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Technological business strategies for environmental sustainability among Asia-Pacific Economic Cooperation forum (APEC) member states: a bibliometric study

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Abstract

The implementation of sustainable development within the member states of the Asia-Pacific Economic Cooperation forum (APEC) takes into account business technologies and strategies as key to progress. As such, this paper proposes a methodology for a systematization of the literature that recognizes the importance and growth of the topic over time. It encompasses an analysis of the countries with the greatest scientific output, the most productive authors, and a characterization of the areas and variables researched, as well as some possible future lines of research. The bibliometric analysis was based on a review of 234 scientific papers in the *Scopus* database. The main results reveal increasing interest in information systems and technologies in relation to environmental problems, with interdisciplinary perspectives to environmental sustainability.

Keywords: technology, business strategies, APEC, environmental sustainability, bibliometrics.

Estrategias tecnológicas empresariales para la sostenibilidad medioambiental entre los estados miembros del Foro de Cooperación Económica Asia-Pacífico (APEC): un estudio bibliométrico

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Abstract

La implementación del desarrollo sostenible en los Estados miembros del Foro de Cooperación Económica Asia-Pacífico (APEC) tiene en cuenta las tecnologías y estrategias empresariales como clave para el progreso. Por ello, este trabajo propone una metodología de sistematización de la literatura que reconoce la importancia y el crecimiento del tema a lo largo del tiempo. Abarca un análisis de los países con mayor producción científica, los autores más productivos y una caracterización de las áreas y variables investigadas, así como algunas posibles líneas de investigación futuras. El análisis bibliométrico se basó en una revisión de 234 artículos científicos en la base de datos Scopus. Los principales resultados revelan un creciente interés por los sistemas y tecnologías de la información en relación con los problemas ambientales, con perspectivas interdisciplinarias para la sostenibilidad ambiental.

Palabras clave: tecnología, estrategias empresariales, APEC, sostenibilidad medioambiental, bibliometría.

Introduction

Global warming and climate change are important considerations in contemporary research, along with sustainable development. In the case of business and management, "green" information technology, and strategies for its adoption, has become increasingly important to companies. Businesses are an essential element in addressing environmental depredation, but there is a need to transform enterprise on a global scale (Elliot, 2011). Environmental initiatives are adopted through green information and technology systems (green IT/S) based on specific business, technological, and systems strategies (Jenkin, Webster & McShane, 2011).

The influence of technological integration is associated with strategic activities related to the exchange of resources, such as equipment and personnel, that help to improve manufacturing performance in the supply chain (Vachon & Classen, 2007). A key example of business strategies through technology, remanufacturing systems represent a business opportunity and, in many cases, support for sustainable development (Jiang, Zhang & Sutherland, 2011). Meanwhile, empirical estimates reveal that ICT (under a four-component index) and globalization contribute to reducing CO2 emissions (Ahmed, Nathaniel & Shahbaz, 2021).

When it comes to the bibliometric approach to literature review, antecedents include a study on life cycle valuation mapping in which topics such as energy, industrial ecology, and greenhouse gases are explored (Hou, Mao, Zhao, Du & Zoo, 2015). Another example is a study on new perspectives for comprehensive valuation in innovation and technology for sustainable mining activity (Aznar-Sánchez, Velasco-Muñoz, Belmonte-Ureña & Manzano-Agugliano, 2019). Further notable bibliometric studies focus on sustainable development of new products, global health development, sustainable valuation of renewable energy, environmental research and business strategy, greenhouse technology trends, relationship between life cycle and traceability, environmental sustainability in relation to information technology and reduction of particulate matter, and volatile organic compounds in biorefineries (Thomé, Scavarda, Ceryno & Remmen 2016; Zhou et al., 2018; Sarkodie & Owusu, 2020; Farrukh, Meng, Wu, Nawaz, 2020; Aznar-Sánchez et al., 2020; Corallo, Latino, Menegoli & Pontrandolfo, 2020; Sartori et al., 2014; Ubando et al., 2021).

Thus, over the past decade, bibliometric studies have extensively covered areas such as information technologies and systems, business strategies, and environmental sustainability. Yet these three topics have not been examined together in a single study, which is why the present research, the first on business technological strategies for sustainable development, makes an important contribution. Moreover, delimiting the context to the 21 APEC countries lends the study rigor.

This study is organized into five sections including this introduction. The second section presents the methodology employed for the biometric analysis, along with the choice of database and search terms, as well as the data analysis. The third describes the main results represented in bibliometric indicators—evolution of scientific output, countries, institutions, most productive journals and authors, and most-cited articles—identifying the most-cited article by way of a similarity network, bibliographic coupling, and co-

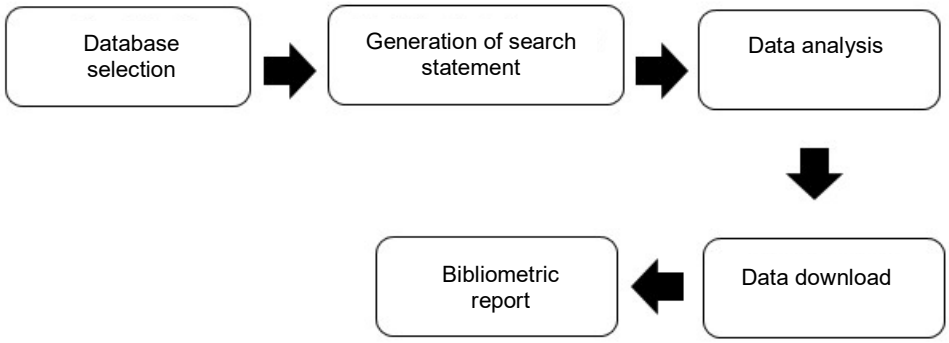
occurrence of terms. The fourth section sets out the conclusions based on a synthesis of the study's main contributions. Finally, the limitations and some future lines of research are presented.

