

Role of International Universities in Generating Green Technologies

Lourden Selvamani V,[†] Dhilipan C and P G Arul

Department of International Business, School of Management, Pondicherry University, Kalapet, Puducherry 605 014, India

Received: 3 March 2019; accepted: 19 February 2020

The purpose of this paper is to analyse the participatory role of universities in generating green patent in the transport segment. The study utilizes the World Intellectual Property Organizations (WIPO) product International Patent Classification (IPC) green inventory patent and patent scope database for the period from 1970 to 2018 for 152 contracting states. We found that patent applications had been growing around the world, but at a slower phase. At present 756 universities are actively generating green patents particularly universities from China. In aggregate Universities applied 6108 PCT applications and national patents in the category of transport environmentally sound technologies. This research contributes to the evidence on the role of universities in sustainable development.

Keywords: Green patents, sustainable transport, sustainable development, patenting, green technologies, IPC Code, WIPO

Global urgency of climate change kindled promoting sustainable development in all countries.¹ The concept of sustainable developmental activities should increase usage span of renewable and non-renewable resources for the next generation, it is a long term focus incorporating economic, social and environmental aspects.² Government is prepared to leverage climate change through adaptive planning, being aware of the impact of climate change and constructing effective plans through their efforts are however limited.¹⁴ In response to pressure from the government, industries have adopted a carbon management practise to reduce greenhouse emission and strategies to address climate change.^{15, 16} Moreover, various factors can engage with sustainable development practices and make contributions. Recently, universities started to address sustainability crisis by incorporating sustainable development action in curricula, research, operations, outreach and assessment and reporting.³

Apart from traditional missions of teaching and carrying out research; universities in response to address challenges of creating new knowledge, rising cost and funding resources burdens; it is fostering to collaborate with industry and society.^{6, 23}

Thus, universities boundary has been shredded and taken shape with “third mission” which is defined as “the economic use of research, knowledge, intellectual property rights, patents, spinoffs, technology transfer; in broad sense, everything towards society”.²⁴ At the core, function of third

mission is to contribute to the economic development and the wellbeing of the society by fostering knowledge transfer for its users and act as a stakeholder to regional development change through generating knowledge and technology in term of patents, spins offs and entrepreneurship.^{5, 6, 16}

The role of universities is to innovate well documented by numerous studies and has evaluated universities knowledge for economic growth and innovation impact through their capability in knowledge creation and wealth across regions.⁷ Acknowledging the urgent need for sustainable development and the importance of innovation, there is a legitimate concern to trace universities’ research responsibilities to address sustainability crisis. Studies in line with universities’ participation in the sustainable development agenda are scare.^{8, 9} Earlier, research were centered on sustainable development in combination with education, management practice in eco-friendly transport and policy analysis for higher education.^{3, 4, 17, 18} To fill the gap, given the climatic change crisis and sustainable developmental goals, the necessity to explore university patenting activities at international level in creating innovative environmentally sound technologies in promoting sustainable development was felt. In this paper, the idea of university confluent role with regard to sustainable development that substantiated by generating environmentally sound technologies i.e., patent applications is explored.

The purpose of this research is to evidence the active role of universities in addressing key issues of

[†]Corresponding author: Email: manilourden659@gmail.com

society, through measuring the contribution of environmentally sound technologies in transportation. The green inventory of the World Intellectual Property Organization (WIPO) is being resorted to explore the green transportation technologies applications. It was found that globally 761 universities are active in generating environmentally sound technologies related to Transportation; Second Chinese universities are the major players in creating such transport green patents, followed by U.S. and South Korea. Tracing the countries of universities origin we found that China is still a dominant player followed by South Korea and the U.S. The results contribute to the evidence of higher education and sustainable development by shedding light university's role in innovation.³

Projections noted that by 2040, the world shall need 30% more energy than what it uses today.¹⁰ Nowadays "Eco campus" is gaining momentum especially, innovation within the boundary of academicians with an attempt to embrace the underlying nature of sustainability. Eco campus means "Environmentally sustainability within campus" which mainly focuses on efficient use of energy and water ,minimizes waste pollution and also economic efficiency".³ Adding to this UNESCO's world conference on science held in Budapest 1999 held "Declaration on science and the use of scientific knowledge" strongly indicate universities responsibilities to contribute with their research for sustainable development.²⁵

