Patent Data as Proxy for Innovation in Philippine Universities: A Preliminary Survey of the Landscape

Manuel O. Diaz, Jr.

College of Business and Accountancy, Tarlac State University, Romulo Blvd., San Vicente, Tarlac City 2300, Philippines.

Email: mo.diaz03321@student.tsu.edu.ph

Abstract

This study presents a preliminary survey of the innovation landscape within Philippine Higher Education Institutions (HEIs), utilizing patent data as a key indicator for innovation activity. It reveals a strong focus on 'Human Necessities' (IPC Section A), particularly in foods/foodstuffs (A23L) and medical/veterinary science and hygiene (A61K). Areas like textiles and paper, fixed constructions, and new technological development show limited activity, suggesting potential areas for future growth and exploration given the Philippines' skilled workforce. This study emphasizes the utility of patent data as an objective measure and proxy for innovation activity in HEIs.

Keywords

Patent Data, Innovation Landscape, Philippine Higher Education Institutions (HEIs), Research Output, International Patent Classification (IPC)

Introduction

HEIs in the Philippines, as with the rest of the world, were traditionally teaching institutions. It is only very recently, perhaps in the last couple of decades or so, that the dual role of teaching and research found wider adoption. The transition, however, from disseminating knowledge to actually producing it is not without challenges. The pivot to research is largely driven by the vision of the HEIs and a myriad of factors that influence their actions, among them the right administrative leadership, proper institutional framework, faculty with strong qualifications, support mechanisms, and competitive salaries and wages (Lunag, et al., 2023).

There are two basic metrics for research in HEIs. The first relates to the number of degrees the HEI has awarded which required a research component, such as a thesis or dissertation, as a condition for the award. The second relates to the number of academic publications the HEI has produced. Theses or dissertations make up what is referred to as grey literature, because these are

Submission:22 January 2026; **Acceptance:** 22 February 2026; **Available online:** March 2026

usually not published for dissemination to a wide audience. On the other hand, academic publication (or academic literature) is intended for the widest dissemination possible, such as academic journals, conference proceeding, and books.

Research metrics provide insights on the production of new knowledge. However, it stops short of providing an indication of which new knowledge translates to, or at least has the potential to translate to new or improved product. The novelty that comes with a new product, or the improvement over an existing product, is called innovation. Considering that HEIs are actively engaged in the production of new knowledge, it should not be surprising for them to be natural breeding grounds for innovation. In fact, HEIs should aim to be natural breeding grounds for innovation. Innovation is taking production of new knowledge a step further by applying it to practical use by way of the development of a new, or the improvement of an existing, product.

In academic literature, innovation is defined as the creative process of development and application of new or improved ideas to produce outcomes that are practical and of value (Taylor, 2017), often solving a problem or fulfilling a need in a novel way. It is a closely related concept to knowledge creation, or research, which is the production of new knowledge from existing knowledge, either from derivation or discovery (Allard, 2004). Innovation depends on knowledge creation (Popadiuk and Choo, 2006). The latter accounts for the new or improved idea, which is a key ingredient of the former. Innovation builds up on knowledge created and adds value by bringing in practical outcomes and the potential of commercialization of a new or improved product.

This study describes the current level of innovation and maps the innovation landscape in the higher education sector in the Philippines. It uses patent data as key indicator for innovation activity in HEIs and aims to develop insights on the apparent direction that research and innovation in the country is taking, which can serve as baseline for future directions. A modest literature search has not produced results that would have indicated that a similar undertaking has been done in the past, or at least recently, and this study fills that gap.

Literature Review

With a broadened definition of innovation, the World Intellectual Property Organization (WIPO, 2025) annually publishes the Global Innovation Index (GII), which provides performance measures and a ranking of the innovation ecosystems across 132 economies based on 81 indicators from international public and private sources.