Method

This study entails an explanatory descriptive analysis by way of bibliometric indicators, which enable identification of production and circulation dynamics that prove useful to scientific communities (Gómez, Chaviano & Ballesteros, 2021). Thus, the bibliometric indicators of scientific production will be focused on their growth patterns over time; the main countries, institutions, and authors who are covering the topic; the most-cited articles; and the most important journals publishing research on business strategies and technologies for environmental sustainability.

The study draws on the methodological process proposed by Osorio, Rodríguez & Peláez (2021), which contains the five stages outlined in Figure 1: database selection, search term selection, data analysis, data download, and bibliometric report.

Figure 1. Methodological research process



Source: Osorio, Rodríguez & Peláez (2020).

Database selection

The selection of a database containing indexed scientific journals aids the bibliometric process. For this study, the *Scopus* database is employed given its coverage of publications that meet a strict set of requirements related to scientific indexing and academic relevance.

Generation of search statement

For the search statement selection process, an initial search using the key words "technology", "technologies", "business strategy", "business strategies" was conducted, which allowed for a logical nexus between the business technological strategies. In addition, the Boolean connector "and" allows these strategies to be related to environmental sustainability. Nest, the context was limited to APEC to determine the

impact of scientific output on the Asia-Pacific region. The result of the search was the 21 economies (only 18 of which were found to have published articles in the field) belonging to the forum: Australia, Brunei Canada, Chile, China, Hong Kong, Indonesia, Japan, South Korea, Malaysia, Mexico, New Zealand, Papua Nueva Guinea, Peru, Philippines, Russia, Singapore, China, Thailand, United States, and Vietnam. Finally, segmentation was based on the business, administration, and accounting study areas.

Next the search statement was entered, which yielded 234 papers for analysis.

(TITLE-ABS-KEY (*technology*) OR TITLE-ABS-KEY (*technologies*) OR TITLE-ABS-KEY (*"business strategy"*) OR TITLE-ABS-KEY (*"business strategies"*) AND TITLE-ABS-KEY (*"Environmental sustainability"*)) AND (LIMIT-TO (SUBJAREA , *"BUSI"*)) AND (LIMIT-TO (AFFILCOUNTRY , *"United States"*) OR LIMIT-TO (AFFILCOUNTRY , *"China"*) OR LIMIT-TO (AFFILCOUNTRY , *"Australia"*) OR LIMIT-TO (AFFILCOUNTRY , *"Malaysia"*) OR LIMIT-TO (AFFILCOUNTRY , *"Canada"*) OR LIMIT-TO (AFFILCOUNTRY , *"Japan"*) OR LIMIT-TO (AFFILCOUNTRY , *"South Korea"*) OR LIMIT-TO (AFFILCOUNTRY , *"New Zealand"*) OR LIMIT-TO (AFFILCOUNTRY , *"Russian Federation"*) OR LIMIT-TO (AFFILCOUNTRY , *"Viet Nam"*) OR LIMIT-TO (AFFILCOUNTRY , *"Thailand"*) OR LIMIT-TO (AFFILCOUNTRY , *"Hong Kong"*) OR LIMIT-TO (AFFILCOUNTRY , *"Indonesia"*) OR LIMIT-TO (AFFILCOUNTRY , *"Taiwan"*) OR LIMIT-TO (AFFILCOUNTRY , *"Philippines"*) OR LIMIT-TO (AFFILCOUNTRY , *"Chile"*) OR LIMIT-TO (AFFILCOUNTRY , *"Mexico"*) OR LIMIT-TO (AFFILCOUNTRY , *"Peru"*))

Data analysis

The data on scientific output was first analyzed using the descriptive tools provided by *Scopus*, representing the results in graphs and tables. Then, network mapping on bibliographic coupling and keyword correlation was carried out using the VOSviewer software tool, which can be used to build networks of scientific publications, scientific journals, research organizations, countries, and/or keywords (Van Eck & Waltman, 2020). Then, the *Connected Papers* tool, created by Tarnavsky, Smolyansky, Harpaz & Perets, enabled recognition of the most-cited articles in the theoretical framework and, in turn, creation of a similarity network of most-cited articles related to the text. Finally, the qualitative analysis enabled identification of future lines of research on business strategies or technologies for environmental sustainability in the Asia-Pacific region.

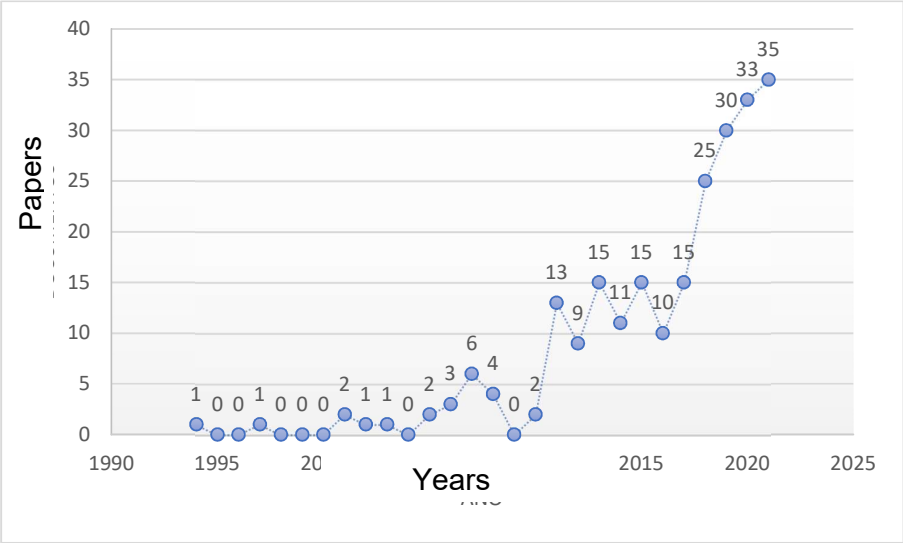
Results

Evolution of scientific output

Scientific output focusing on business strategies and technologies for environmental sustainability within APEC has been constantly evolving since 1994, when the first article

on the topic appeared. This first article stressed the need for planned corporate change in relation to the debate on environmental sustainability (Roome, N, 1994). Thereafter, between one and two papers were published each year until 2006 when there were three, then six the following year. Though there were no publications in 2009, between 2011 and 2017, output rose considerably: there were 13, 9, 15, 11, 15, 10 and 15 articles in each of the respective years. Output continued its steady growth over the next four years, peaking in 2021 with 35 published works as at September.

