Measuring the quality of patents among Latin-American universities

Alberto Méndez-Morales, Rafael Ochoa-Urrego & Timothy O. Randhir

To cite this article: Alberto Méndez-Morales, Rafael Ochoa-Urrego & Timothy O. Randhir (2021): Measuring the quality of patents among Latin-American universities, Studies in Higher Education, DOI: 10.1080/03075079.2021.2020749

To link to this article: https://doi.org/10.1080/03075079.2021.2020749
Measuring the quality of patents among Latin-American universities

Alberto Méndez-Morales a, Rafael Ochoa-Urrego b and Timothy O. Randhir c

aCentro de Investigación en Ciencias Económicas, Universidad Militar Nueva Granada, Bogota, Colombia; bDepartamento de Administración de Empresas, Universidad Central, Bogota, Colombia; cDepartment Of Environmental Conservation, University of Massachusetts, Amherst, MA, USA

ABSTRACT

Patents are essential for university technology diffusion to society; however, patent quality in universities, especially in Latin America, has been poorly studied. We create a quality index for patents granted to regional universities by using patent quality variables as patent production, technical relevance, use of top knowledge, technological scope, cooperation, and internationalization. Results show that, on average, Brazilian universities had higher quality than their peers in other countries and that Universidad Tecnológica de Panamá occupies the first position of the ranking for 2016. The main contribution of this paper is to create the first Index for patent quality at universities in the region, and for what we know, the first country aggregated measure of patent quality for universities. This noble measure is related to research quality in Scopus and Web of Science databases and can be used to complement international university rankings to measure a dimension not previously used by those rankings.

KEYWORDS

Bibliometrics; Patent quality; Invention; University patents; Higher education; University

Introduction

Over the years, universities have been positioned as centers of education and research per excellence (Bercovitz and Feldman 2006). Recently, universities have played a role as institutions of technological development and innovation towards economic development (Secundo et al. 2017). Also, they are critical in transferring technology to other agents in society (Shane 2004). As a result, the worldwide demand for intellectual property (IP) titles has reached historic levels, with a doubling of patents issued in the last 50 years. Moreover, countries such as China, Japan, Korea, and the United States, have reached a historical number of patents (WTO & OMC 2017). With this increasing emphasis, universities started to play a significant role in research objectives and funding sources for research and development (R&D) (Roesler and Broekel 2017).

Quantifying the contribution of universities can help in improving R&D investments and incentives for innovation. Indicators like patent production can be used to evaluate universities' contributions to aggregated technological development. Patents, defined as documents issued by governments upon application describing inventions and creating exploitation monopolies (WIPO 2008), are particularly interesting for science policy research as a simple metric that can be evaluated for economic impacts. Besides, patent-related indicators are helpful in analysis because of their widespread availability as reliable and comprehensive data sources (Hall and Jaffe 2001; Wong and Singh 2010). Since research in an academic environment results in inventions, patents are essential as
indicators of technology transfer from a university to firms in biology, engineering, pharmacology, electronics, biotechnology, and chemical industries.

University patents arise due to a process related to the second institutional mission (research), impacting the university’s third mission: transferring knowledge to society (Secundo et al. 2017). Without the existence of patents, it would be difficult for universities to fulfill the third mission, giving that third parties looking for knowledge transfer expect some degree of property to financially exploit knowledge, that basically, is a quasi-public good; in that sense, patents solve appropriability issues granting private property to knowledge (Arrow 1972; Nelson 1959; Owen-Smith and Powell 2003).

At an institutional level, the United States in 1960 created a framework that helped simplify university patents and encouraged the development of a community of university patent administrators (Popp-Berman 2008). In the 1970s, this community allied itself with government advocates of patent policy liberalization and small business representatives in a successful effort to pass the Bayh-Dole Act (Bayh and Dole 1980) to enable universities to profit from patents resulting from research funded by federal resources. This law resulted in several implementations worldwide that encouraged universities to create new patents based on their research to enable the transfer of technologies to benefit society (della Malva, Lissoni, and Llerena 2013; Fisch, Block, and Sandner 2016; Kauppinen 2014; Sellenthin 2009).

Developed countries and their universities create more patents than their counterparts in developing countries; this difference can be attributed, among others, to low access to public funding in developing countries (Sawyerr 2004; Thorn 2006), a weak collaboration between industry and universities (Qiu, Liu, and Gao 2017) and inadequate training of scientific and administrative staff (Lim 2018) limiting the potential for patents in these countries. Thus, to create a fair comparison among universities in Latin America, this study compares university patent quality on a regional scale as a first step in the analysis.