The Innovation Quotient (IQ), a similar study of 40 countries by The Economist Impact, placed the Philippines at 25th, besting India and neighboring Thailand. The country was just below Belgium in terms of policy and compliance, fourth in terms of business considerations showing better scores than developed economies such as the UK, Australia, Japan and many others, but a very low socio-economic environment score at the bottom 20% (Sahgal, et al., 2023). Both the GII and the IQ, being of global coverage, are of general focus. A more targeted scope of evaluation was made by the United States Agency for International Development (USAID). It published an assessment of the Philippine innovation ecosystem based on a scorecard for the supply, demand,

and enabling environment in terms of education and human capital development, research and knowledge creation, knowledge transfer, IP, start-up and spin-off companies, as well as collaboration (Klich and Dix, 2020).

Billones, et al. (2020) used the Oxentia Elements Review guide to evaluate the Philippine innovation ecosystem. The methodology, however, relied heavily on subjective ratings which may be too subjective to be convincing. There is no recent literature that has directly reported findings on innovation metrics for HEIs in the Philippines. This study contributes to literature on the subject.

Methodology

Data Collection and Sources

This study employs a descriptive, quantitative research design centered on patent document analysis. The primary data source is the PATENTSCOPE database, administered by the World Intellectual Property Organization (WIPO). PATENTSCOPE was selected for its global coverage, incorporating patent records from over 70 national and regional intellectual property offices alongside international Patent Cooperation Treaty (PCT) applications. This breadth minimizes geographical selection bias and provides a comprehensive repository for analyzing the Philippine HEI patenting landscape.

A Boolean search query was executed to retrieve all relevant patent documents. The query logic mandated the presence of the term ‘Philippines’ within the front-page data (including applicant, inventor, or agent fields) AND at least one of the following institutional keywords: "university", "college", or "institute". No temporal filters were applied. This initial search, conducted in February 2024, yielded 679 patent documents.

Data Refinement and Validation

The retrieved dataset underwent a structured, multi-phase cleaning protocol to ensure analytical validity. Non-HEI entities were excluded in the first phase. Each document was manually inspected, and patents were systematically excluded if the applicant was: an individual without a declared institutional affiliation; a governmental or public research institute (e.g., agencies under the Department of Science and Technology; a foreign higher education institution; or a non-tertiary educational body (e.g., secondary schools).

Institutional names were standardized in the second phase. Applicant names were harmonized to their official designations as recognized by the Philippine Commission on Higher Education (CHED). Variations (e.g., ‘UP Diliman,’ ‘Univ. of the Phil. Diliman’) were consolidated under a single, canonical identifier per institution.

In the third phase, collaborative patents were examined closer. For patents co-applied by multiple HEIs, each collaborating institution was assigned a full unit count. This approach, consistent with prior innovation studies (e.g., Hagedoorn & Cloodt, 2003), recognizes the integral contribution of each partner and prevents the undercounting of collaborative output. Following this refinement, the final analytical corpus consisted of 613 unique patent documents. However,

because each collaborating institution was assigned a full unit count for joint filings, the dataset represents 641 total institutional attributions across 43 distinct Philippine HEIs, with publication dates appearing between 2002 and 2023. It is important to note that although the query included records as far back as 1985, no documents meeting the HEI criteria were found for the first 17 years of the search window.

Analytical Framework and Techniques

The analysis was conducted at two interconnected levels: institutional and technological. As part of institutional performance analysis, ***s***imple patent counts were aggregated per HEI to establish a baseline measure of innovation output volume. These counts facilitated the ranking of institutions and the examination of longitudinal filing trends from 2002 to 2023.

Technological landscape mapping, on the other hand, entailed classification of each patent's technological domain using the International Patent Classification (IPC) system. The IPC's hierarchical structure—comprising Sections (e.g., A: Human Necessities), Classes (e.g., A23), and Subclasses (e.g., A23L)—enabled a granular analysis of innovation focus areas. IPC codes were aggregated to identify the most prevalent technological fields at the Section, Class, and Subclass levels.

