisation outputs by high-low range

FY 2003	*Disclosures* (*16,792*)*		*Licenses* (*4964*)*		*Spinouts* (*432*)*	
Range	0–200	201–500+	0–49	49–100+	1–7	7–13+
Universities CAN/USA	188	15	170	23	181	12
Percent of total	93%	7%	89%	11%	94%	6%
Sum of approximate totals	9184	5481	2147	1900	258	132
Avg. per reporting population	71.2 disclosures filed		9.28 license options executed		1.8 startups	

*actual reported totals.

On all three measures of performance, only a very small percentage of North American universities are performing at extremely high levels. The approximate number of reports in each high-low range of activities reported provides a good idea of the total volume of outputs that universities in each range produces. To illustrate, in the startups category, only 12 universities were producing in the high range. They constituted a mere 6% of all universities reporting in 2003. These 12 universities (or 6% of the entire population) were responsible for creating 132 startup companies as compared to the low producing range of 181 universities (or 94% of the population) that produced approximately 258 startup companies. The average startup company per university figure of 1.8 indicates that the performance outputs in the top half of the range is up to seven times that of the typical university reporting. This is a staggering contrast between the top 12 performing universities in North America in terms of new startup creation.

Overall, approximately one third of disclosures, one third of licenses and one third of all startups reported are created from 7%, 11% and 6% respectively of all North American universities. This highlights an extremely large disparity in all three output performance measures between top range universities and low range universities. The averages of each output when compared against the sum for all universities reporting in each category, further elaborates the magnitude of this statistical divide.

In order to determine if these patterns exist over a longer period of reporting, cumulative data were examined over a period of 12 years ranging between 1991 and 2003. It should be noted that the findings contain a non-static range of reporting universities: some universities came into the study and some dropped out during the 12 year period for which data are examined.

Tables 5 and 6 represent the reported outputs of licenses and startups that were active over this period for universities in North America. Clearly, the pattern that emerged in the 2003 findings appears to hold over time. Finally, two tables are presented to illustrate the high–low range distribution of outputs and *outcomes* (in the form of revenues generated) over the 12-year period. The findings are presented in Table 7.

Table 5 Cumulative active licenses within Canadian/US universities

No. of licenses cumulative	*0*	*1–10*	*11–25*	*26–50*	*51–75*	*76–100*	*100–199*	*200–299*	*300–399*	*400–499*	*500–599*	*600–699*	*700–799*	*800–899*	*900–999*	*1000+*
USA	6	15	27	33	14	8	22	10	6	5	4	2	4	0	2	4
CAN	2	10	7	5	1	2	8	1	–	–	–	–	–	–	–	–
Total	8	25	34	38	15	10	30	11	6	5	4	2	4	0	2	4

Table 6 Cumulative startups operational in 2003 within Canadian/US universities

No. of startups	0	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	80+
USA cumulative	18	79	18	12	11	3	1	2	1	2
Canadian cumulative	5	14	6	2	1	2	0	2	1	
USA/CAN total	23	93	24	14	12	5	1	4	2	2

Table 7 CAN/US commercialisation active outputs by high–low range 1991–2003

	Startups		*Licenses*	
Range	0–40	41–80+	0–499	500–1000+
USA aggregate	138	9	146	16
Canada aggregate	28	5	36	–
USA/CAN total	166	14	182	16
Percent of total	92%	8%	92%	8%

Table 8 presents the actual percentage of revenues that are received by the top 23 licensing universities as determined by Table 4.

Table 8 CAN/US revenue received from outputs

	Total revenue	*Revenue of top 23 performers*	*Percentage of revenue*
License income	$1,250,818,557	$888,306,260	71

Based on the assembled, calculated and examined data, the broad proportion of universities performing at the high level and universities performing at the low level remain unchanged over time. As the dataset resulting from cumulative reporting over the 12-year period is dynamic and does not contain separate sets of individual data to examine at discrete intervals, it is not possible to determine whether or not the growth in outputs of the high performing universities is increasing, decreasing or remains unchanged.