However, there is a limitation of data on university patent activity for developing countries. In Latin America, the lack of consolidated information and research about the topic is striking for universities (public and private), firms, individuals, and the military industry. For instance, the number of issued patent families (Figure 1) in universities has been increasing at a 17.3% compound annual growth rate (CAGR) during 1997–2016, while Brazil had 33% of total patents within the region in the same period (Figure 2).

While several documents discuss university patenting activity in Latin-American countries (Calderón-Martínez and García-Quevedo 2013; Martins Costa Póvoa and Siqueira Rapini 2010; Morales et al. 2015), the quality of those patents are studied in minor proportions (Barroso, Quoniam, and

![Figure 1. Growth of university family patent activity in Latin-America. Source: Derwent Innovation, authors calculations.](image-url)
Pacheco 2009). Low technology transfer in Latin-American universities to society (Morales et al. 2015) could be due to several reasons (Morales et al. 2015); technology transfer offices are not well developed, inadequate legal frameworks, the inexperience in institutions, lack of research projects pointed to technology creation, or low quality of technology backed up by patents (Hall and Maffioli 2008). However, if the quality of patents is low, the transfer process will not be successful. Thus, there is a need to measure patent quality in universities accurately.

Unfortunately, gathering university patent data at the regional level is not easy. The type of patent issued by regional universities is unknown, thus, the quality of those patents can not be comparable to the ones of developed countries. In other words, the quality of patents of Latin-American universities is unknown.

The main contribution of this paper is to measure the quality of patents issued by Latin-American Universities to evaluate which institutions are developing better technologies at a regional level. The results of this research are helpful for university management, especially for technology transfer offices that compare the quality of the technology production against their regional peers. Besides, also for policy reasons with governments interested in how universities create and transfer knowledge to society. This goal will be challenging to achieve if the created technologies have low-quality levels. Other researchers can use the Index to compare, evaluate, and make management and policy recommendations to improve the technological activities at universities. This measure could help decision-makers at universities, governments, and industries make better decisions and focus their efforts on improving the technology created by universities, improving outputs and capabilities.

The goal is to create a measure in which universities’ quality of inventions is evaluated using seven different variables related to patent quality (Technical quality, technical relevance, Technical Scope, R&D expenditure/cooperation, production, internationalization, and top knowledge). This is an improvement from university rankings in which typically, the fourth university mission is not evaluated (Torres-Samuel et al. 2018) and in which at the same time, the results are biased in favor of big size universities given the methodologies based on perception and countings of Nobel prizes that are far away from regional universities reality (Fauzi et al. 2020).

As far as we know, this is the first attempt to construct this type of measure for higher education institutions, not only in Latin America but globally. This research’s main objective is to determine which universities have better capacities to develop quality inventions at the Latin-American level for the year 2016; however, we developed the measure since 1997, and the results for the full Index can be consulted on Appendix C.

In this study, we focus on the results for the 2016 index, not because this final year is particularly essential, but because, given the vast amount of information gathered and computed, we believe that focusing solely on one year will be helpful to understand the methodology and results. The paper is presented as follows. The second section of the paper describes the primary indicators in

![Figure 2. Country distribution of university family patent activity in Latin America. Source: Own calculations based on data from Derwent Innovation.](image)
patent quality literature, followed by methodology and data description. In the last two sections, we present the results for the 2016 index followed by conclusions and discussion.

Measurement of patent quality at universities

Since 1990, researchers have been studying ways to identify patents’ technological, legal, and economic value. Those measurements help to understand if technological portfolios of companies are suited for market proposes like technology transactions, firm valuation, and mergers and acquisitions due diligence (Grimaldi and Cricelli 2020; Hall, Jaffe, and Trajtenberg 2005; Li et al. 2020; Reitzig 2004; van Zeebroeck 2011; van Zeebroeck and van Pottelsberghe de la Potterie 2011). Scholars have developed measures to uncover the characteristics related to the quality of a patent to achieve this. As with research papers, patents are documents prone to create bibliometric measures related to their main features. One significant advantage, the information about patent documents is free and can be gathered in official repositories, even when there are some time lags in accessing the data.