It is important to note that a single patent document may be assigned multiple IPC codes if it spans different technological domains. Because of this, the final analytical corpus of 613 unique patent documents resulted in a significantly higher count of 1,714 total IPC classifications across the dataset. While raw patent counts establish a baseline for innovation output volume, IPC references serve as a complementary metric for the diversity and breadth of an institution's technological footprint.

This methodological framework provides a reproducible, document-based approach for profiling innovation in an academic context, utilizing patents as a structured and internationally recognized proxy for applied research output.

Results and Discussion

In the knowledge economy, the importance of innovation and knowledge creation cannot be overemphasized. Knowledge creation is one of the key drivers of competitiveness and productivity. Meanwhile, innovation is widely held to be one of the most important factors that contribute to the knowledge economy and business performance (Zeb, 2022). In the academic setting, innovation and knowledge creation are synonymous to research (and experimental development), which the Frascati Manual 2015 defines as the creative and systematic undertaking to increase the stock of knowledge and to find novel applications of existing knowledge (OECD, 2015).

A known metric for innovation is the use of patent data (Burhan, et al., 2017). While there are many alternative ways of evaluating innovation, patent has been extensively used and is a rich source of data for studies (Sampson, 2017, Nagaoka, et al., 2010). It provides insights on the dynamics and activities of the invention ecosystem (Saheb and Saheb, 2020). Patent information

has been used to model the growth of inventions (Furman, et al., 2002), to measure inventive output (Jaffe and Palmer, 1997), and to describe inventive activity (Scherer, 1965) and diffusion of technology (Ernst, 1997). It has been found to be a good indicator of inventive activity in relation to R&D expenditure (Pakes and Griliches, 1980). Priority patent applications under the Patent Cooperation Treaty have also been used as a complete 'matrix' of all patent counts to measure inventive activity (De Rassenfosse, et al., 2013).

Patent count has been used as measure of regional production of new knowledge (Acs, et al., 2002). Specifically, patent count has been used to analyze innovation performance (Hagedoorn and Cloodt, 2003) while patent count per capita has been used to estimate technology innovation ranking (Svensson, 2015). It has also been used to measure levels and trends of innovation activity (Dechezleprêtre and Martin, 2010).

The use of patent data as metric for innovation is not without limitations, or criticisms. However, patents correlate with innovation activity (Acs at al., 2002) and represent new technology (Dziallas and Blind, 2019). As such, it remains a good indicator of innovation. The rigorous patenting process provides assurance that patents offer consistency and objectiveness (Boone, et al., 2018). While using multiple indicators outside of patent information may seem more thorough, statistical overlaps between indicators have been found to be quite strong (Hagedoorn and Cloodt, 2003). Meanwhile, the quality of patents as indicator of innovation can be significantly improved using detailed patent information (Lanjouw and Schankerman, 2004).

In this study, 679 patent documents were retrieved from the WIPO database using PATENTSCOPE. Of the total documents retrieved, 12 are from individuals with no clear HEI affiliation, 21 are from government research organizations, 32 are from foreign universities, and 1 from a regional science high school. If these are removed from the data set, the net count of unique patent documents is 613. There are 30 joint filings involving multiple institutions. Applying the previously described multiplier effect, where each participating HEI is credited, brings the total institutional filing count to 641.

The retrieved patent documents were published between 2002 and 2023. Although the search parameters were set to capture data starting from 1985 to ensure no early innovators were missed, the results indicate that the Philippine HEI innovation landscape, as measured by patent filings, remained dormant until the early 21st century. During this period, there are 43 HEIs that have applied for at least 1 patent.