Figure 2: Evolution of scientific output



Source: Compiled by author based on the records of *Scopus* (2021)

Most productive journals

Table 1 presents the most productive journals when it comes to business strategies on environmental sustainability among APEC member states. It is worth noting those journals with high scientific impact; seven were assigned to the Q1-SJR category, one to Q2-SJR, and two are currently under assessment prior to classification.

The top ranking publication is the UK-based *Journal Of Cleaner Production,* which covers topics in the fields of business, administration, accounting, energy, engineering, and environmental sciences. It has published a total of 66 papers: 28% of all output in the Q1-SJR category. In second place in the Q1-SJR category, with a total of six published papers, is *Business Strategy And The Environment*. Also UK based, the journal publishes on topics related to business, international management and strategies, and, in the field of environmental science, management, monitoring, policy, and law. The third-ranking journal in this category is the US-published *Technological Forecasting And Social Change*, which focuses on technology and innovation management.

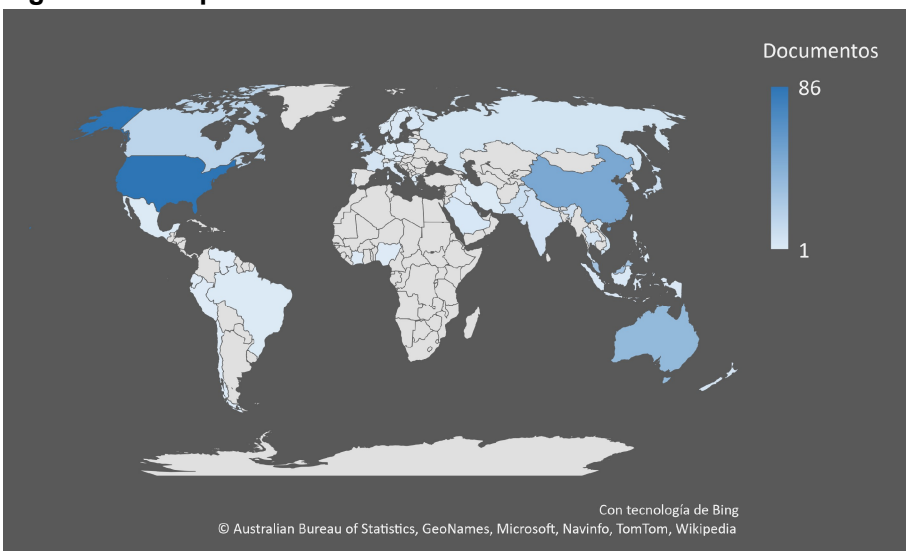
Table 1: Most productive journals

Journal	No. papers	SJR
Journal Of Cleaner Production	66	Q1
Business Strategy And The Environment	6	Q1
Technological Forecasting And Social Change	5	Q1
Journal Of Business Ethics	4	Q1
Corporate Environmental Strategy	3	
Corporate Social Responsibility And Environmental Management	3	Q1
Futures	3	Q1
International Journal Of Production Economics	3	Q1
International Journal Of Supply Chain Management	3	Q1
International Journal Of Technology Management	3	Q2

Source: Compiled by author based on the records of *Scopus* (2021)

Most productive countries Graph 3 shows the level, by APEX members, of scientific output on environmental sustainability business technology strategies. Thus, the United States is the greatest exponent in the Asia-Pacific region, with 86 papers published: 36% of the total output. China and Australia lie in second and third spot with 49 and 37 papers, respectively. They are followed by Malaysia, Canada, Japan, South Korea, Russia, and Vietnam, with 29, 17, 10, 8, 7, and 7 articles, respectively. The countries that are least productive on this topic are New Zealand, Thailand, Hong Kong, Taiwan, Indonesia, Mexico, Philippines, Chile, and Peru, on 6, 6, 4, 4, 3, 2, 2, 1, and 1 papers, respectively. But they are still ahead of Brunei, Papua Nueva Guinea, and Singapore, none of which have published any research on this area.

Figure 3: Most productive countries



Source: Compiled by author using Bing technology, based on the records of *Scopus* (2021)

Most productive universities

Table 2 lists the most productive universities in the sphere of business technologies or strategies on environmental sustainability in the APEC region. The *Universiti Kebangsaan* de Selagnor in Malaysia occupies first place, with five published articles. Thereafter, *Zhejiang University, RMIT University,* and *Beijing Institute of Technology* in China; *Universiti Teknologi* and *Universiti Putra* in Malasia; *University of Lincoln* in the UK; *University of Queensland* in Australia; and *Ton-Duc-Thang University* in Vietnam all share second place, with four published papers each.

Table 2: Most productive universities

University	Papers
Universiti Kebangsaan Malaysia	5
Zhejiang University	4
RMIT University	4
Beijing Institute of Technology	4
Universiti Teknologi Malaysia	4
Universiti Putra Malaysia	4
University of Lincoln	4
The University of Queensland	4
Ton-Duc-Thang University	4
Universiti Sains Malaysia	3

Source: Compiled by author based on the records of Scopus (2021)

Most productive authors

Table 3 presents the 10 authors who have published the most on technological environmental sustainability strategies among APEC countries. It shows that five authors share first place, each with five published papers to their name: Anthony, B, of *Norges Teknisk-Naturvitenskapelige Universitet* in Norway, who has centered on *green computing, IT adoption, and business process management;* Nilashi, M of *Universiti Sains* in Malasia, who specializes in the *technology acceptance model;* Samad, S, from *Princess Nourah bint Abdulrahman University* in Saudi Arabia, who also focuses on the *technology acceptance model;* Sarkis, J, of *Worcester Polytechnic Institute* in the USA, whose output has concentrated on *green supply management, environmentally preferable purchasing,* and *green practices;* and Wahab, D.A. of *Universiti Kebangsaan* in Malasia, with published research on *closed-loop supply chain, remanufacturing,* and *reverse logistics.* These authors are followed by another five: Ahmed, Z; Bakshi, B.R; Bose, I; Cai, S, & Cheng, J.C.P, with two published papers each.