5 Discussion

5.1 The importance of a pattern of disparity?

The reporting variables used to measure performance within North American universities suggests that there is a small percentage of institutions involved in knowledge transfer that are responsible for an inordinate amount of reported outputs. Empirical and theoretical studies conducted on the subject of university commercialisation have posited several reasons as to why these disparities might exist. Incidentally, the preponderance of research carried out on commercialisation has been overwhelmingly directed at universities within the high range of performance (Shane, 2004) and most research has been case based. Does the evidence fit the concept of innovation outlined in this paper?

First and obviously, better science produces better IP. The result is greater opportunity and more potential value. Zucker et al. (2002) found that star scientists (as determined through publication rankings), were almost exclusively in top universities, and that the study of migratory patterns of top scientists and teams provided great predictive power for commercialisation outputs and success. This fits well with the concept of innovation as we have described it, where the potential value of innovation is a function of the potential value of knowledge. Our findings also comport with evidence reported in resource based studies and the virtuous circle created from scientific excellence and historic success (Lockett and Wright, 2005). It is likely that the top tier universities found in our study are strong in the areas of transfer staff, investment capital (venture capitalists evaluate success based partly on past success), and the networks created by these activities.

Second, although knowledge quality and the migration of top scientists to the best universities may explain some of the patterns detected in the data, these attributes do not directly address the issue of the *transformation* element of the innovation process. Witt and Zellner (2004) state that commercialisation within universities is essentially a process that is *entrepreneurial* in nature, where entrepreneurship is predominantly a knowledge transformation process. In order to trigger knowledge transfer, opportunities must first be recognised. But entrepreneurial skills in unfruitful contexts may not prevail in securing successful knowledge transfer. Organisational rigidities, lack of resources and barriers to entrepreneurial entry can act as barriers to commercialisation output and success. Organisational environments are perceived to play a role in the disparities that exist in performance outputs (Henrekson and Rosenberg, 2001). Roberts and Malone (1996) propose that there are two key dimensions that help to explain the performance disparities between the majority of low performers and minority of high performers: level of selectivity and level of support. They offer a two-by-two matrix that shows how support structures may need to be different, depending upon the environment and the capacity of a university to conduct knowledge transfer activities. Our concept of innovation does not specifically account for organisational factors.

