An Index-based Measure of University Technology Transfer

by

Melba Kurman

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Melba Kurman
Triple Helix Innovation, Ithaca, NY 14850

ABSTRACT
University technology transfer stakeholders lack a simple, yet meaningful way to measure how effectively and quickly a university is able to license patents into commercially successful products and to spin off startups that in turn, create jobs. Current leading count-based measures fail to account for the fact that many significant technology transfer outcomes follow a skewed distribution that when summed, provide inadequate insight into a university's ability to quickly place its patent portfolio into productive external use. This article introduces a set of three core index-based measures that overcome the limitations of conventional metrics and econometric models: a commercialization health index, job creation health index, and a licensing-speed health index. The concept underlying the technology transfer health indexes is borrowed from the *h index* utilized by university tenure committees to measure scholarly impact and productivity over time. The index-based measures described in this article are simple for technology transfer practitioners to apply, can be calculated using existing data, and are immune to skewing by atypical outcomes such a single, high-earning patent, and be difficult to intentionally manipulate. With little cost and no additional infrastructure, index-based measures of university technology transfer activity yield meaningful metrics that could be input into larger, economic impact studies. The index-based measures described here reward universities that have sustained and impactful technology transfer activity over time; widespread application of index-based measures would incent universities to become better stewards of federally funded scientific research.

1. AN INDEX-BASED MEASURE OF UNIVERSITY TECHNOLOGY TRANSFER

University technology transfer stakeholders lack a simple, yet meaningful way to benchmark how effectively universities are transforming patents into commercially beneficial use. An ideal measure would reward universities whose technology transfer activities focus on meeting the original intent of the Bayh Dole Act of 1980, to apply innovative university research to serve the greater good by speedily transferring patents into commercially successful products and creating startups that in turn, create jobs. The ideal metric would be simple for technology transfer practitioners to apply, would utilize existing data, would be immune to skewing by atypical outcomes such a single, high-earning patent, and be difficult to intentionally manipulate. This paper introduces a practical new method to benchmark university technology transfer performance, a set of index-based measures that address the tendency of several, core university technology transfer outcomes to follow a skewed distribution [1].

The index-based measures proposed in this article introduce additional insight into a university's activity by quantifying the *distribution* of reported outcomes rather than their *sum*. Many significant outcomes of the formal university technology transfer process follow a skewed distribution that when summed, provide inadequate insight into a university's ability to quickly place its patent portfolio into productive external use. For example, a sum of patent license revenue does not reveal the distribution of revenue per patent, a critical oversight given the fact that in a typical university patent portfolio, a few patents earn most of a university's patent licensing revenue [2]. Similarly, summing the number of jobs created by university startups with no regard to the distribution of jobs per startup fails to reveal a university's ability to spin off a robust number of startups that in turn, create substantial employment opportunities.

An additional innate limitation of count-based metrics is that they do not effectively measure the rate at which a specific activity is performed. An index-based measure, however, is able to quantify at what rate, or how quickly a university licenses new inventions into some form of third-party use. Applying

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an index-based measure to calculate the distribution of months lapsed between each disclosed invention and its executed license, quantifies the speed at which a university's technology transfer office is able to place its inventions into a contractual arrangement for external, third party application.

Two measures proposed in this article address the skewing inherent in count-based measures of patent license revenue and startup job creation. The third provides a way to quantify the rate at which a technology transfer office licenses university inventions. These index-based measures measure the health of a university's technology transfer activity, hence are referred to collectively as technology transfer health indexes:

- *a commercialization health index* measures the distribution of revenue per patent to quantify a university's performance in placing patents into commercial use
- *a job created health index* measures the distribution of jobs per university startup to quantify a university's performance in creating several startups that in turn, create jobs
- *a licensing speed health index* measures the distribution of months that pass from invention disclosure to commercial or non-commercial license, quantifying how quickly a university is able to license disclosed inventions into external, third party use

1.1 Commonly used methods to measure university technology transfer activity

Today, most universities measure and publicly report their technology transfer activity using simple counts of outputs, such as licensing revenue earned by a university's patent portfolio, new invention disclosures received, patents issued, or the number of new startups formed [3]. Annual tallies of technology transfer outcomes are simple to apply and provide a valuable glimpse and historical record of the results achieved by a technology transfer office. Yet count-based metrics (hereafter referred to in this article as "conventional metrics") are an inadequate measure of a university's technology transfer activity when applied to measure portfolio-based activities, or, in other words, for outcomes that follow a distribution.