Table 3: Most productive authors

No.	Definition	Papers
1	Anthony, B.	3
2	Nilashi, M.	3
3	Samad, S.	3
4	Sarkis, J.	3
5	Wahab, D.A.	3
6	Ahmed, Z.	2
7	Bakshi, B.R.	2

8	Bose, I.	2
9	Cai, S.	2
10	Cheng, J.C.P.	2

Source: Compiled by author based on the records of Scopus (2021)

Most-cited papers

Table 4 sets out the most-cited papers focusing on the topic in question. In first place with 317 citations is a paper by Elliot, S, (2011), which examined a literature framework on information technologies for transforming business, given its status as a contributor to environmental sustainability challenges. This is followed, with 276 citations, by a multi-level study aimed at guiding the future of green information technologies (Jenkin, Webster & McShane, 2011).

Third, the authors Vachon and Klassen (2007) have been cited 170 times for their paper on how to improve environmental best practices in the supply chain through the implementation of environmental technologies. Situated in fourth place with 130 citations, Saravanan et al. (2018) focused on the production of environmental and renewable fuels in accordance with the most salient characteristics of India's national biofuel policy. The fifth-most-cited article, by Wang et al. (2018), evaluated energy consumption and the environmental impact of asphalt during its life cycle, finding that rubberized asphalt can be considered a green technology in terms of its contribution to reducing greenhouse gases; it recorded 120 citations.

Sixth, with 120 citations, Dangelico, Pontrandolfo and Pujari studied the development of new sustainable products in textile and upholstered furniture industries, while exploring whether the production of these ecological alternatives opened up the market to new technological products and opportunities. Smerecnik & Andersen (2011), in seventh place, had 98 citations; this study sought to understand the diffusion of sustainable environmental industries in ski hotels and resorts in North America. In eighth place with 91 citations, Jiang, Zhang and Sutherland, 2011) presented a multiple criteria decision-making model (MCDM) to select the manufacturing technology intended to promote environmental sustainability.

Cited 89 times and placed ninth, Roome, N, 1994, proposed that research and development management will need not only to apply new management techniques but to play a leading role in assuring innovative structures with which to develop environmentally sensitive structures. It should be noted that this was the first article to focus entirely on the topic of business technology strategies for environmental sustainability in APEC.

Finally, in tenth spot, with 87 citations, Petkov et al. (2011), suggested comparative indicators to promote domestic energy conservation.

Table 4. Most-cited papers

Paper	Definition	Year	Author(s)
Transdisciplinary perspectives on environmental sustainability: A resource base and framework for it-enabled business transformation	Elliot, S	2011	317
An agenda for 'Green' information technology and systems research	Jenkin, Webster & McShane	2011	276
Supply chain management and environmental technologies: The role of integration	Vacko & Klassen	2007	170
Biofuel policy in India: A review of policy barriers in sustainable marketing of biofuel	Saravanan et al.,	2018	130
Energy consumption and environmental impact of rubberized asphalt pavement	Wang et al.,	2018	120
Developing sustainable new products in the textile and upholstered furniture industries: Role of external integrative capabilities	Dangelico, Pontrandolfo & Pujari	2013	120
The diffusion of environmental sustainability innovations in North American hotels and ski resorts	Smerecnik & Andersen	2011	98
Development of multi-criteria decision making model for remanufacturing technology portfolio selection	Jiang et al.,	2011	91
Business Strategy, R&D Management and Environmental Imperatives	Roome, N	1994	89
Motivating domestic energy conservation through comparative, community-based feedback in mobile and social media	Petkov et al.,	2011	87

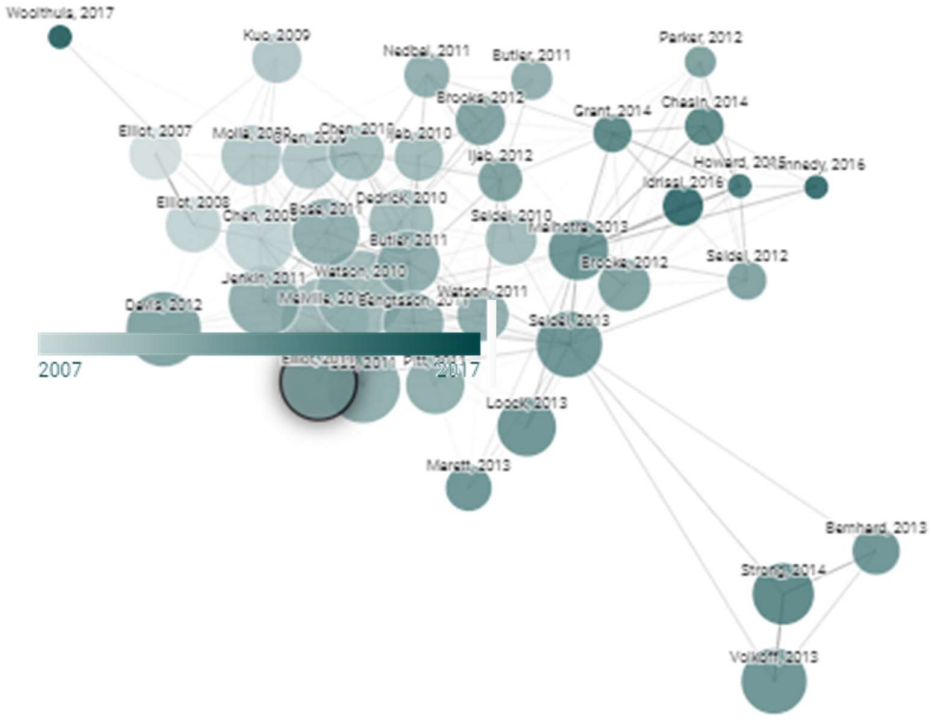
Source Compiled by author based on the records of Scopus (2021)