The literature identifies some characteristics associated with the quality of patents, such as backward and forward citations, claims, scope, number of countries protected, and patent families.

The backward citations made in a patent document can measure the previous knowledge of the technology. Thus, the number of backward citations can signal a novel combination of technology based on several technical precedents. Consequently, higher technical quality and economic value can be created by universities (Hall, Jaffe, and Trajtenberg 2005; Harhoff et al. 1999; Li et al. 2020; Reitzig 2003). The forward citations are also an indicator of quality, specifically related to the relevance of that technology on creating new ones. Hall, Jaffe, and Trajtenberg (2005) relates stock market company value positively on the number of forward citations of patents owned by companies. In other words, the market rewards a company with higher values if its technologies are relevant to the market. At the same time, for universities, forward citations are clues related to the possible future technologies created by academic institutions. Thus, it is possible that if a university is creating a high cited patent, in the future, that patent can be traded by higher values or with higher royalties (Bonaccorsi and Thoma 2007; Caviggioli, Scellato, and Ughetto 2013; Ernst and Omland 2011; Harhoff et al. 1999; Harrigan and Fang 2020; Hikkerova, Kammoun, and Lantz 2014; Lanjouw and Schankerman 2002; van Zeebroeck 2011).

With citations, patent claims could be another measure of the technical scope of patents. Claims are the set of requests that an assignee has made to the authority to protect a given technology. Thus, the higher the set of claims, the higher the protection level granted by a patent. If a university, on average, is obtaining higher numbers of claims related to patents, the higher the protection against possible offenders and the higher is the economic value of that patent (Caviggioli, Scellato, and Ughetto 2013; Harrigan et al. 2017; Lanjouw and Schankerman 2004; Ouyang and Weng 2011; Reitzig 2003; Trappey et al. 2012; van Zeebroeck and van Pottelsberghe de la Potterie 2011; Zhao and Liu 2020).

Also, the scope of patents has been measured with another type of variable. For instance, the number of words included on patent claims (Gilbert and Shapiro 1990; Klemperer 1990; Marco, Sarnoff, and deGrazia 2019), or in the case of Lerner (1994) the number of International Patent Classification (IPC) of patents. However, this measure’s idea is related to patent claims; the higher the scope of patents, the better protected the technology is against possible infractions (Sun, Zhao, and Sun 2020).

Patents offer protection at a national level. Thus, if a university wants to appropriate the knowledge related to a specific technology and its economic effects, it needs to extend the number of territories in which the patent is protected. However, the cost of that type of protection is high because the patent needs to be translated to national languages, be presented and backed up on local patent offices, and defended in local courts. It seems logical that the extension of national coverage of university patents would be related to the expected returns to the protected technology. Therefore, a
patent with higher market coverage would have a higher economic value given that it cover several markets.

Also, the set of related patents issued at national levels and backed up by the same technology is named a **patent family**. There are several examples of research using the number of patents inside a patent family to measure quality and value (Ernst and Omland 2011; Fabry et al. 2006; Guellec and Van Pottelsberghe De La Potterie 2000; Kabore and Park 2019; Lanjouw, Pakes, and Putnam 1998; Lanjouw and Schankerman 2004; Reitzig 2003, 2004).

Also, it is essential to include the renewal fees as the cost associated with maintaining the protection rights related to technology. If a university decides to maintain its patent property rights over time, it needs to pay those renewal fees. So, it can be assumed that there is a relationship between the university’s net present value related to technology and the number of renewals made by a university. Consequently, the number of renewals can be related to higher levels of technical quality and economic value. In other words, the expected profitability of the patent is higher (de Rassenfosse and Jaffe 2018; Harhoff 2016; Og et al. 2020).

Furthermore, patent oppositions can be used to measure the level of importance that third parties are giving to the patent. Those oppositions are challenges to the patent’s validity because the opponent believes that it could be infringing its economic rights or because the patent fails to identify prior art. Most of the time, those oppositions are related to the opponent’s cash flows, given that it believes that the income related to its technologies will decline if the challenged patent is granted. Thus, oppositions are proxy variables of the potential revenue associated with the challenged patent. As renewal fees, oppositions could be proxies of potential profitability for university patents (Grimaldi and Cricelli 2020; van Zeebroeck 2011).