Previous studies analyses the patent activity of various countries by utilising details collected from USPTO for the period of 1971 to 2010 related to nuclear power generation, alternative energy production and energy conservation and found out developing trend in low carbon energy technologies.¹³ Recent works also highlighted the green technologies status over a period 2005 to 2017 by adopting recently constructed IPC green inventory of World Intellectual Property Organization and analysed the patent published data to understand exponential growth during 2013.¹¹ However, the author concluded that the green technologies are growing at a slower pace. Sustainable development context was embraced by higher education context from the 1990s, common principles of sustainability in higher education encompass a moral obligation to contribute towards regional development, engage in public outreach, and undertake sustainable research.¹² Therefore, recognizing the importance of innovation in sustainable technologies and the role universities played remain

underexplored in terms of sustainable technologies generation which this paper addresses. It is argued that understanding the trend of university participation in sustainable innovation would allow the policy makers to push more policies at university level rather than vaguely promote the university to collaborate with industry.

WIPO PCT in green energy technologies launched by WIPO in 2010 to access patent applications filed in WIPO directly as well as in national or regional offices of 152 contracting states. International Patent Classification (IPC) Green patent inventory has patent applications information on alternative energy production, energy conservation, transportation, waste management and agriculture and forestry. However, the scope of this paper is limited to analysing patent applications filed under 'transportation category' which is classified to "vehicles in general; vehicles other than rail vehicles; rail vehicles and marine propulsion". WIPO retrievable information contains patent information about publication date along with application ID, publication ID, inventors, applicant details and IPC code. It should be noted that applicant can file an application in any office in the world, e.g. the Tsinghua University of China may file an application in China; or file in the US; or directly to WIPO. However, the applicant's origin is considered a base for the analysis. For example, an application from the different office of Tsinghua University was considered as the patent application filed by the Tsinghua University of China. A patent application was considered as a "university application" when it was filed under the name of university or spelling variant, technology transfer offices of respective universities, university-industry collaboration units. Typically, patent application may contain many IPC codes. However, patent applications with one green transportation IPC were taken into account and even if a patent application has co-applicants along with the university, it was considered as a university application. For extracting the intended data, proceeded with 4 key stages.

Stage1

In green patent inventory the required IPC codes under 'Transportation' were gathered.

Stage 2

A simple search was queried with "IPC code" in 'International Class' field and 'University' in applicant field so as to include all universities in 152 contracting states, e.g., query was made in

‘International Class’ field as “B61” and applicant name ‘University’, the date was set as 1/1/1970 to 31/12/2018, a total of 48 years. Both PCT applications and National applications were included.

Stage 3

The individual dataset were grouped and duplicate entries were cleaned using ‘Open Refine’.²²

Stage 4

With cleaned data, all patent information are classified accordingly with respect to countries of applicant universities, subtopics of ‘Eco transportation’ IPC codes and ‘year’ on which patent applications are published in excel containing 6108 patent applicant information.

Results and Discussion

The universities of 152 contracting states have applied 6108 PCT applications and National applications in the past 48 years, *i.e.*, 1970 to 2018. Overall 761 universities have made a contribution to push transport related to environmental sound technologies. Figure 1 presents the patent publication trend of environmentally sound technologies related to transport which indicate increasing trend. The patent publication was at 208 in 2010 and multiplied to 2046 in 2017 almost nine fold impressive growth, slow growth is observed from 2003 till 2017. However, in 2018 only a few were recorded.

Figure 2 shows the total patent application made in transport and share of university applications, In general, vehicle segment maximum number application have been registered at 4,461,779 whereas universities contribution stands at 4,890, which is significantly high in contribution as compared to any other segments such as, ‘Vehicles other than rail vehicles’, followed by ‘Marine vessel propulsion and rail vehicles’. On the other hand, ‘Rail vehicles’ segment