Most-cited papers

Graph 4 presents the results of the similarity mapping of articles based on the most-cited paper: in this case, the study titled “Transdisciplinary perspectives on environmental sustainability: A resource base and framework for it-enabled business transformation,” which has 317 citations. In this article, Elliot, S (2011) examined environmental sustainability challenges from a cross-disciplinary perspective, with a

view to gaining an understanding of the phenomenon through a thorough exploration of complexities associated with corporate transformation of business technologies. Thus, *Connected Papers* was used for similarity network mapping of articles that pursue similar research lines, in which it is assumed that two articles with closely overlapping citations and references have a higher likelihood of dealing with a similar topic (Connected papers, 2021). Ultimately, 41 papers related to the principal paper were obtained.

Figure 4: Similarity network in relation to most-cited paper



Source *Connected Papers*, based on most-cited paper (2021).

In this regard, Table 4 presents the ten articles, of the 41 related ones, that present the highest level of coupling with the most-cited article. In first place is the paper by Melville, N (2010), which has a similarity of 29.9% with the most-cited paper; its research agenda concerns innovation in information systems for sustainability, and seeks to improve environmental and economic performance of companies. In second place, with a similarity of 29.8%, is Watson, Boudreau, and Chen (2010), which proposes a new subfield on information technology skills geared towards energy efficiency. It is worth noting that the same authors, in pursuit of ecological sustainability, ventured a conceptual model related to the roles of information systems (Chen, Boudreau & Watson, 2008), which was 17.6% similar.

Third, the paper by Seidel, Recker & Brocke (2013), 17.8% similar, explored the implementation of environmentally sustainable commercial practices in a global software solutions company. In fifth place, with a similarity of 16%, is a paper by Dedrick,

J (2010) which, exploring existing research on green information systems, presents an IT investment and carbon productivity model.

Table 4: Similar articles in relation to most-cited article

Paper	Authors	Year	Author(s)
Transdisciplinary Perspectives on Environmental Sustainability: A resource base and framework for IT-Enabled Business Transformation	Elliot, S	2011	100
Information systems Innovation for environmental sustainability	Melville, S	2010	29.9
Information systems and environmentally sustainable development information and new direction for the IS community	Watson, Boudreau & Chen	2010	29.8
Sensemaking and sustainable practicing: functional affordance of information systems in green transformation	Seidel, Recker & Brocke	2013	17.8
Information systems and ecological sustainability	Chen, Boudreau & Watson	2008	17.6
Green IS: Concepts and issues for information systems research	Dedrick, J.L	2010	16
From green to sustainability: information technology and an integrated sustainability framework	Dao, Langella & Carbo	2011	16
Compliance with institutional imperatives on environmental sustainability building theory on the role of Green IS	Butler, T	2011	15.9
An agenda for Green Information technology and systems research	Jenkin, Webster & McShane	2011	15.5
Information technology as a change actant in sustainability innovation: insights from Uppsala	Bengtsson & Agerfalk	2011	14.3

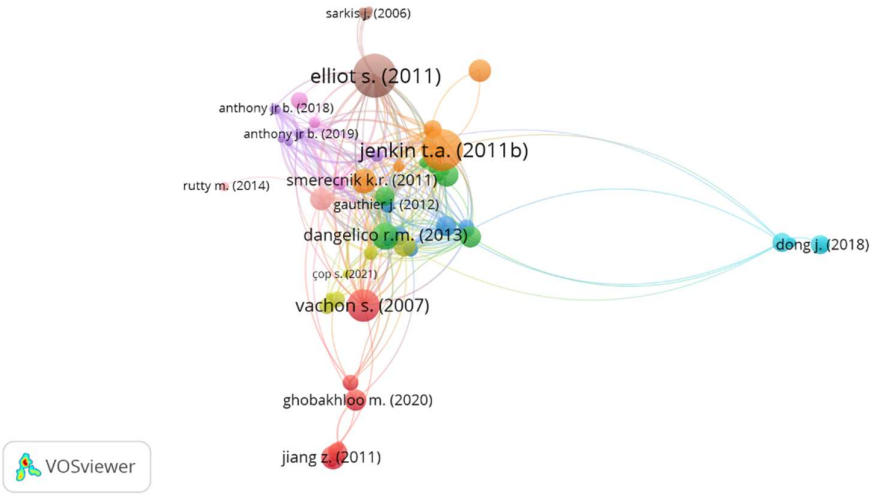
Source Compiled by author based on the records of *Connected Papers* (2021)

Bibliographic coupling

Next, Graph 5 presents the bibliographic coupling network, which analyzes the relationship between articles by measuring their references to a third article (Pizzi, Caputo, Corvino & Venturelli, 2020). Bibliographic coupling allows certain related research trends between articles to be determined. For this case of 234 papers, a minimum of ten citations per paper was set; 100 articles reached the threshold, and 55

articles were found to be related (equivalent to 23% of all output) Finally, the analysis allowed for the coupling of ten clusters.