Typically, the R&D expenditure backing up technologies can be related to derived patent quality. The main logic behind this is that if universities’ technology was developed using more resources, then the need for higher cash flows to cover development costs is urgent. However, R&D expenditure related to technologies is unobservable, at least using patent information. For this reason, it is necessary to use proxy variables to measure it. A proxy variable that can be gathered using patents is the number of inventors. It can be assumed that the higher the number of inventors, the bigger the technology project budget.

In the same way, a patent family with more registered inventors has to be one with more budget and maybe, more expected future cash flows going to university’s future budgets. Also, the inventor’s quantity can be related to collaborations between universities and firms, research centers, and other universities. Thompson (2018, 2016) and Og et al. (2020) observe that the number of inventors is related to patent quality. They conclude that individual inventors tend to have lower technical quality levels and less likelihood of being approved by patent authorities.

Universities also tend to increase the quality of research and development. The academic staff enhances those results by performing patent applications, publishing scientific papers, or both. Simultaneously, technology development improves by the knowledge flow from universities to industry. The literature shows that the relationship between industry and university generates high knowledge flows and better technology transfer processes (Tijssen 2001). In terms of patent documents, this flow can be tracked by measuring the number of scientific papers cited by patents. In Ding et al. (2017), it is possible to see that a patent could cite an article if the quality of the first is high. Then, suppose a patent examiner approves that citation. In that case, it means that it is relevant for the development of the patent, and thus, the patent is using top knowledge for the creation of related technology (Ding et al. 2017; Hicks et al. 2000; Tijssen 2001).

To sum up, patent documents can reflect several characteristics related to the quality of the technology developed by universities. Backward and forward citations, claims, IPC scope, patent family internationalization, renewals, oppositions, number of inventors, citations to scientific papers are characteristics that can be measured on university patents to determine the level of development of their technologies. Unfortunately, not all this type of data is available for Latin-American patents.
Materials and methods

Patent data for Latin-American universities were gathered from the Derwent Innovation Database (Clarivate Analytics 2018, 2019). Initially, we covered patents from Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Guayana, Mexico, Nicaragua, Panama, Peru, Uruguay, and Venezuela. Those patents were initially presented in those countries’ local offices, regardless of whether the filing strategy was the Paris Treaty or the Patent Cooperation Treaty (PCT). Also, we looked for patents presented only by Latin-American assignees to avoid imported patents in our data. With these conditions, we end up with a database of 73,473 individual patents for all types of applicants (Firms, individual inventors, government institutions, universities) in the period 1996–2017. In appendix A, we present the number of ranked universities per country and year. For our year of interest, 2016, 84 universities were measured and ranked.

We used the Tableau Prep software (Tableau 2020) to separate university patents. At least one of the patent assignees has to be a regional university in the final database, regardless of its position on the patent application. It resulted in 8,837 individual patent documents for 1997–2016. Finally, we want to analyze the quality of patents. Still, focusing on the related technology, then, we used the Inpadoc Family Code (Lingua 2005) to group all technology-related patents for a final database of 2,893 university patent families (1997–2016), 456 families in the case of 2016. We stopped our calculation for the year 2016 because, since the year 2017, the coverage of used variables on the Derwent Innovation Database is low.

Figures 1 and 2 show the evolution of patent families in our data; Brazilian Universities represent one-third of the university patent families in Latin America. In Figure 3, the top 10 universities for the number of patent families are presented.

We use seven variables (Table 1) to build the Index of patent quality for Latin-American universities.

Some variables with high impact on the measure of quality, like renewals, claims, or oppositions, were not used for our Index, not because we believe they are not essential or they are not reporting valuable information, but because the Derwent Innovation Database has a low coverage of those variables (10% in the case of claims and 0% in renewals and oppositions). In the future, we expect to have the possibility to gather this information and create a more robust measure of university quality patents.

To avoid overdispersion in the data, we used a winsorization technique (Boudt, Todorov, and Wang 2020). The 99th percentile replaced the outliers in each of the seven variables. To compare our data a min–max normalization technique was implemented using equation 1. Given that we qualify the maximum value as the better one for every indicator. The methodology used for all

![Figure 3. Top 10 universities for the number of family patents. Source: Clarivate Analytics (2019), author calculations.](image-url)
The normalized indicator \( Y_{U} \) is:

\[
\text{Normalized Indicator}_{Y,U} = \frac{\log_{10}(I_{y,U} + 1) - \log_{10}\min(I_{y} + 1)}{\log_{10}\max(I_{y} + 1) - \log_{10}\min(I_{y} + 1)}
\]

The use of logs before normalization is because our variables are log-normal. Therefore, we want to transform our variables to assure a minimum departure from normality. In Appendix B, scatter graphs before and after log transformation and the Shapiro–Wilk tests for normality are presented. Technology scope, R&D/cooperation, Top Knowledge, Technical quality, and Technology relevance follow a normal distribution; however, production and internationalization are not passing the SW tests. After normalization, we calculated descriptive statistics of variables, which can be seen in Table 2.