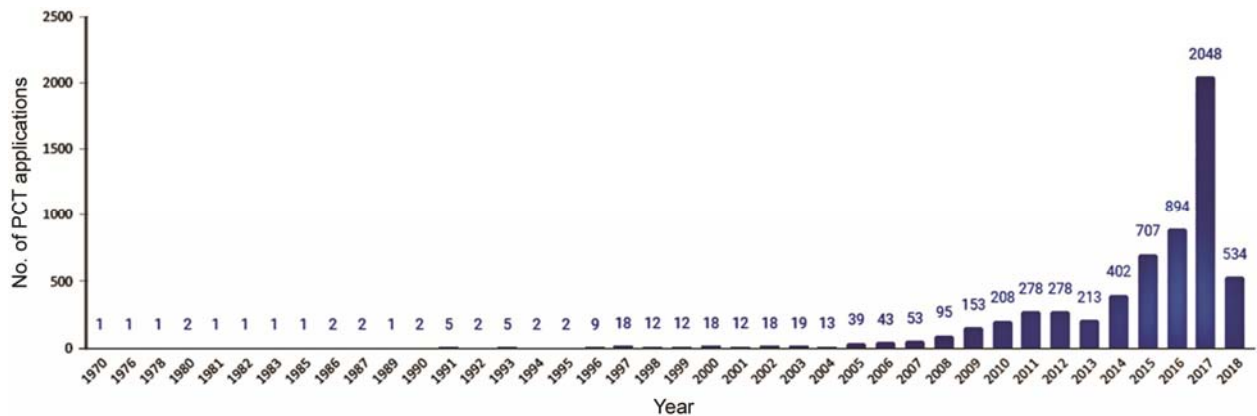


Fig. 1 — Publication trend of PCT application related to ‘Transport Environmentally Sound Technologies’ during 1970-2018.

recorded least contribution in both total patent applications and university patent applications on the whole 620,425 patent applications filed over 48 years whereas universities only contributed 6,108 which is just 1% of total patent applications made.

Figure 3 represents, top applicant countries based on universities origin, the extraction revealed that

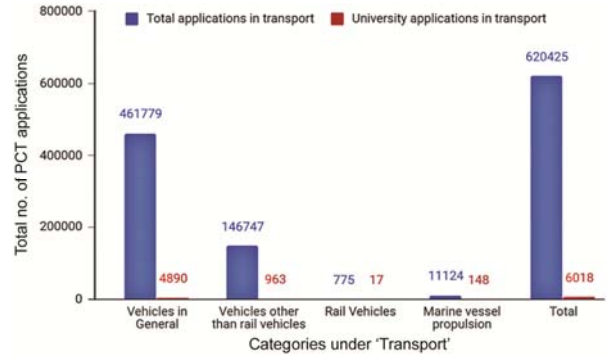


Fig. 2 — Total PCT ‘Transport’ applications in comparison with ‘University’ applications.

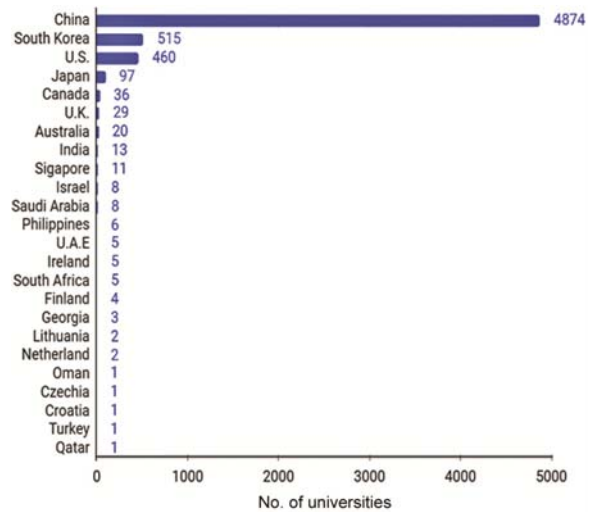


Fig. 3 — Top applicant countries based on universities origin.

only 24 applicant countries out of 152 contracting states have marked activity in generating environmentally sound technologies. A substantial disparity can be observed within participatory countries or only a few countries applicants are very active in creating environmentally sound technologies like, China 4,874 (79%) which is a significant participator, followed by South Korea 515 (8%), U.S 460 (7%). Conversely, other contributions are less than 1%. On the other hand, Figure 4 presents universities active in each contracting state, it was observed that universities of China are the global leader with 64.9% (494) participation to 761 universities, followed by universities in U.S. 1 with 1.3% (86) and South Korea with 11.2% (85).

Table 1, represents the number of patent applications filed under each scheme classified by

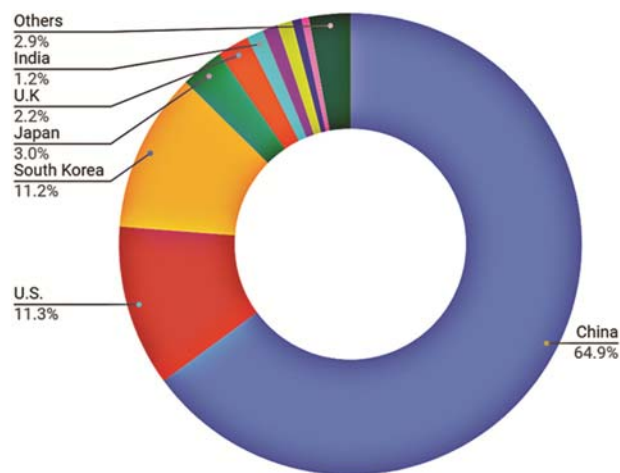


Fig. 4 — Distribution of participatory universities in contracting states.