Figure 5: Bibliographic coupling network



Source: Compiled by author in VOSviewer based on the records of *Scopus* (2021)

Table 5: Bibliographic coupling clusters

Cluster	Items	Researchers	Research topics
1. Red	8	Ghobakhloo, M; Huang,Y; Jiang, Z; Li, Y; Suhariyanto, T; Tozanli, Ö; Vachon, S; Yusop, N.	Manufacturing Performance, Remanufacturing Technology, Supply chain platforms, Multi-Life Cycle Assessment,
2. Green	8	Arnold, D; Dangelico, R; Daniels, P; Farrukh, M; Fearne, A; Jung, S; Roome, N; Teh, D.	Business Strategy, Environmental Imperatives, Small Apparel Business Strategy, Value Chain Analysis, External Integrative Capabilities
3. Dark Blue	8	Brennan, I; Chege, S; Gabler, C; Gauthier, J; Hiatt, S; Loucks, E; O´Connor, A; Shin, H	Corporate Social Responsibility, small- and medium-sized businesses in sustainability, Public and Private Politics, Sustainable Innovation Adoption,

4. Yellow	7	Auliandri, T; Bai, C; Chuang, S; Nilashi, M; Yacob, P; Yadegaridehkordi, E; çop s	Green Manufacturing, Manufacturing Management, Small- and medium- sized enterprises, Building manufacturing, Green Information Technology
5. Lilac	5	Anthony, B; Anthony JR, B; Anthony JR, B; Chugh, R; Khor,K	Technology management, Green IT/IS practice, Green IS practice assessment, Information Technology Strategy, Management information system, Green Information and Communication Technology
6. Light Blue	5	Ali Shah, S; Dong, J; Ghosh, A; Portugal-Pereira, J; Zhang, A	Waste-to-Energy, Renewable energy, Life cycle assessment, Waste-to-energy technologies, Internet of things, Smart waste management, Circular Economy
7. Orange	5	Haigh, N; Jenkin, T; Jenkin, T; Petkov, P; Smerecnik, K	Information systems, information technology, Diffusion of environmental sustainability innovations,

Source: Compiled by author in VOSviewer based on the records of *Scopus* (2021)

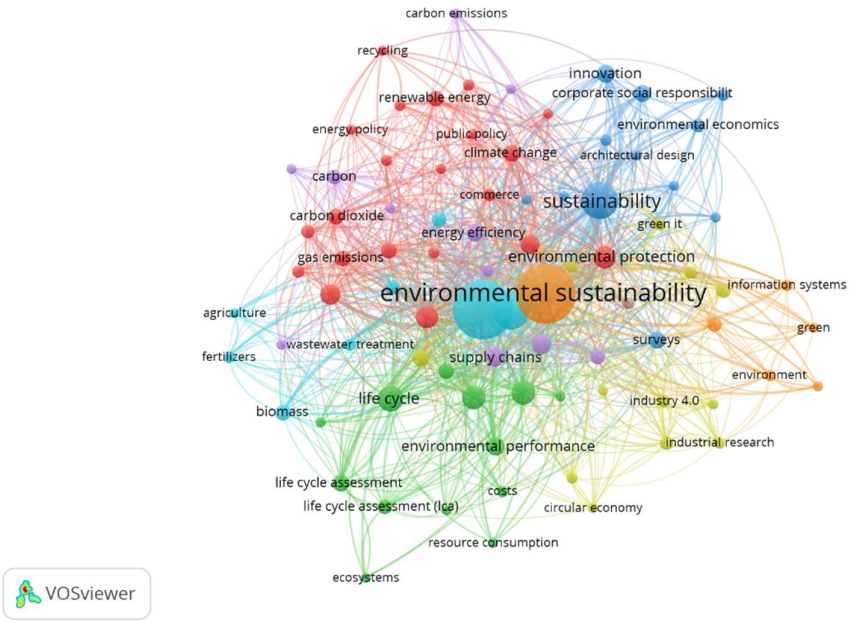
Term co-occurrence

Figure 6 represents the term co-occurrence. The size of the nodes represents the frequency of occurrence of a keyword, and the link shows the strength of the association between terms (Kumar, Sureka & Pandey, 2020). Having set a minimum occurrence of four per term, 84 terms reached the threshold.

Figure 6 groups together words with a high level of correlation with each other, represented by nodes of different colors. As a result 84 terms were obtained, broken down into in eight clusters. Cluster 1 (red) focuses on environmental protection, and is related to terms such as carbon dioxide, carbon footprint, climate change, social and

economic effects, economic growth, gas emissions, global warming, and others. In turn, Cluster 2 (green) is related to environmental impact, and contains words such as cost-benefit analysis, life cycle, life cycle valuation, resource consumption, and others. Cluster 3 (dark blue) refers to sustainability, and is made up of terms such as corporate social responsibility, energy conservation, environmental policy, green computing, innovation, and others. Cluster 4 (yellow) concerns the waste management with words related to the circular economy, competition, green information technology, the internet of things, supply chain management, and others. Cluster 5 represents the supply chain, and its terms refer to the likes of carbon emissions, decision-making, game theory, energy efficiency, pollution, and manufacturing. Cluster 6 (light blue) approaches the topic of sustainable development, with words relating to agriculture, the development of countries, environmental technology, control of pollution, wastewater treatment, and so on. Cluster 7 (orange) addresses the topic of environmental sustainability, and includes terms that make reference to the environment, environmental respect, information systems, and others. Finally, Cluster 8 (cappuccino) covers the topic of digital technologies.

Figure 6: Network of co-occurrence of terms



Source: Compiled by author in VOSviewer based on the records of *Scopus* (2021)

Table 6: Most frequently occurring terms

No.	Term	Occurrence
1	Sustainable development	122
2	Environmental sustainability	126
3	Environmental technology	46
4	Sustainability	50
5	Life cycle	23
6	Environmental protection	20
7	Environmental management	20
8	Environmental impact	20
9	Economic and social effects	18
10	Greenhouse gases	15

Source: Compiled by author in VOSviewer based on the records of *Scopus* (2021)

Discussion

The topics addresses by researchers are presented in Graph 5 through ten clusters. Next, the ten main clusters will be described, covering the following topics: Remanufacturing technology, sustainable business strategies, corporate social responsibility, green initiatives, green information system, energy loss, internet of things, and green information technology.

Remanufacturing Technology (Cluster 1)

The foremost topics addressed in this cluster refer to supply chain models, the impact of digital technologies, multiple life-cycle evaluation for sustainable products, marketing strategy, and the role of digitalized manufacturing. According to Ghobakhloo & Fathi (2020), the aim of remanufacturing technology is to utilize IT resources in small manufacturing companies, for which the development of a digital lean manufacturing system is recommended as a strategy for corporate survival in the industry 4.0 environment. The impact of digital technologies on economic--environmental performance in the context of industry 4.0 is represented by Li, Dai, and Cui (2020), whose results demonstrate that these technologies make an impact through supply chain platforms, and that environmental dynamism is improved to a great extent under these mediating effects.