Figure 1 shows a stacked chart of the number of patent filings for each of the ten HEIs with the highest number of patents filed. The earliest patent filing from an HEI was made in 2002 by University of the Philippines (UP) Diliman and UP Los Baños. Both universities show a level of consistency in producing patents every year since. Filings from the Technological University of the Philippines (TUP) started in 2014, and it has since shown consistency too. The Polytechnic University of the Philippines (PUP) saw a sudden peak and breakthrough in 2016, thereafter showing consistent numbers as well. There is indication that 2017 marked a growing trend in the HEI production of patentable research output, which peaked in 2021, but suddenly dropped the following year. The peak happened during the lockdown period brought by the coronavirus pandemic.

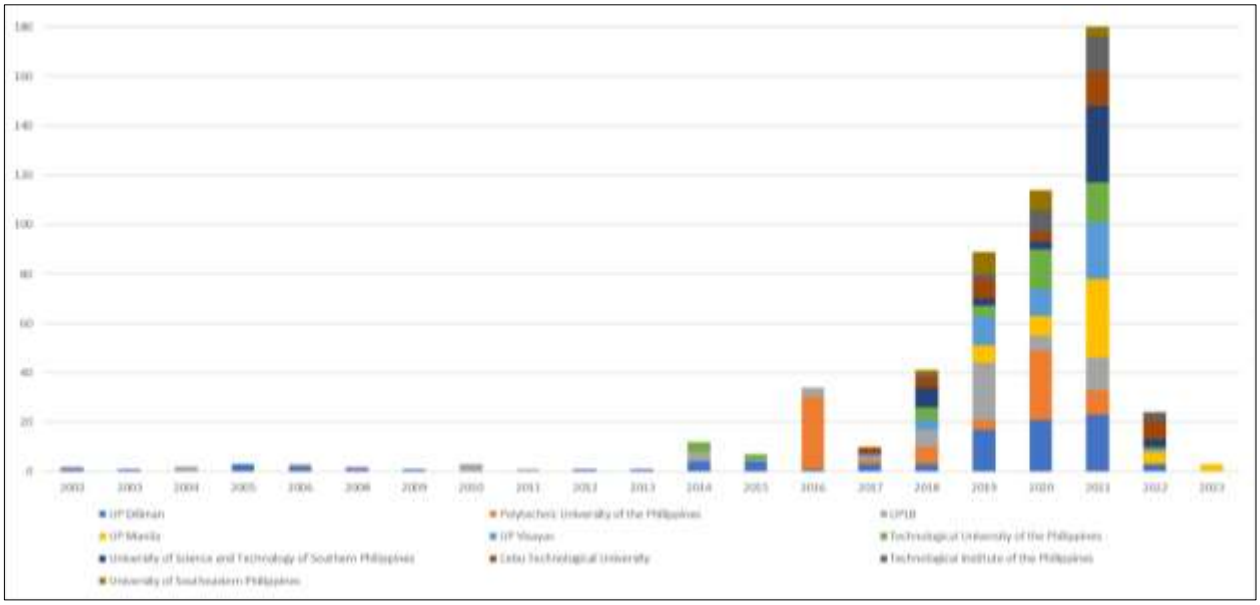

Figure 1. Stacked area chart of annual patent filings (2002–2023) for the ten Philippine HEIs with the highest cumulative patent output.

It is interesting to note that in 2021, the Philippines ranked 51st in the Global Innovation Index, and slid down 8 places the following year. The country ranked 72nd in terms of innovation inputs and 40th in terms of innovation outputs, and both dipped to 76th and 51st in 2022 respectively. These can be seen to directly correlate with the number of patent filings for the same period.