Table 1 — University’s transportation environmentally sound technologies

Transportation	Transportation (Sub topic)	IPC	Number of university patent applications	
Vehicles in general	Hybrid vehicles, gear system, control, thereof	B60K 6/00, 6/20	875	
		B60W 20/00		
		F16H 3/00-3/78, 48/00-48/30		
		H02K 29/08		22
		H02K 49/10		130
		B60L 7/10-7/22		208
		B60L 8/00		84
		B60L 9/00		40
		B60L 50/50-58/40		265
		B60K 16/00		37
Vehicles other than rail vehicles	Charging stations for electric vehicles; Drag reduction	H02J 7/00	3319	
		B62D 5/00, 35/02	218	
		B63B 1/34-1/40		
Rail vehicles	Human-powered vehicle	B62K	745	
		B62M 1/00, 3/00, 5/00, 6/00		
		B61, B61D 17/02		17
Marine vessel propulsion	Drag reduction	B63H 9/00	44	
		B63H 13/00	5	
	Propulsive devices directly acted on by wind	B63H 19/02, 19/04	29	
		B63H 16/00	26	
	Propulsion by muscle power	B63H 21/18		
		B64G 1/44	44	
	Cosmonautic vehicles using solar energy			
Total			6108	

WIPO and IPC code for each technology we can infer that under vehicles general has a majority of filing had been registered. The least number of applications are made under 'Rail vehicles. 'Charging station for the electric vehicle' has recorded the highest applications in the basket, which infer the rising trend or more research are concentrated in that technology domain. Followed by 'Vehicles in general', are vehicles other than 'Rail' domain are concentrated by universities, it should be noted that substantial difference is noticed between numbers of patent applications across 'Transportation technologies'.

During 2004 to 2010, there were huge investments in renewable sources; such boom in investments intensified demand in lieu of technological change and tight competition. Eventually, since universities supplies innovation, industry has on academics research, which validates the patent application to augment amongst universities since 2003. It was found that Chinese universities are dominant in developing environmentally sound technologies pertaining to transport rooted to inflows of foreign direct investment, pro-patent amendments to Chinese patent laws, environmental friendly innovation policy and intensifies Chinese research and development.^{21, 26} Similarly, most of the counties has innovated policies instruments and strategies for sustainable development and for eco-friendly innovation; albeit most of countries have not imitated financial programme for green technology.²⁷ However, apart from Chinese universities, other universities are insignificant. Policy makers should focus on encouraging innovations, technologies and patenting activity in universities which are in line with environmental technologies should be recognized, as the role of universities in patent generation is less than one per cent.

Limitation

This research suffers from a few drawbacks in data collection. The study relied on WIPO patent database rather than European patent database or the United States Patent and Trademark Office database. The information was limited to map patents from filling to granted and the survey was conducted only for transportation technology category, however, future studies may include other categories of technologies also.

Conclusion

Given the role of knowledge producer, indeed the universities have greater responsibility to create a better sustainable future and provide impetus to

achieve sustainable development goals. The result implies that green technologies has sharply increased, which might be resonated by surge in investments in renewable sources. The results project the growth and strong evidence on the role of universities in generating green technologies related to transportation though very less compared with total patent applications. It was observed that applications were filed by universities from a certain region; only China, United States, South Korea and Japan are accounted for more participation which is as same as justified earlier.¹¹ Chinese universities are notably the world leader in patent filing in recent years followed by United States, South Korea, and Japan. Embedding research policies and practices for sustainable development at national level and universities would play a critical role in aligning the academic research towards addressing economic, regional and societal needs. Finally, the role of universities towards environmental sound technologies generates at the nascent level and growing.