In turn, Huang and Wang (2017) present remanufacturing models under technology licensing, applying the Stackelberg game to achieve equilibrium strategies from the perspective of chain members' profits. Environmental strategies have expressed considerable interest in the development of environmental technologies for enterprise. As such, Tozanli, Kongar, and Surendra (2020) expressed the need to incorporate smart technologies in the formation of fabrication and logistics architectures to ensure that supply chain activities are executed sustainably. Finally, it is important to evaluate product life cycles from a broad-based point of view; in this spirit, Suhariyanto, Wahab and Rahman (2017) utilized multiple life cycle assessment (MLCA) perspectives to evaluate the environmental impacts on the multiple life cycle (MLC) product system.

Sustainability Strategy in Business (Cluster 2)

The literature has approached the development of entrepreneurial sustainability strategies by drawing on topics such as sustainable development of new products,

bibliometric review of the environmental business strategy, sustainable supply chain dimensions, sustainable future, and construction of sustainable business strategies. Dangelico, Pontrandolfo, and Pujari (2013) investigated the inclusion of competencies external to a company in the development of ecological products, finding that this involves integration capacities and actors outside the supply chain. For the context of textiles, Jung and Jin (2014) explored slow fashion based on Churchill's paradigm for developing measures, identifying the following dimensions: equity, localism, authenticity, exclusivity, and functionality.

Farrukh, Meng Wu & Nawaz (2020), for their part, conducted a bibliometric historical analysis of research into corporate and environmental strategy, noting that a surge in interest in the topic has rendered it a key academic medium for advancing knowledge regarding environmental sustainability in business. Another study found that the area of sustainability needs to bring together social and environmental aspects in order to create a sustainable competitive window through value chain analysis (Fearne, García & Dent, 2012). Finally, to close this cluster, the authors Teh and Corbitt (2015) explored the importance of aligning ecological sustainability and general business strategies, assessing the scope of eco-sustainability in the adoption of sustainability strategies and policies.

Corporate Social Responsibility (Cluster 3)

Cluster 3 presents the field of corporate social responsibility (CSR) from the perspectives of environmentally sustainable business plans, the influence of technological innovation on small and medium-sized enterprises (SMEs), organizational responses to public and private policies, environmental sustainability in the petroleum industry, and the use of renewable energy and financial performance. For instance, Gabler, Panagopoulos, Vlachos, and Rapp (2017) revealed six elements for an environmentally sustainable business plan: unifying the organizational vision, creating visible leadership, addressing multiple stakeholders, focusing on innovation, communicating the message, and implementing the strategy.

One study discovered that environmental sustainability is related to the positive impact of commercial activities, given that company performance can improve with management innovation and the involvement of employees in environmental protection practices (Chege & Wang, 2020). In turn, Hiatt, Grandy & Lee (2015) examined the influence of public policies on internal practice responses, and the influence of private policies on "external framing activities".

Companies can combine CSR and the environmental sustainability discourse to establish a comprehensive environmental policy, improving their position in the industrial context and enabling protection through intra-industrial homogeneity. (O'Connor & Gronewold, 2012). Finally, Shin, Ellinger, Nolan, DeCoster, and Lane (2018) demonstrate that superior financial performance can stem from the influence and utilization of renewable energies, complemented by social and environmental benefits.

Green Initiatives (Cluster 4)

This cluster involves green initiatives, including strategies that address environmentally friendly packaging, eco hotels, environmental sustainability for manufacturing SMEs, sustainability indicators for the construction of green buildings, and green transformational leadership policy. Thus, Auliandri, Rohman & Rofiq (2018) detected environmental concern in purchase intention, and that, in the case of young consumers

in relation to green packaging, intention is influenced by personal norms, perceived behavioral control (PBC), and willingness to pay.

The development of a new soft computing method to find the best eco-friendly hotels shows that the combination of dimensionality reduction and prediction machine learning techniques is robust in TripAdvisor's quality factors (Nilashi et al., 2019). Meanwhile, the relationship between green initiatives and environmental sustainability was explored by Yacob, Wong, and Khor (2019). Using a mediation analysis, they identified managers' green intentions through the implementation of green technologies. However, they found that adoption does not influence the environmental sustainability of manufacturing SMEs. Another study found that indicators of energy efficiency and environmental quality are the most important in the construction of green buildings in Malaysia, and that the least important are water efficiency and innovation (Yadegaridehkordi et al., 2020). Finally, Çop, Olorunsola and Alola (2021) researched the importance of applying efficient ecological strategies, finding that transformational green leadership has a positive effect on green work engagement and green team resilience.

Green Information System (Cluster 5)

Green information systems are approached in this cluster by way of topics such as: development of green information technology and systems in collaborative companies, the practices of green ISs based on collaborative agents for the attainment of environmental sustainability, integration of green ISs for the environmental performance of organizations, use of environmentally sustainable ICT and reducing the IS gap, and ITs with sustainable consumption.

First of all, Anthony Jnr, Majid, and Romli (2020), for the case of collaborative enterprises, examined the purpose of implementing IT/IS practices, concluding that process virtualization theory is influenced by green initiatives that are oriented towards sustainability. Along similar lines, the same three authors explored collaborative agents by developing a collaborative agent-based web architecture to support IT professions in evaluating the sustainability of their green IS practices. (Anthony Jr, Majid & Romli, 2018). And the lead author, Anthony Jr (2019), explored environmental performance based on the belief-action-outcome framework and the natural-resource-based-view theory, noting that green ISs have a positive impact on environmental performance through pollution prevention.