To calculate the Index, we have two weights approaches; in the first one, we let each indicator have the same weight; in this case, we want numbers to speak by themselves. There are plenty of precedents for this type of approach. The Global Innovation Index (Dutta and Lanvin 2019) is composed of several variables divided into classes. In this method, the total score for each country is calculated as the simple average of all classes; then, if a specific class contains more variables than another one, those classes will have a higher weight. In the case of the Global Competitiveness Report (Schwab and Zahidi 2020), the Index is calculated as the arithmetic average of all variables. Similarly, in Grimaldi, Cricelli, and Rogo (2018), an index of patent quality for the defense sector was created having the summation of all variables. In our case, the first approach was the same; the simple average of variables creates country index qualification. In this case, and given that we have seven different variables, each variable weight will be 14.29%.

In our second approach, we perform a Principal Component Analysis (PCA) to determine the main component weights of the Index. Then, we calculate the weight for each variable using the total weight for each component. In this case, the calculated weights can be seen in Table 3.

There are two principal components in the Index; in the first one, we have five variables, each with a weight of 13.37%. The second is composed of two variables, each one with a 16.6% weight. A separated index was calculated for each approach, and then we calculated Kendall’s tau B correlation coefficient (Lapata 2006). These tests show that the ranks are pretty similar, and Kendall’s correlation is 96.97%. For future index calculations, more patent quality variables could include more variability, and then, a variable reweight calculation has to be done; in the meantime, we select the first equally weighted approach given the high correlation between both approaches. Thus, the yearly Index is

### Table 1. Variables in Patent Quality Index.

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical quality</td>
<td>The average backward citations per patent family</td>
</tr>
<tr>
<td>Technology relevance</td>
<td>Average forward citation per patent family</td>
</tr>
<tr>
<td>Technological scope</td>
<td>The average number of three-digit international patent classifications per patent family</td>
</tr>
<tr>
<td>R&amp;D expenditure-cooperation</td>
<td>The average number of inventors per patent family</td>
</tr>
<tr>
<td>Internationalization</td>
<td>The average number of countries in which the patent family was assigned</td>
</tr>
<tr>
<td>Production</td>
<td>The average number of patent families issued by the university</td>
</tr>
<tr>
<td>Top knowledge</td>
<td>The average number of scientific papers cited per patent family</td>
</tr>
</tbody>
</table>

### Table 2. Descriptive statistics of variables included in the ranking.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>84</td>
<td>0.231</td>
<td>0.196</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Technology scope</td>
<td>84</td>
<td>0.286</td>
<td>0.263</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>R&amp;D cooperation</td>
<td>84</td>
<td>0.401</td>
<td>0.213</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Top knowledge</td>
<td>84</td>
<td>0.208</td>
<td>0.247</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Technical quality</td>
<td>84</td>
<td>0.254</td>
<td>0.257</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Technological relevance</td>
<td>84</td>
<td>0.035</td>
<td>0.165</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Internationalization</td>
<td>84</td>
<td>0.200</td>
<td>0.260</td>
<td>0.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>
calculated as can be seen in equation 2.

\[
\text{Index}_{Y,U} = TQ_{Y,U} + TR_{Y,U} + TS_{Y,U} + RDC_{Y,U} + INT_{Y,U} + PDT_{Y,U} + TKW_{Y,U}
\]  

(2)

**Results**

*Measuring index reliability and validity*

University indexes, like the ones of Academic Ranking Of World Universities (ARWU), Times Higher Education (THE), or Quacquarelli Symonds (QS), could be used to measure university patent quality index validity. In this case, we would like to measure the correlation between ranks. Unfortunately, none of those indexes have a comprehensive record for Latin-American universities; therefore, a comparison will be incomplete. At the same time, those indexes include other categories not related to technological development, which may cause a bias in the comparison and tend to classify low-ranked institutions in not defined positions. At the same time, it is well known that those rankings tend to be biased towards prominent universities with Nobel Prizes and are well known globally (Fauzi et al. 2020), which in the case of Latin America, are exceptions.