As a practical tool for performance benchmarking, index-based measures offer several advantages over conventional, count-based measures. Conventional technology transfer metrics are prone to skewing if their count includes high-value, but atypical outcomes, such as a single, high-earning patent. In contrast, index-based measures improve only when a university has demonstrated consistent, impactful and productive activity over time. Index-based measures are more immune to intentional manipulation than convention metrics. For example, an index-based metric is not improved by high-volume, low-value transactions that may inflate the sum of conventional, tally-based metrics. Index-based metrics are versatile, and can measure technology transfer performance of a single university, of a group of universities in a particular region, or of a group of inventors in a specific university department. Finally, each index-based measure described in this article yields a single metric that can serve as data input into large-scale studies that attempt to document and measure the downstream benefit of federally funded university research.

In addition to annual activity metrics, another significant source of performance measurements are the econometric models created in formal academic studies of the university technology transfer process. Several excellent and methodologically rigorous research studies (too many to list here) utilize empirical data and statistical techniques to create econometric models. These models attempt to assess various aspects of university technology commercialization activity such as a university's efficiency or productivity in managing the invention patenting and licensing process, or spinning off startups [4],[5],[6]. However, despite their value as a rich source insight into a complex ecosystem, the models generated by formal scholarship on university technology transfer performance have not been widely utilized by university technology transfer stakeholders for practical performance benchmarking purposes [7].

1.2 Learning from performance evaluation methods used by faculty tenure committees

The notion of replacing simple counts of outcomes with an index-based measure is derived from the *h index*, the method used by university tenure committees to evaluate scholarly performance [8]. By taking into account the distribution of citations across a scholar's entire portfolio of published papers, the *h index* provides a single metric that represents both productivity (the number of publications a scholar has written) and scholarly impact (the number of times each of his papers was cited by other scholars). The *h* index measures scholarly performance by quantifying the distribution of citations per every published paper a scholar has written throughout their career (see Figure 1).

Before the widespread adoption of the *h index* as a tool to measure scholarly performance, faculty tenure committees quantified scholarly performance according to simple counts of selected bibliographic indicators. Common count-based measures included a scholar's total number of papers or the number of times a scholar's papers were cited by other scholars. The drawback of simple counts of bibliographic indicators was that sum-based measures failed to reveal exactly *how* a scholar managed to accumulate a large number of citations or journal articles across her entire body of published work.

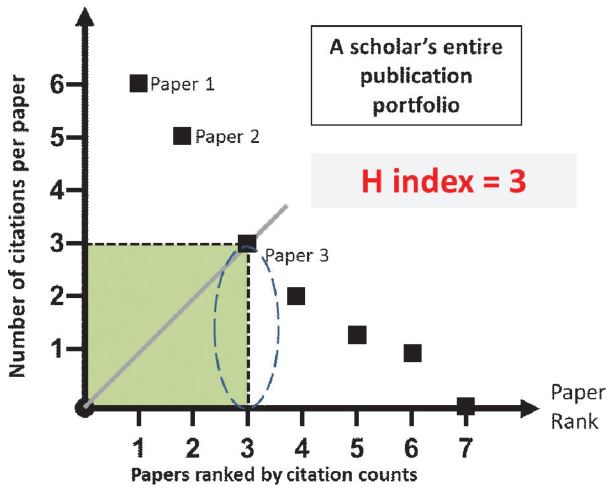

Figure 1. The h index quantifies scholarly performance and impact. To calculate a scholar's h index, each paper is ranked according to the number of times it was cited, from greatest to least. On a chart, papers are placed on an x axis and citations on the y axis; a curve results. The next step is to draw a line from the origin of the graph at a 45 degree angle until it reaches the curve. Where the line meets the curve, drop a vertical line down to the x axis. As indicated by the dashed circular line, this scholar has an h index of 3.