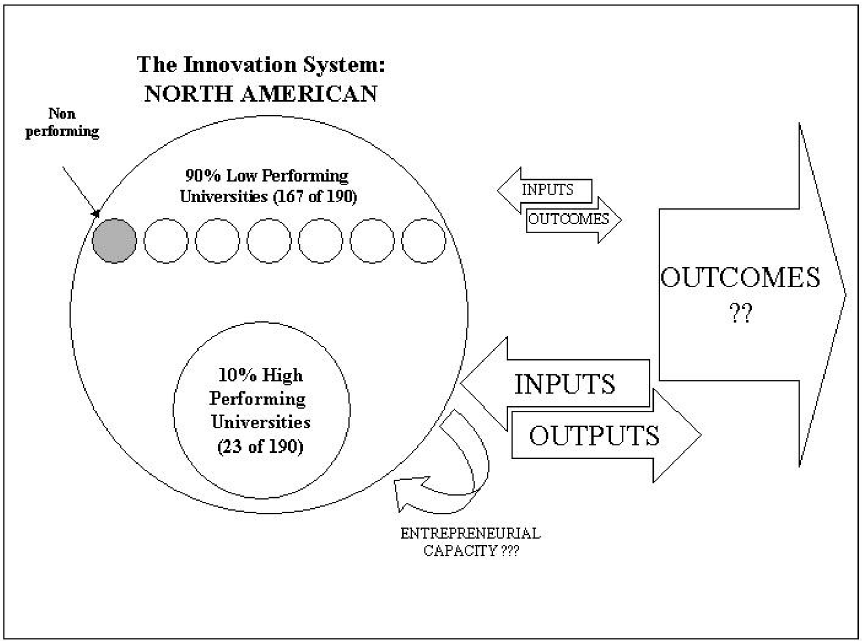
Third, concentrating specifically on the ‘entrepreneurial capacity’ element of our definition of a successful innovation system, review of the literature provides only a few theoretical articles and even fewer empirical studies on the importance of entrepreneurship, to commercialisation in universities (Bercovitz and Feldman, 2004). Yencken and Gillin (2003) illustrate that entrepreneurial capacity has a definite knowledge component, and that learning and doing is an integral component of the fostering of that capacity. Hindle and Yencken (2004) actually set out to provide a function of innovation that highlights the vast importance attributed to entrepreneurial capacity. There are studies that investigate managerial and organisational factors, (O'Shea et al., 2005), business development capacity (Locket, Wright, 2005), team dynamics (Ensley and Hmielski, 2005), core competency development (Luggen and Koruna, 2004) and exogenous factors such as triple helix networks that involve government, universities and industry (Langford et al., 2005) and the effects of geographical proximity and potential knowledge spillover (Zucker et al., 1998). Yet, there is a paucity of empirical testing on the relationship between entrepreneurs, 'entrepreneurial capacity' and performance. A handful of academic papers have focused on entrepreneurship education and discuss the overlapping areas of concern with technology transfer (Siegel and Phan, 2004; Emerson and Boni, 2005). Study of 'surrogate' entrepreneurs (i.e., people other than the originators of the IP at the heart of the venture) and their implications for technology transfer have also yielded some evidence that startup ventures created by entrepreneurs external to the university grow more rapidly (Franklin et al., 2005). 'White coat' Scientists may be good researchers but they are often very poor entrepreneurs. Even so, there involvement in knowledge transfer is deemed to be crucial, but mainly in a scientific role.

Thus a small hole appears in the literature that may help to match our empirical findings with our concept of innovation. If entrepreneurship is such an important component of the innovation function, why is there not a greater literature of study concentrated on this factor with respect to universities' internal innovation systems and the value of innovation produced by them? Regarding the latter issue we asked ourselves whether or not the output measures we used were appropriate for measuring innovation, and more specifically, the potential value that can be derived from innovation. Arguments have been made that the current system of output evaluation does not take into account all the crucial measures that are necessary to effectively monitor and study the innovation process (Bramwell and Wolfe, 2005). We assumed a linear function of disclosures to licenses and startups created, and the data support this assumption through the emerging, closely knit patterns of all three variables. Complexity of measurement in terms of the 'value' aspect of innovation seems to be not quite as linear as the relationship between disclosures and licenses and startups. Using data displayed in Table 8, the disparity in terms of actual dollar value with regards to licensing income received from all forms of outputs (royalties, cashed in equity, sale, etc.) yields an astonishing number of 71% of all revenues based within the top performing 23 (11%) of universities in North America. The function of 'outputs to outcomes' (where 'outcome' is 'dollar value' measured in actual US dollars) is almost seven to one. The empirical data presented provide ample evidence of the fact that not only does the disparity exist with regard to universities creating innovation systems, but that output measures only begin to tell the story. The innovation value being produced by the top range of performing universities is even more concentrated than output measures reveal.

How can these results be interpreted with respect to innovation policy? The evidence shows that the majority of knowledge factors and potentially entrepreneurial capacity factors are concentrated in a very small percentage of North American universities. One explanation that might be surmised is that inputs, not outputs are the more appropriate measure of the innovation process in North America and that this has resulted in an inordinate amount of the capacity to produce and transform knowledge. If there is indeed an experiential component to learning, then the 'entrepreneurial capacity' to transform knowledge potential into realised value is growing in the high performing universities much faster than within the low performing universities. A putative model is presented below in order to illustrate the emerging patterns and what factors of the innovation system may be causing them.