Building on the analysis of institutional rankings, the aggregate technological focus of Philippine HEI innovation was mapped at the macro level. The distribution of all IPC code references across the entire dataset—totaling 1,714 classifications—is presented in the pie chart of Figure 2. The visualization reveals a pronounced concentration, with Section A (Human Necessities) accounting for 1,027 references, or approximately 60% of all activity. This is followed distantly by Section C (Chemistry and Metallurgy) with 298 references and Section G (Physics) with 168 references. Moderate activity is recorded in Section B (Performing Operations; Transporting) with 108 references, while Sections H (Electricity) and F (Mechanical Engineering) contribute 50 and 37 references, respectively. In contrast, Sections D (Textiles and Paper) and E (Fixed Constructions) are markedly underrepresented, with only 11 and 13 references each. The most limited activity is observed in Section Y (New Technological Developments), with merely 2 references. This distribution underscores a strong thematic convergence on fields related to basic human needs.

Given the predominance of innovations classified under Section A, a further qualitative analysis of the dominant technological subcategories within this sector was conducted. The innovation activity is concentrated in two primary classes: Class A23, pertaining to foods or foodstuffs and their treatment, and Class A61, covering medical or veterinary science and hygiene. Within these classes, the most frequently referenced subclasses are A23L (foods, foodstuffs, or non-alcoholic beverages) and A61K (preparations for medical, dental, or toilet purposes), as

defined by the IPC guide (WIPO, 2024). Other identifiable areas of activity within Section A include food preservation (A23B), therapeutic chemical activity (A61P), and baking technology (A21D). Beyond Section A, consistent but less concentrated activity is found in Section C (Chemistry and Metallurgy), with notable subclasses like G01N (measuring and testing) in Section G (Physics). The minimal output in Sections D (Textiles), E (Fixed Constructions), and Y (New Technological Developments) indicates technological domains that are currently peripheral to HEI research despite their potential strategic importance.

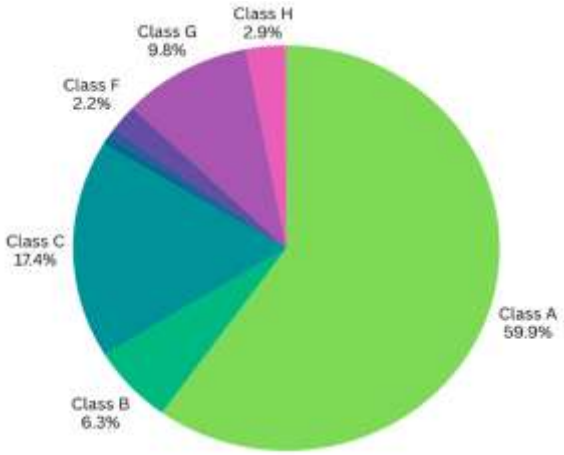

Figure 2. Distribution of patent documents from Philippine HEIs across International Patent Classification (IPC) Sections, 2002–2023.

The patent landscape analysis from 2002 to 2023 presents a dual narrative of growing innovation activity within Philippine HEIs alongside significant structural constraints. The upward trend in patent filings from 2017 to a 2021 peak suggests a positive response to policy shifts encouraging the dual teaching-research mission and greater engagement with intellectual property. However, the sharp decline in 2022, coinciding with a drop in the Philippines' Global Innovation Index ranking, exposes the fragility of this progress and its vulnerability to systemic shocks, such as the COVID-19 pandemic's disruption of research operations and funding.

The extreme concentration of innovation in IPC Section A (Human Necessities), particularly in food science (A23L) and basic medical preparations (A61K), is the most salient finding. This focus likely reflects a combination of factors: alignment with national research priorities and funding streams aimed at food security and public health, the applied nature of research in agricultural and state universities (which dominate the top ranks), and lower relative barriers to entry in these fields in terms of laboratory infrastructure. While this research addresses critical domestic needs, the comparative neglect of fields like Textiles (D), Fixed Constructions (E), and New Technological Developments (Y) represents a strategic gap. Given the Philippines' large workforce of engineering and technology graduates and the presence of numerous institutions specializing in these fields, this underrepresentation suggests a disconnect between academic research and the technological needs of key industrial and infrastructure sectors.