The *h index* has been rapidly and widely adopted to quantify university faculty performance since its application makes it difficult for a scholar to cloak an uneven or even poor record of scholarly publishing activity. For example, if evaluated according to a sum of citations, three hypothetical scholars whose published papers enjoyed the same number of citations might appear to have similar impact and productivity. If evaluated according to their respective *h indexes*, however, it would emerge that these three scholars are performing at different levels. Perhaps the first scholar's seemingly impressive citation count is based on a single, highly-cited paper (analogous to a university earning most of its revenue from a single, blockbuster patent). The second scholar, eager to improve the sum of his citation count, may be churning out a high volume of papers that actually received only one or two citations apiece. The third hypothetical scholar in this comparison has published several papers that have each have been cited several times by other researchers. In short, these three scholars, when measured according to the distribution of citations per paper in an index-based metric, are actually performing quite differently. To faculty tenure committees, the third scholar is the ideal tenure candidate. A scholar earns a large *h index* when her publishing record consists of several papers that have been cited several times by other scholars, indicating sustained and impactful scholarly output.

The concept underlying the *h index* lends itself beautifully to assessing technology transfer activity whose outcomes follow a distribution. The following sections of this paper describe how to calculate a university's commercialization health index, a job creation health index, and a licensing speed health index.

1.3 Calculating the commercialization health index

The first of three technology transfer health indexes described in this article is the *commercialization health index* that quantifies a university's ability to place a significant number of its patents into commercially beneficial use. Calculating a university's commercialization health index is simple and utilizes data already present in any university technology transfer database. The first step is to chart each patent according to how much revenue it has earned over its lifetime, from highest to lowest in increments of $1000 and draw a curve connecting the dots (as demonstrated in Figure 1). Next, from the graph's origin, draw a 45 degree diagonal line to intersect the resulting curve. Extend a vertical line from the intersection point on the curve down to the x axis. In this example, this university's commercialization health index is the value of the dotted vertical line in Figure 2; this university has a commercialization health index of three.

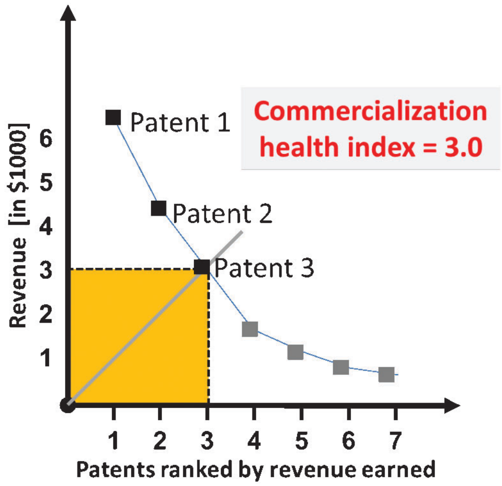

Figure 2. Calculating a commercialization health index. To calculate a commercialization health index, first rank patents according to their lifetime revenue, from greatest to least. Then on a chart, plot each patent as a point. The y axis should be revenue in units of $1000. The x axis should be patents in order of earnings. Extend a 45 degree angle line from the origin of the graph. Where the 45 degree line meets the curve, drop a vertical line down to the x axis. That number represents this university's commercialization health index, in this example, 3.

A university will have a high commercialization health index when its patent portfolio earns moderate amounts of license revenue from a significant percentage of its patent portfolio, indicating active contribution to a number of third-party commercial product development efforts.

1.4 Three universities with similar revenue, but different performance

In the average university patent portfolio, the value distribution of patents is skewed and the almost all of the revenue is earned by a few big outliers [9]. To demonstrate the value of a measure that takes into account the earnings of all of the patents in a university portfolio, consider the insight gained by applying the commercialization health index to quantify and compare the commercial productivity of three hypothetical universities A, B and C. These three universities earn similar amounts of license revenue and their technology transfer ecosystem is similarly resourced. If measured according to a tally of revenue, each university appears to be equally effective at placing its patent portfolio into commercial use. However, if measured according to the distribution of revenue across the entire patent portfolio, a different picture emerges (see Figure 3).

The commercialization health index provides a new lens through which to view technology transfer performance and if adopted, might disrupt existing rankings of universities according to their revenue earned from patent licensing. In this example, hypothetical University A has the highest commercialization health index. University A is similar to a scholar whose publishing record includes several papers that have each been cited several times by other scholars. University A has a robust technology transfer strategy as indicated by a patent portfolio in which several patents earn licensing royalties, indicating that University A is making a significant contribution to several companies' commercial product development strategies.