However, those indexes include a category that may be related to patent quality, this is, research results. In this case, Kendall’s correlation among ranks for measures like number of papers, number of cites, cites per paper, and H index (Hirsch 2005) for Scopus and Web of Science, and the patent quality index were measured. Those analyses tend to emphasize that we have a reliable measure of quality, especially compared to the number of papers, cites, and H index with Kendall’s tau between 0.3993 and 0.4416 for Scopus, and 0.4308 and 0.4844 in the case of Web of Science. In panel A of Figure 4, it can be seen the scatter plots between ranks. At the same time, it seems like the number of cites per paper has the lowest correlation with patent quality ranks with 0.1774 and 0.2443 Kendall’s correlations.

![Panel A. Scopus. Panel B. Web of Science](image-url)

*Figure 4.* Scatter plots and Kendall correlations for patent quality ranking, Scopus and Web of Science bibliometric indicators. Source: Scopus and WoS. Own calculations.
In order to measure the reliability of the Index, Cronbach’s alphas were measured (Table 4), trying to determine if the relationship among variables is strong and if the exclusion of variables will influence reliability. Based on the fact that we have only seven variables, the result of Cronbach’s alpha can be considered decent with a result of 0.636 (Taber 2018). Finally, a Spearman-Brown test was performed to determine the number of necessary variables to include in the Index to obtain an 0.8 alpha, and the result was 2.29. The inclusion of variables like claims, renewals, and oppositions, that we cannot gather, in a future index, can help to increase reliability, however, currently, that data is non-existing for Latin America.

Index results
As was posted in previous sections, we calculate separated indexes from 1997 to 2016. Still, we want to focus on the 2016 result to guide readers to interpret the yearly Index. Nevertheless, in Appendix C, we present a table with ranks and scores for 1997–2016. It can be noted in Appendix C that one university can be ranked in the top positions in one year and just not be ranked in the next. The cause for this is that we create a flow index instead of a stock index. That means that we are not measuring the system’s inputs or the institutional capacity to generate high-quality patents; instead, we are measuring the system’s output. Thus, if a university has no patent activity for one year, it will not appear on the Index. So, suppose a university wants to appear regularly at the top of the ranks. In that case, it must have a continuous flow of quality patent production. This fact reflects that for a university to have valuable technology development, it must develop constant and continuous knowledge.

Figure 5 presents the index calculation results split into seven variables, the final index measure and the ranks. It can be noticed that Universidad Tecnológica de Panamá occupies the first position of the rank with a total score of 3.31 out of seven. Curiously, a small institution occupies the first position in the rank; however, in 2016, CAF (Latin America’s Development Bank) developed a program to increase the production and quality of patents in universities; the pilot program was developed in this institution. The results of the Index are a sample of the success of the pilot program. In the future, it will be interesting to understand if the program generates full capacities to maintain the output of quality patents in the long term.

In the second position of the rank, we can find Universidade Federal do Santa Maria in Brazil, which has the highest technical quality and the highest usage of top knowledge with an overall qualification of 3.30, close to the top one. It is worth noting that Brazil has six institutions in the first ten positions of the 2016 index. Furthermore, in Appendix C, it is possible to see that on thirteen occasions among 1997–2016, Brazilian universities occupy the first position of the ranking. Therefore, it seems that Latin-American institutions need to learn about the patent process of Brazilian universities and how to achieve quality.

The ranking of production, measured by the number of family patents produced by each institution, is led by Universidad Tecnológica de Panamá, followed closely by Universidade Estadual do Campinas in Brazil and Universidad de Chile, both with 0.9 of the highest possible score. As can be seen in Table 2, the average score of universities in production is 0.231; on
average, universities in 2016 produced 23% of the number of patent families of Universidad Tecnológica de Panamá.

In the introduction section, we declare that we want to create an index not driven by patents counts; the second position of the overall ranking shows that we are reaching our goal. Even

Figure 5. Results for the University Patent Quality Index in 2016.
when Universidade Federal do Santa Maria has the lowest possible production score, it qualifies in the second-ranking position.