The dominance of State Universities and Colleges (SUCs) in patent output highlights the pivotal role of public funding and policy direction. The concentration of top-performing SUCs in Metro Manila further points to the persistent regional inequality in research capacity and resource allocation. The case of UP Diliman demonstrates that sustained public investment can build a relatively diversified research portfolio, even within a concentrated national landscape. Conversely, the limited presence of private HEIs in the top ranks, with the notable exception of the Technological Institute of the Philippines (TIP), indicates that current incentives are insufficient to fully leverage the private sector's potential for research and innovation. This finding highlights a significant structural paradox: while the private sector accounts for 61% of national R&D spending, 90% of the top-patenting HEIs are public. This indicates that the 'underdeveloped research culture' cited by NEDA (2022) is particularly acute in the private academic sector, or that private-sector R&D is bypassing the patent system in favor of other forms of intellectual property.

This study confirms the utility of patent data as a structured, objective metric for benchmarking HEI innovation, particularly in a context where alternative metrics like high-impact publications are still developing. However, the limitations of patent data are also evident. The low patenting activity in certain sectors may not equate to a lack of innovation but could reflect a prevalence of process innovations, software, or other outputs better protected by copyrights or trade secrets, or a culture less inclined to engage with the patent system due to cost and complexity (Arundel & Kabla, 1998).

In summary, this analysis of patent data reveals an innovation landscape within Philippine HEIs that is both progressing and constrained. The findings demonstrate measurable growth in patenting activity, a clear dominance of state universities, and a pronounced concentration of research in fields addressing fundamental human needs. Simultaneously, they expose significant vulnerabilities: systemic fragility evidenced by recent declines, stark geographical and sectoral imbalances, and a disconnect between research output and the technological needs of several key industries. The following conclusion synthesizes these insights and presents targeted recommendations to strengthen and diversify the national innovation ecosystem.

Conclusion

This study has provided a preliminary, evidence-based survey of the innovation landscape within Philippine HEIs using patent data as a key proxy. The analysis of 613 unique patent documents (representing 641 institutional attributions) from 43 institutions between 2002 and 2023 yields a clear profile: innovation output is growing yet volatile, geographically concentrated, and technologically narrow. The top-performing institutions are predominantly SUCs located in Metro Manila, with the UP system as the most prolific contributor. Patent activity saw a notable increase from 2017, peaking in 2021, before a sharp decline in 2022, a trend that correlates with the country's recent regression in the Global Innovation Index and underscores the system's susceptibility to disruption.

The technological focus is overwhelmingly concentrated on IPC Section A (Human Necessities), which constitutes approximately 60% of all IPC classifications, with dominant activity in food science (A23L) and medical preparations (A61K). In contrast, minimal patenting

activity is evident in Sections D (Textiles and Paper), E (Fixed Constructions), and Y (New Technological Developments), representing a significant gap given the country's skilled technical workforce and industrial needs. The analysis confirms that patent data serves as a valuable, objective metric for benchmarking applied research and revealing strategic priorities and omissions within the HEI sector.

These findings highlight the need to cultivate a more robust, diversified, and resilient innovation ecosystem in the Philippines. HEIs must move beyond treating research as a degree requirement and cultivate it as a core, valued mission. To counteract low national R&D expenditure (0.2% of GDP) and concentrated research outputs, government funding agencies should develop targeted grant programs to incentivize research in underrepresented but strategically vital fields such as advanced textiles, sustainable construction, and emerging technologies. Funding should also prioritize building research capacity in regional HEIs to mitigate geographical disparity.

Awareness and utilization of existing support mechanisms must be amplified, and HEIs should actively bridge the gap between their researchers and these resources to lower the cost and complexity barriers to patenting. To better align the private sector's share of R&D expenditure with academic output, policymakers should facilitate public-private research partnerships and collaborative consortia, as well as foster cross-pollination of ideas. Models that link private sector challenges with academic research expertise, supported by matched funding, can help replicate the research productivity seen in leading SUCs across a broader institutional base.