In contrast, similar to a scholar whose citation count is based almost entirely on a single paper, hypothetical University B earns almost all of its revenue from a single patent, a fact that a conventional tally-based measure does not reveal. Despite a seemingly robust commercialization effort, most of

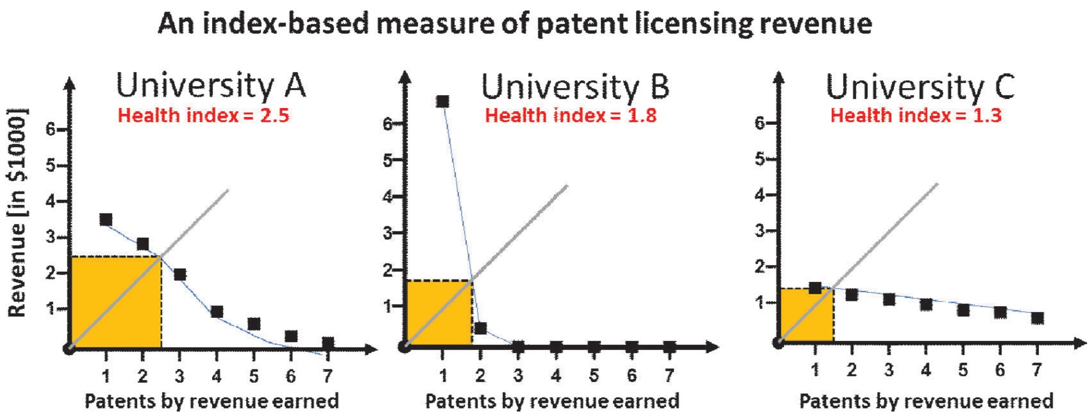

Figure 3. Universities A, B and C earn similar amounts of patent licensing revenue according to conventional metrics. However, when measured according to their commercialization health index, or the distribution of revenue per patent, a different picture emerges. In this example, University A has the largest commercialization health index of 2.5. University A exhibits a technology transfer effort that has yielded a significant number of patent licenses that have earned substantial amounts of revenue over time.

University B's patent portfolio remains unlicensed and weakness disguised by the lucrative income contributed by its single, blockbuster patent. University B, although fortunate enough to own a lucrative patent, may actually be failing to meet its obligations accorded by the Bayh Dole Act of 1980, to efficiently foster the broad adoption of the patents that arise from federally funded scientific research.

Hypothetical University C has the smallest commercialization health index. Its flat distribution of royalty revenue is a potential indicator that few of its licensed patents are earning royalties from product sales. One possibility might be that University C — perhaps under pressure to produce revenue from its patent portfolio — is licensing its patent portfolio using fee-laden, exclusive licenses that have not yet yielded royalties from licensee product sales. If this were the case, University C's small commercialization health index would indicate that its technology transfer strategy consists of charging third parties with a high "tech transfer tax" in exchange for exclusive access to university technologies. In this situation, University C's small commercialization health index would indicate that University C is actually constricting rather than facilitating the beneficially outward flow of university patents.

However, poor commercial productivity is not the only explanation for University C's small health index. If University C's absence of patent licensing revenue were due to a licensing strategy based on non-exclusive licenses with a small upfront fee but no royalties from downstream product sales, University C might be effectively transferring its patents into external, third-party use. In fact, due to its use of royalty-free licenses, University C may be making a tremendous contribution to a significant number of commercially beneficial products, a fact that conventional metrics would fail to indicate. While University C still fares poorly when measured by a commercialization index, the benefit of an index-based measure of patent revenue may be to introduce additional viewpoints into the debate of ultimate mission of the university technology transfer process. A low commercialization health index may enable some universities to make a stronger case that their focus is not on earning licensing revenue, but on faculty service, offering quick, royalty free patent licenses, or eschewing exclusive patent licenses altogether in favor of fostering long-term industry sponsored research partnerships in which IP is shared.

1.5 Quantifying a university's ability to create jobs by licensing patents to form startups

The *job creation health index* sheds light into another facet of university technology transfer performance: a university's ability to create significant number of startups based on licensed university-owned patents that in turn, create jobs. The job creation index quantifies the distribution of full-time employees in active university startups (see Figure 4). A university will have a high job creation index when its licensed patents have contributed to the formation of several thriving startups that each have a significant number of full-time employees. A university that can claim only a single large startup or several startups that employ only one or two full-time employees will have a smaller job creation index.