References

- 1 Stern N, Stern Review, The Economics of Climate Change, *New Economics Foundation*, (2006).
- 2 Hall J K, Daneke, G A & Lenox M J, Sustainable development and entrepreneurship: Past contributions and future directions, *Journal of Business Venturing*, 25 (5) (2010) 439-448.
- 3 Waas T, Verbruggen A & Wright T, University research for sustainable development: Definition and characteristics explored, *Journal of Cleaner Production*, 18 (7) (2010) 629-636.
- 4 Lozano R, Diffusion of sustainable development in universities' curricula: An empirical example from Cardiff University, *Journal of Cleaner Production*, 18 (7) (2010) 637-644.
- 5 D'Este P & Patel P, University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy*, 36 (9) (2007) 1295-1313.
- 6 D'Este P & Perkmann M, Why do academics engage with industry? The entrepreneurial university and individual motivations, *The Journal of Technology Transfer*, 36 (3) (2011) 316-339.
- 7 Henderson R, Jaffe A B & Trajtenberg M, Universities as a source of commercial technology: A detailed analysis of university patenting, 1965-1988, *Review of Economics and Statistics*, 80 (1) (1998) 119-127.
- 8 Leodir Löbler M, Gomes da Silva B, Pozzobon D M & Maffini Gomes C, Strategic orientation towards sustainable innovation: A case study in a Brazilian University, *Journal of Technology Management & Innovation*, 7 (2) (2012) 196-206.
- 9 Cecere G, Corrocher N, Gossart C & Ozman M, Technological pervasiveness and variety of innovators in Green ICT: A patent-based analysis, *Research Policy*, 43 (10) (2014) 1827-1839.

- 10 IEA (International Energy Agency) (2017): World Energy Outlook, Paris: OECD Publishing (2017), <http://dx.doi.org/10.1787/weo-2017-en> (accessed on 12 August 2019).
- 11 Lorena R, León, Kyle, Bergquist, Sacha Wunsch-Vincent, NingXu & Kunihiko F, Measuring innovation in energy technologies: Green patents as captured by WIPO's IPC green inventory, *WIPO* (2015).
- 12 Corcoran P B & Wals A E, Higher education and the challenge of sustainability, *Dordrecht: Kluwer Academic Publishers*, 10 (2004) 1-306.
- 13 Albino V, Lorenzo A, Rosa M D & Antonio M P, Understanding the development trends of low-carbon energy technologies: A patent analysis, *Applied Energy*, 135 (2014) 836-854.
- 14 Baker I, Peterson A, Brown G & McAlpine C, Local government response to the impacts of climate change: An evaluation of local climate adaptation plans, *Landscape and Urban Planning*, 107 (2) (2012) 127-136.
- 15 Sullivan R & Gouldson A, The governance of corporate responses to climate change: An international comparison, *Business Strategy and the Environment*, 26 (4) (2017) 413-425.
- 16 Asplund P & Nordman N, *Attitudes Toward the Third Mission: A Selection of Interviews from Seven Universities in Sweden*, (1999) CERUM Working Paper No. 15.
- 17 Vidican G, The role of universities in innovation and sustainable development, *Sustainable Development and Planning IV*, 1 (2009) 131-139.
- 18 Zhou J, Proactive sustainable university transportation: Marginal effects, intrinsic values, and university students' mode choice, *International Journal of Sustainable Transportation*, 10 (9) (2016) 815-824.
- 19 Mowery D C, Nelson R R, Sampat B N & Ziedonis A A, The growth of patenting and licensing by US universities: An assessment of the effects of the Bayh–Dole Act of 1980, *Research Policy*, 30 (1) (2001) 99-119.
- 20 Sheikh F A, Science, Technology and Innovation Policy 2013 of India and informal sector innovations, *Current Science*, 106 (1) (2014) 21-23.
- 21 Christofilopoulos E & Mantzanakis S, China-2025: Research and Innovation Landscape, *Φορσαϊμ*, 10 (3) (2016).
- 22 Verborgh R & De Wilde M, *Using Open Refine*, (Packt Publishing Ltd.) 2013.
- 23 Ankrah S & Omar A T, Universities–industry collaboration: A systematic review, *Scandinavian Journal of Management*, 31 (3) (2015) 387-408.
- 24 Dan M C, The third mission of universities in the development strategy of Vienna city, *Informatica Economica*, 16 (4) (2012) 49–56.
- 25 New Commitment A, Declaration on science and the use of scientific knowledge, *Science*, (1999).
- 26 Hu A G & Jefferson G H, A great wall of patents: What is behind China's recent patent explosion? *Journal of Development Economics*, 90 (1) (2009) 57-68.
- 27 Jang E K, Park M S, Roh T W & Han K J, Policy instruments for eco-innovation in Asian countries, *Sustainability*, 7 (9) (2015) 12586-12614.