What the model in Figure 1 shows, is that if the authors' formulation of the innovation process is correct, then 'innovation systems' are potentially conceived by policy makers at an overly 'macro' and insufficiently 'micro' perspective. Perhaps, being government employees and dispensers of government money, many policy makers can only think in national terms and at the national level. They fail to have empathy for the micro perspective at the level of the individual university. It also shows that an increase in value-creating inputs (money, better scholars and the rest) results from success. If this is indeed the case, then the consequence for individual universities not in the high performing range is that they face even larger constraints than was originally envisaged.

Figure 1 A model of the emerging patterns in innovation systems



In many cases, the investment required for building innovation systems within universities is akin to new venture creation. The revenues do not completely cover costs in the first few years. So, knowledge transfer centres in universities are bound to be loss-making centres in their early stages. They actually lose money, without any guarantee that the wares from commercialisation will ever grow large enough to cover the fixed costs of infrastructure. This presents a poor set of incentives to innovate. It is a disincentive liable to keep badly performing universities potentially performing badly. It is the centre of an un-virtuous circle.

There are many limitations to the study and discussion presented in this paper. First, the study was based upon a very narrow cross section of activities that universities actually perform with respect to commercialisation. Second, as inputs were not examined, many of the assumptions made about innovation systems are based upon an inadequate coverage of theoretical arguments found in the literature. Third, our study overlooked many important internal and external factors. Finally, the results presented in this study are non-inferential, and thus do not have any correlative or predictive power for explaining relationships.

5.2 Implications for research

This study, though unashamedly exploratory in nature, provides potentially valuable insights into the innovation process as it pertains to public research institutions and emphasises the differences between micro (entrepreneurial capacity) and macro (economies of scale of research excellence and funding inputs) factors. Micro factors currently tend to be overlooked in current policies and practices. Although the impact of knowledge-based innovation produced within the public research system benefits the economy at a macro level, it does not always benefit the producing universities themselves, at least not on a direct financial level. The approach adopted in this study has yielded sufficient non-obvious insight to indicate that further research is both indicated and warranted. It should focus on evaluation of the *impacts* of innovation on multiple actors (including those in the university who produce the innovation) as the *functional components* that comprise the process of innovation itself. This emphasis may underpin the need for new investigations and interpretations in three key areas:

- *Knowledge management.* Research is needed to inform more efficient and effective methods for managing the technology transformation process (Lane and Klavans, 2005) at both the micro and macro levels as well as rigorous examination of all outcomes that may be construed as having ‘innovation value’, and therefore should be evaluated (e.g., innovation systems, entrepreneurial capacity development, and the knowledge aspects of both learning and doing).
- *Technology transfer metrics in the university context.* There is a need for the development of definitions and measurement instruments of factors contributing to the capacity of a university to be entrepreneurial and practice innovation. How do we evaluate the individual and organisational aspects of entrepreneurial capacity and can perceived differences in entrepreneurial capacity explain differences between university innovation systems that perform extremely well, and those that do not?
- *Practitioner.* Greater research must be focused upon facets of entrepreneurial behaviour and its implications for technology intelligence, planning, resource allocation, and decision-making processes for university and industry innovation systems. As innovation is key to competitive advantage, how can entrepreneurial capacity be better tapped, focused and if need be, created/released to ensure the maximisation of value in terms of services, processes and products necessary to wealth creation for institutions, new ventures, and established firms. Linking technological planning with entrepreneurial planning may yield fruitful outcomes for all stakeholders involved.

6 Conclusion

Our study identifies a glaring gap in extant research concerning the weakness of the innovation process and the lack of attention given to entrepreneurial capacity within universities. There is virtually no research in the vitally important area of entrepreneurial capacity. Without such research, we can never answer the generic question: *how* should we build the skills *of whom* to do *what*? To enhance the value of innovation from public research investments, we urgently need further research on why performance disparities exist, how to overcome them, and what measures accurately represent innovation processes and outcomes within the university system.

The pattern of disparities in university commercialisation outputs presented in this paper provides stark evidence of the sombre reality faced by low performing universities. The rich are getting richer and the poor are too poor to invest in the future.

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