Future research should build upon this landscape overview through detailed, qualitative case studies of high-performing and niche HEIs to understand the drivers of their success. Longitudinal tracking of patent trends, especially the post-2021 decline, is needed to disentangle the effects of the pandemic from structural issues. Finally, complementary studies integrating publication data, research expenditure figures, and survey-based metrics would provide a more holistic view of the Philippine HEI innovation system, guiding more effective policy and institutional strategy.

Acknowledgements

There is no grant or funding bodies to be acknowledged for preparing this paper.

References

Acs, Z.J., Anselin, L. and Varga, A. (2002). Patents and innovation counts as measures of regional production of new knowledge, *Research Policy*, *31*(7): 1069-1085. https://doi.org/10.1016/S0048-7333(01)00184-6

Allard, S. (2004). Knowledge Creation. In Holsapple, C.W. (eds) *Handbook on Knowledge Management 1*. International Handbooks on Information Systems, Vol 1. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-24746-3_18

Arundel, A., and Kabla, I. (1998). What percentage of innovations are patented? empirical estimates for European firms. *Research Policy, 27*(2): 127-141. https://doi.org/10.1016/S0048-7333(98)00033-X.

Billones, R. K. C., Cases, C. M. P., Olegario, T. V., Vicerra, R. R. P., Bugtai, N. T. and Dadios, E. P. (2020). A Systematic Evaluation of the Philippine Innovation Ecosystem, 2020 *IEEE 12th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*, Manila, Philippines, 2020, pp. 1-5, https://doi.org/10.1109/HNICEM51456.2020.9400074

Boone, C., Lokshin, B., Guenter, H., Belderbos, R. (2018). Top management team nationality diversity, corporate entrepreneurship, and innovation in multinational firms. *Strategic Management Journal, 40*(2): 277-302. https://onlinelibrary.wiley.com/doi/10.1002/smj.2976

Burhan, M., Singh, A. K., and Jain, S. K. (2017). Patents as proxy for measuring innovations: A case of changing patent filing behavior in Indian public funded research organizations. *Technological Forecasting and Social Change, 123*: pp. 181-190. https://doi.org/10.1016/j.techfore.2016.04.002

CHED (2024). *Higher Education Indicators, 2020 Statistics* [Dataset]. Commission on Higher Education, Quezon City, Philippines. Retrieved 14/02/2024. http://www.ched.gov.ph/statistics

De Rassenfosse, G., Dernis, H., Guellec, D., Picci, L. and de la Potterie, B.V.P. (2013). The worldwide count of priority patents: a new indicator of inventive activity, *Research Policy, 42*(3): 720-737. https://doi.org/10.1016/j.respol.2012.11.002

Dechezleprêtre, A. and Martin, R. (2010). Low carbon innovation in the UK: evidence from patent data, in *Report for the UK Committee on Climate Change, Centre for Climate Change Economics and Policy, Grantham Research Institute on Climate Change and the Environment, 4*. https://www.cccep.ac.uk/wp-content/uploads/2015/10/PP-low-carbon-innovation-UK.pdf

Dziallas, M. and Blind, K. (2019). Innovation indicators throughout the innovation process: an extensive literature analysis. *Technovation, 80-81*, pp. 3-29. https://doi.org/10.1016/j.technovation.2018.05.005

Ernst, H. The Use of Patent Data for Technological Forecasting: The Diffusion of CNC-Technology in the Machine Tool Industry. *Small Business Economics 9,* 361–381 (1997). https://doi.org/10.1023/A:1007921808138

Furman, J. L., Porter, M. E., Stern, S. (2002). The determinants of national innovative capacity. *Research Policy, 31*(6). https://doi.org/10.1016/S0048-7333(01)00152-4

Hagedoorn, J., and Cloodt, M. (2003). Measuring innovative performance: is there an advantage in using multiple indicators? *Research Policy, 32*(8):1365-1379. https://www.sciencedirect.com/science/article/abs/pii/S0048733302001373

Jaffe, A. B. and Palmer, K. (1997). Environmental regulation and innovation: a panel data study, *The Review of Economics and Statistics, 79*(4): 610-619. https://www.jstor.org/stable/2951413

Klich, A. and Dix, M. O. (2020). *Philippines Innovation Ecosystem Assessment: 2019 Update*. USAID/Philippines Office of Education, RTI International, NC USA.