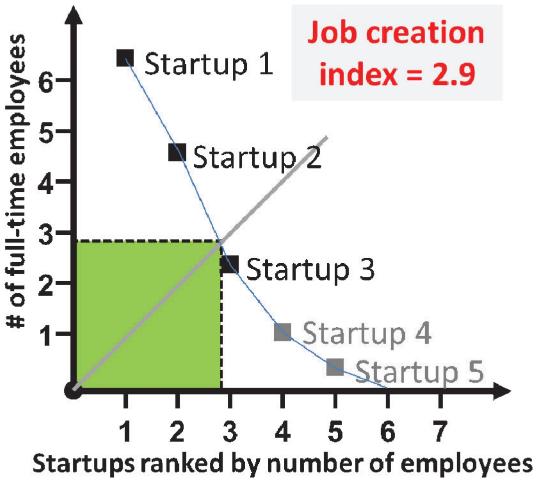

Figure 4. To calculate a job creation health index, rank and chart a university's startups by the number of full time employees per startup, from greatest to fewest. Plot the numbers of a graph, with the y axis being the number of full time employees and the x axis the startups. Draw a 45 degree diagonal line from the graph's origin to intersect the resulting curve. Drop a vertical line from the curve to the x axis which represents this university's job creation index, which in this example, is 2.9.

In response to growing public pressure, many university technology transfer offices have begun to regularly track, measure and report the total number of full-time employees in startups of university origin. Current methods to count job creation arising from university startups are based on simple sums. Simple job counts, however, fail to indicate whether a university's startup strategy is yielding a significant number of startups that over time have grown into multi-employee companies. In the same way a blockbuster patent may create the false impression of a commercially productive patent portfolio, a single "blockbuster startup" may create the potentially misleading impression that a university has made a sustained and impactful contribution to its regional economy.

Quantifying the distribution of jobs created per university startup sheds light onto whether a university's startup formation strategies are serving its regional economy. Universities should not be held solely responsible for creating jobs in their regions. However, university technology, ideally, should be made available to entrepreneurs on reasonable terms to encourage the formation of new startups that create new jobs, hence provide broader regional economic benefit.

Consider that fledgling but promising university startups tend to move closer to regions that offer a more qualified labor force, a richer innovation ecosystem and more funding opportunities [10]. Therefore, a region's economy may be better served by a university whose patent licensing strategy enables the formation of a large number of startups to create a diverse and thriving regional ecosystem. Insight introduced by the job creation health index may motivate some universities to re-consider sub-optimal startup strategies. For example, a university that imposes a too-rigorous screening process in an attempt to license patents only to the so-called "winners" may end up with a lower job creation index than a university that cheaply and liberally licenses patents to a larger number of startups.

As described here, the job creation health index measures the jobs created by startups that have formally licensed a university-owned patent. The same index-based approach, however, could be applied to calculate the job creation index for a broader group of startups, for example, those whose primary university connection does not involve a licensed university patent, but instead, consists of a student founder, faculty advisors or other connections to the university. The versatility of the job creation health index enables its application to a broad variety of university startups; however, to ensure integrity of results, universities need to be transparent as to which university startups they included in their calculation of their job creation index.

1.6 Quantifying how quickly a university licenses its inventions

A *licensing speed health index* quantifies how quickly a university's technology transfer office is able to license new patents, inventions or research materials to a third party for commercial or non-commercial use. Unlike the commercialization health index or the jobs created index, the licensing speed index is a direct measure of speed, or adoption, rather than commercial uptake or economic development. Ideally, a university technology transfer office should be able to quickly usher all types of disclosed intellectual property into a broad variety of external uses as represented by an agreement. As industry product cycles become shorter and more iterative, faster technology commercialization is associated with positive outcomes for companies, such as being first to market and gaining a competitive edge against slower rivals [11].