Technical scope, measured by the number of distinct IPC’s inside a patent family is led by Universidad Nacional del Sur in Argentina, and Universidad Católica del Norte in Chile. The value of family patents of those institutions can be higher given that they have a wide range of use. The average score of this variable is 0.286.

Universidade de Alagoas in Brazil has the highest score of R&D expenditure and cooperation measured by the average number of inventors by patent family. The proxy results tell us that, on average, this institution would tend to expend more resources and tend to occupy a higher number of researchers to develop its technologies. The average of 0.40 in this variable is the highest of the Index; it seems that it is the quality characteristic used by Latin American universities.

Following de Faria, Noseleit, and Los (2020), it can be assumed that universities cooperating more with companies, other universities, inside research groups, and faculties will generate more valuable knowledge. It can be concluded that other things being equal, universities in the top rankings will create more embedded knowledge from those research projects (Franco and Pinho 2019). We found that historically (1997–2016), Cuban universities are disposed to have more cooperation signals between and within the universities. For example, Universidad de la Habana appears in the second position of the top knowledge rankings in 2016 after Universidade Federal de Alagoas in Brazil.

As shown in Table 2, on average, academic insights measured in the top knowledge variable is 0,21 of the highest possible score; in this case, that score is for Universidade Federal do Santa Maria (Figure 5). Thus, this university tends to use more advanced knowledge to develop patent families, which is expected to create more valuable technologies. In the same direction, the average score for technical quality, measured by the number of cited patents, is 0,25 of the highest score of Universidade Federal do Santa Maria. As it can be seen, the citation practices to patents and papers in this institution are the better ones. Therefore, it is expected that the technical background of those patents tends to be solid and that the value of those patents to be higher.

Technological relevance, measured by the number of countries in which the patent family is protected, has an average score of 0.20. It can be said that universities tend to protect their technologies in one-fifth of the regions used by Universidade Federal Fluminense in Brazil. Therefore, this institution would tend to have the highest expected returns of its technologies, assuming that they need to cover the cost of transactions related to the internationalization strategy (Cuellar, Méndez-Morales, and Herrera 2021). Seven of the top ten universities ranked by internationalization are in Brazil. They have a broader international strategy than their counterparts in other Latin-American countries.

In general, the top positions tend to score the highest in at least one indicator. For example, Universidade Federal de Santa Maria-Brazil has the highest technical quality and closeness to top knowledge in the data. Universidad Tecnológica de Panamá has the highest production score; Universidade do Sao Paulo (Brazil) is the institution with more citations to its patents (technology relevance). Notably, Universidade Estadual de Campinas (Brazil) scores high in several indicators. Even when that university does not have the highest scores in any indicator, its position is third. This means that a strong balance among all quality characteristics can help universities to be on a top position.
The average score of a maximum of 7 points was 1,62, with a median of 1,74. Universities ranked among the 2nd and 84th positions represent 99% of the distribution. Only Universidad Tecnológica de Panamá is out of this range. Given that the maximum score in the ranking is 7, a total score of 3,31 for the first position is low compared to previous scores between 1997–2016 in Appendix C, and total scores of the first positions tend to decrease while we increase the number of ranked universities.

In Figure 6, Panamá score high on the average country qualifications. However, these country ranks only one institution for 2016; in this case, Universidad Tecnológica de Panamá. If the same analysis were made for countries ranking at least two universities, Mexico, Argentina, and Brazil would appear in the first positions (Table 5). However, those countries with only one university creating patents and without more academic agents in the innovation ecosystem are also valuable. Perhaps if other universities in those countries began to cooperate with these institutions, we would see improvements in future ranking scores. At the same time, in a country like Colombia in