In turn, the study by Chugh, Wibowo, and Grandhi, 2016 spoke of the importance of sustainable IT practices as a form of organizational support for effective sustainable strategies (Chugh, Wibowo, & Grandhi, 2016). Finally, Khor, Thurasamy, Ahmad, Halim, and May-Chiun (2015) presented a general description of the application of green IT/ISs, pointing towards the opportunities for commercial practices available to IT managers with a socioeconomic inclination.

Waste-to-energy and IoT (Cluster 6)

Energy loss and the internet of things is represented in the present cluster by way of the following topics: the energy trilemma of waste-to-energy technologies, comparison of waste-to-energy gasification and incineration technologies, patterns and trends in IoT research, economic and environmental benefits of waste-to-energy technologies, and barriers to smart waste management for a circular economy.

Ahah, Longsheng, Solangi, Ahmad & Ali (2020) explored green economic recovery after COVID-19 as an opportunity for the transition to renewable energy. They also proposed,

given the importance of limiting carbon levels and preventing future crises, a decision support framework based on the energy trilemma. Transformation into energy can contribute to the development of waste-to-energy technology and a waste management plan for decision makers, according to Dong et al. (2018). In another study, Portugal-Pereira and Lee (2015) evaluated costs of living along with the environmental impacts of waste conversion, demonstrating that the co-production of liquid fuels and electricity generates fewer local environmental impacts, but that the unit cost of energy is more than double that of traditional technologies.

Future IoT applications in the construction industry is the focus of research by Hgosh, Edwards & Hosseini (2021), who identified the likes of high-speed reporting, complete process control, data explosion leading to deep data analysis, and strict ethical and legal expectations among the main effects of IoT adoption. The final study in this cluster addressed smart waste management for a waste-free circular economy in China. Among the barriers, it cited a lack of environmental education or culture of environmental protection, lack of knowledge about smart waste management, and a lack of market pressures or demands.

Green Information Technology (Cluster 7)

The area of green information systems and information technology encompasses research on environmental sustainability strategies and practices, a green IS and IT research agenda, motives for domestic energy conservation, and the diffusion of environmental sustainability innovation at hotels. As such, Haigh and Griffiths (2008) investigated information systems from a multidisciplinary approach, as well as quantifying and qualifying the impact of ISs on environmental sustainability.

Given the dearth of research on green information technology, Jenkin, Webster & McShane, 2011 argued that future studies should focus on green IT/ISs based on an alignment within and between the levels of environmental orientation, initiatives, and impacts.
Meanwhile, Petkov, Köbler, Foth, and Krcmar (2011) provide an early glimpse into consumer motivation in the field of energy. Finally, Smerecnik & Andersen (2010) shed light on how to promote sustainability in the hotel sector, based on an understanding of applicable innovations and the variables that affect the rate of adoption.

Conclusions

This study covers a period of scientific development, between 1994 and September 2021, focusing on business technology strategies among Asia-Pacific Economic Cooperation forum member states. What is notable about this trajectory is the surge in academic interest in the topic from 2010, measured though a continual increase in scientific output, through to a productive peak in 2021, with 35 papers. The most productive journals are also presented, in which the Q1-SJR classification is attained by seven journals; this attests to the topic's impact.

The study took into account the 21 APEC members, of which 18 recorded an academic output of some degree. The Asian continent dominates when it comes to the most productive research institutions, followed by Australia and the United Kingdom. At the country level, Brunei, Papua New Guinea and Singapore have not conducted any

Scopus research on business technology strategies. In turn, the United States, China and Australia are the most productive countries, accounting for 73% of the total scientific production. Indonesia, Mexico, the Philippines, Chile, and Peru are the least productive of those countries that have conducted research, accounting for 3% of total output. This illustrates a need for future research to identify the research context of these countries in relation to technological strategies.

Authors who stand out in the field of technological business strategies in the Asia-Pacific region have developed research on green information systems and green information technology, remanufacturing and environmental manufacturing in supply chains, environmental renewable technologies, and life cycle assessment. The top two most-cited papers constitute the backbone of a necessary bibliography for the development of future research; "*Transdisciplinary perspectives on environmental sustainability: A resource base and framework for it-enabled business transformation*" is the first placed with 317 citations, followed by "*An agenda for 'Green' information technology and systems research*" which, according to the similarity network, has a similarity of 15.5% to the first article.

The bibliographic coupling network enabled the recognition of seven clusters, broken down into seven themes: remanufacturing technology, sustainable business strategies, corporate social responsibility, green initiatives, green information systems, energy loss, the internet of things, and green information technology. Finally, the co-occurrence of terms network presents the keywords with the greatest affinity to business technology strategies, which includes the likes of sustainable development, environmental sustainability, environmental technology, sustainability, and life cycle.

Limitations and Future Lines of Research

The analysis of other databases is necessary for future research. In this case *Scopus* was used, affording a universe of 234 papers, but it could be that other research--especially that conducted in countries for which the present study detected none--was published in different sources. This limitation should be overcome for a more universal scientific discourse.

In addition, 2021--the year in which this paper was written--was the most productive. This shows that business technology strategies have become increasingly relevant in the discourse of environmental sustainability, which sets the scene for analysis of the future context of the topic.

When it comes to future research, Ahmed, Cary, Shahbaz & Vo (2021) argued that to help formulate better energy policies it is necessary to disaggregate the impact of different energy research and development budgets in which energy efficiency and energy technologies are embedded. In addition, these budgets can control more variables and analyze the asymmetric impact. On the other hand, for the adoption of green information technologies in manufacturing industries, a comparative study between countries is needed, since different countries may require different evaluation criteria (Asadi et al., 2021). In this regard, N'dri, Islam & Kakinaka (2021) studied information and communication technology and environmental sustainability in developing countries, and suggested that future research should draw on the impact of ICT and sustainability in a more comprehensive way.

On the other hand, Çop, Olorunsola, & Alola (2020) recommended a focus on more industries most likely to have direct effects on the environment, while also suggesting testing the effects of green transformational leadership on the four dimensions of psychological capital. Green policies promote the management of water, energy, and food resources, and so future research could involve a comparative analysis of the environmental sustainability agenda, using Tapio's elasticity method for more convincing findings.

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