Lanjouw, J. O. and Schankerman, M. (2004). Patent quality and research productivity: measuring innovation with multiple indicators. *The Economic Journal, 114*(495): 441-465. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1468-0297.2004.00216.x

Lunag, M. Jr., Posadas, C.L., Lamadrid, R. L., Ducas, A. (2023). Building sustainable research and innovation ecosystem in the Philippine higher education institutions. Educational *Research for Policy and Practice, 23*(1):1-26. www.doi.org/10.1007/s10671-023-09355-2

Nagaoka, S., Motohashi, K. and Goto, A. (2010). Patent statistics as an innovation indicator, in Hall, B. H. and Rosenberg, N. (Eds). *Handbook of the Economics of Innovation, 2*: 1083-1127. North-Holland, https://www.sciencedirect.com/science/article/abs/pii/S0169721810020095

NEDA (2022). *Philippine Development Plan 2023-2028*, National Economic and Development Authority, Mandaluyong City, Philippines. https://pdp.neda.gov.ph/philippine-development-plan-2023-2028/

OECD (2015). *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement for Scientific, Technological and Innovation Activities*, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264239012-en

Pakes, A. and Griliches, Z. (1980). Patents and R&D at the firm level: a first report. *Economics Letter No. 5*, pp. 377-381. https://www.sciencedirect.com/science/article/abs/pii/0165176580901366

Popadiuk, S. and Choo, C. W. (2006). Innovation and knowledge creation: How are these concepts related? *International Journal of Information Management, 26*(4), pp. 302-312. https://doi.org/10.1016/j.ijinfomgt.2006.03.011

Saheb, T. and Saheb, T. (2020). Understanding the development trends of big data technologies: an analysis of patents and the cited scholarly works. *Journal of Big Data, 7*. https://doi.org/10.1186/s40537-020-00287-9

Sahgal, V., Rhee, A., Ankita, Dreith, S., Sayal, L., Simon, B., Sharma, S., Wood, N., Simms, A., Alarcon, D., and Andreasson, K. (2023) Innovation Quotient Global Findings Report. *Economist Impact.* https://impact.economist.com/new-globalisation/innovation-quotient/downloads/keyfindings2023.pdf

Sampson, R. C. (2017). R&D Alliances and Firm Performance: The Impact of Technological Diversity and Alliance Organization on Innovation. *Academy of Management Journal, 50*(2). https://doi.org/10.5465/amj.2007.24634443

Scherer, F. M. (1965). Firm size, market structure, opportunity, and the output of patented inventions, *The American Economic Review, 55*(5): 1097-1125. https://www.jstor.org/stable/1809230

Svensson, R. (2015). *Measuring innovation using patent data* [Technical Report]. IFN Working Paper, Stockholm. https://www.ifn.se/wfiles/wp/wp1067.pdf

Taylor, S. P. (2017). What is innovation? A study of the definitions, academic models and applicability of innovation to an example of social housing in England. *Open Journal of Social Sciences, 5* (11). pp. 128-146. https://doi.org/10.4236/jss.2017.511010

WIPO (2025). *Global Innovation Index 2025*. World Intellectual Property Organization. [Website] https://www.wipo.int/en/web/global-innovation-index

Zeb, S. (2022). The role of knowledge economy in Asian business. *Future Business Journal, 8*(1). https://doi.org/10.1186/s43093-021-00112-6