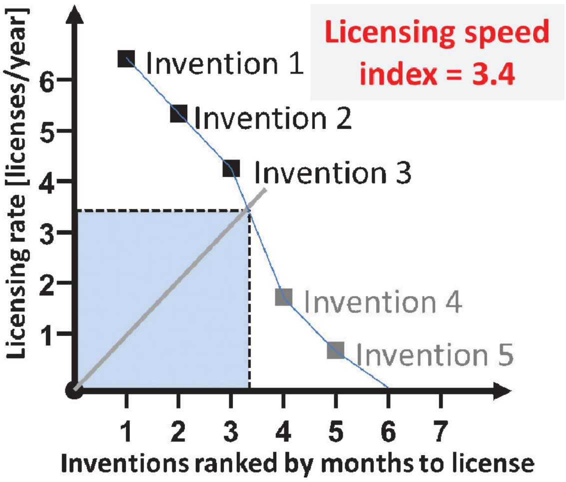

Figure 5. To calculate the licensing speed index, rank each licensed invention according to the number of months that lapsed between the date of its disclosure and its executed license. Divide the number of months into twelve. Chart that number on the y axis. Chart each invention on the x axis. Draw a 45 degree diagonal line from the origin and at the point of the intersection, draw a vertical line, which represents the licensing speed index, in this case 3.4

A high licensing speed index suggests that a university technology transfer office is quickly fostering adoption of university inventions. The licensing speed index rewards universities technology transfer strategy has a strong service orientation. A high licensing speed index indicates that a technology transfer unit efficiently handles external requests for research materials and offers a quick and efficient license negotiation process. A benefit of publicly comparing the licensing speed index of different universities might be to make low-scoring universities more accountable for inefficiencies that hinder technology adoption such as an inordinately slow licensing process.

1.7 Discussion

Of the three health indexes described in this article, the commercialization health index may be the most vulnerable to public misinterpretation and controversy due to the fact that it is a measure of revenue earned by a university patent portfolio. It's important to point out here that regardless whether it is measured by its sum or by distribution of revenue per patent, patent revenue is widely acknowledged to be a limited measure of a university's ability to effectively transfer its research into commercial use since a good percentage of university technologies in commercial application are never patented or licensed [12]. The majority of university know-how and innovative technologies find their way into beneficial commercial use via open science, notably publications, public meetings and conferences, channels whose technology transfer activity is not captured by the commercialization health index [13]. In addition, university faculty more frequently contribute their knowledge to industry product development efforts in exchanges that do not involve patented knowledge [14]. For this reason, patents and patent licensing revenue are considered by many to be a weak indicator of a university's commercial contribution and innovative output.

High-earning university patent portfolios are the exception rather than the rule [15]. In fact, due to the largely exploratory nature of university scientific research, most university patents are at the proof of concept stage, hence not easily applicable to near-term commercial use [16]. In addition, a significant number of university-owned patents find their way into commercial use informally, without a patent license, yet manage to introduce social and economic value to a third party without earning the university technology transfer office a cent [17]. For several reasons, a university's license revenue earned is a small part of its technology transfer story.

Patent revenue, however, should not be entirely cast out as a measure of a university's ability to place its patents into commercially beneficial, third-party use. Patent revenue earned indicates that a licensed, university-owned patent contributed to a company's ability to develop and sell a commercially successful product. After all, the revenue a university earns from patent licenses is the result of royalties paid by third party licensees based on sales of products that utilize a licensed university patent. Therefore, the greater a company's product sales, the greater the amount of royalties a university earns. Patent revenue can and should remain a measure of the commercial contributions of a university's patent portfolio, but it should be calculated using an index-based measure of revenue distribution per patent rather than a simple count, as is the case today.

Widespread use of the commercialization health index to quantify university technology transfer performance may incent universities to focus *less* on patent revenue earned and *more* on getting patents licensed and into third party use, in other words, on adoption. Count-based measures do not penalize universities whose patent portfolios are largely unlicensed. In fact, a university that manages to maintain a few high-earning patents while most of its patents languish is likely to be deemed effective at transferring its patent portfolio into commercial use. In contrast, unlike a count-based measure, a university's commercialization health index measure is negatively impacted if most of its patent portfolio remains unlicensed.

Unlicensed patents lower a university's commercialization health index metric. Public disclosure of this measure would incent universities to explore alternative licensing strategies to reduce their backlog of unlicensed patents and increase the odds of finding a commercial application for their unlicensed patent. Universities may be incented to seek alternative commercialization strategies for patents that have remained unlicensed for too long. For example, possible alternative strategies include releasing inventions back to their inventors after a specified time period, placing unlicensed patents into a larger patent pool, auctioning off patent licenses on online clearinghouses, or making unlicensed patents and inventions cheaply and quickly available under low-cost, non-exclusive licenses.