**Table 5.** Average partial score by country in 2016. Source: Author’s calculations.

<table>
<thead>
<tr>
<th>Country</th>
<th>Panama</th>
<th>Mexico</th>
<th>Argentina</th>
<th>Brazil</th>
<th>Chile</th>
<th>Uruguay</th>
<th>Colombia</th>
<th>Cuba</th>
<th>Peru</th>
<th>Costa Rica</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranked universities</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>20</td>
<td>11</td>
<td>1</td>
<td>26</td>
<td>4</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Average index 2016</td>
<td>3.31</td>
<td>2.45</td>
<td>2.23</td>
<td>2.18</td>
<td>1.68</td>
<td>1.50</td>
<td>1.33</td>
<td>1.13</td>
<td>1.02</td>
<td>0.35</td>
</tr>
<tr>
<td>Av. Production</td>
<td>1.00</td>
<td>0.27</td>
<td>0.00</td>
<td>0.16</td>
<td>0.29</td>
<td>0.00</td>
<td>0.18</td>
<td>0.18</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>Av. Scope</td>
<td>0.40</td>
<td>0.47</td>
<td>0.25</td>
<td>0.39</td>
<td>0.33</td>
<td>0.83</td>
<td>0.20</td>
<td>0.09</td>
<td>0.22</td>
<td>0.14</td>
</tr>
<tr>
<td>Av. Expenditure /coop.</td>
<td>0.50</td>
<td>0.57</td>
<td>0.40</td>
<td>0.52</td>
<td>0.40</td>
<td>0.67</td>
<td>0.32</td>
<td>0.41</td>
<td>0.33</td>
<td>0.00</td>
</tr>
<tr>
<td>Av. Top Knowledge</td>
<td>0.58</td>
<td>0.27</td>
<td>0.83</td>
<td>0.32</td>
<td>0.24</td>
<td>0.00</td>
<td>0.25</td>
<td>0.10</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>Av. Technical quality</td>
<td>0.02</td>
<td>0.44</td>
<td>0.43</td>
<td>0.32</td>
<td>0.23</td>
<td>0.00</td>
<td>0.11</td>
<td>0.22</td>
<td>0.11</td>
<td>0.00</td>
</tr>
<tr>
<td>Av. Technology relevance</td>
<td>0.49</td>
<td>0.10</td>
<td>0.00</td>
<td>0.06</td>
<td>0.00</td>
<td>0.00</td>
<td>0.04</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Av. Internationalization</td>
<td>0.32</td>
<td>0.33</td>
<td>0.32</td>
<td>0.41</td>
<td>0.19</td>
<td>0.00</td>
<td>0.18</td>
<td>0.13</td>
<td>0.08</td>
<td>0.00</td>
</tr>
</tbody>
</table>
which there are 26 ranked institutions, the low quality of patents of some universities tend to punish
the average, then, in terms of country policy will be helpful to level all universities to the top quality
institutions.

Conclusions
Universities are institutions named to create knowledge embebed on technologies that need to be
transferred to society. However, in order to transfer those technologies society expects high quality
outputs. Unfortunately, the quality of patents representing university technology has not been
studied in deep, specially in Latin America.

Therefore, we create the first measure of patent quality for universities and use Latin American
countries as study case. The created Index shows the quality of patent output measured by seven
different characteristics related to patent quality in literature. We present in deep results for 2016,
and Universidad Tecnológica de Panamá occupies the first position of the rank for 2016. This insti-
tution received aid from CAF during 2016 to improve the quality and quantity of patents, and it
seems that the program in the short term is obtaining the expected results. We found that Brazilian
universities had the highest scores on the calculated rankings since 1997 and that small countries
like Panamá, Uruguay and Costa Rica tend to have a low proportion of ranked institutions. At the
same time, we present the full ranks and scores for institutions in 1997–2016 period.

Our Index is related to some institutional characteristics measured by research quality variables
like number of papers, citations and the H index in Scopus and WoS, and it can be said that is a
valid instrument according to theory despite the fact that we can not gather information of impor-
tant quality measures like number of claims, renewals or oppositions.

The University Patent Quality Index is measuring a different phenomena than the well know uni-
versity indexes (THE and others), because its focus on the output of technology, a characteristic not
measured previously on those indexes, and we believe that if we manage to gather information
worldwide, it could be a complement for those measures.

The results of this research will be helpful for university management, especially in assessing tech-
nology transfer to compare the quality of the technology production against their regional peers. At
the same time, for policy reasons, given that governments are worried about how universities create
and transfer knowledge to society, this goal could be difficult to achieve if the created technologies
have low-quality levels. Researchers can follow a qualitative path, and the Index can enable manage-
ment and policy recommendations to increase the quality of technologies in universities.

Acknowledgement
This study was financed by Universidad Militar Nueva Granada under the project code INV-ECO-3168.

Disclosure statement
No potential conflict of interest was reported by the author(s).

ORCID
Alberto Méndez-Morales http://orcid.org/0000-0001-7971-5305
Rafael Ochoa-Urrego http://orcid.org/0000-0003-1117-4877
Timothy O. Randhir http://orcid.org/0000-0002-1084-9716

References