1.8 Other factors that may affect a university's health indexes

While the ability of index-based measures to depict complex activities in a single metric is appealing, many other factors need to be considered when evaluating the effectiveness of a university's technology transfer efforts. Selected metrics shape an organization's activities [18]. The purpose of the health indexes described in this article should be to reward universities whose technology transfer activities enable broad and quick third-party adoption of patents and the formation of prosperous startups. However, measuring a university according to its commercialization, job creation or licensing speed health indexes introduces both benefits and risks if additional factors are not considered.

Universities with a strong life sciences orientation and the presence of a medical school are more likely to generate licensing revenue [19]. Another issue is the age of a university's technology transfer office. Similar to a junior scholar with a relatively small *h index*, a young technology transfer office will likely lag older offices in patent revenue earned; typically it takes three to seven years for a patent license to generate income [20]. Smaller technology transfer offices typically earn less patent revenue than large, well-staffed technology transfer offices [21]. Finally, a university's health indexes, like its technology transfer activity, will be impacted by its intellectual property policies, as well as faculty philosophies towards commercialization activity [22].

Similarly, a university's ability to generate highly successful startups is a result of a complex blend of factors, including the commercial orientation of on-campus research, its intellectual eminence, and whether university policies favor enabling faculty inventors to take equity in their startups [23]. Universities that create more startups each year are aided by high quality engineering faculty, high levels of research funding, large numbers of new invention disclosures generated each year, and abundant venture capital funding in the state where the university is located [24]. Finally, existing circumstances beyond the control of the university such as the overall health of its regional economy and its local industrial base will likely impact a university's technology transfer activity, regardless of how it's measured.

1.9 Convincing universities to adopt index-based benchmarking

The primary barrier towards widespread adoption of the technology transfer health index is not of an operational nature, but one of uncertainty faced by universities whose rankings may shift when measured in this new way. Health indexes represent a new and potentially disruptive measure that many universities may be reluctant to publicly disclose. Universities incur risk if they publicly revealed their health indexes without knowing in advance how their technology transfer performance and activity compare to their peers.

In private, in response to a call for commercialization health index measures, the author was contacted by several universities. Commercialization health index metrics ranged from 20 at a small university with a relatively new technology transfer operation, to 120 at a university with substantial research funding and a large and well-established technology transfer operation. To arrive at a more meaningful comparison and to create a more direct “apples-to-apples” comparison, university health indexes should be normalized by selected inputs such as research funding, size of the technology transfer office, or the number of university faculty.

Despite the potential of index-based measures to benchmark university technology transfer activity, future research cannot take place until technology transfer stakeholders are able to convince universities to calculate their health indexes and to publicly share the results. When Hirsh was calculated the *h index,* he had access to publicly available data on scholarly publications such as Thomson ISI Web of Science. However, most operational data on a university’s technology transfer process is kept private and is not publicly available. Therefore, without full cooperation from universities, the potential value of technology transfer health indexes as a benchmarking tool will not be realized.

2. CONCLUSION

Applications abound for a measure of university technology transfer activity that is simple to use, quick to calculate and does not require additional data collection or reporting infrastructure. The notion of utilizing index-based measures to benchmark university technology transfer activity opens up new opportunities for future research as well as practical applications. A first step to catalyze widespread adoption would be to add selected index-based measures to supplement the annual tally-based survey of technology transfer activity whose results are maintained by AUTM, the professional organization for university technology transfer practitioners. Federal and state funding agencies should request that universities add their technology transfer health indexes to their current reports on how they spend their research funding.

Aside from performance benchmarking, selected university technology transfer health index measures could serve as data inputs into large-scale reporting infrastructures such as the STAR metrics project whose aim is to track and document the economic impact of federally funded university science [25]. In the longer term, selected index-based measures could help policy makers identify universities with high health indexes in order to study the factors that make these universities more adept at technology transfer. The widespread adoption of technology transfer health indexes as a regular measure in performance benchmarking would incent stakeholders to pursue strategies that would speedily place as many patents as possible into economically beneficial, widespread commercial use.

Corresponding Author
Melba Kurman
641 Highland Road
Ithaca, NY 14850
USA
Phone: 607-227-2876
eMail: melbak@triplehelixinnovation.com

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