

## Role of Patenting Framework for Electric Vehicle Innovations from BRICS Perspective

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Electric vehicle (EV) technologies are one of the fastest-growing segments in green technologies. Development and adoption of EVs in BRICS countries is significant for the attainment of sustainable development goals (SDGs) and to ensure affordable, reliable, and sustainable energy by boosting clean mobility. Towards achieving the SDGs and the Nationally Determined Contribution (NDC) set in the Paris Agreement of 2015, countries are innovating in the domain of EV. The BRICS nations are emerging as a potential market for development and utilization of such technologies. Patenting trends of a country indicate its technological competitiveness and affordability. The present paper analyses the patent trends in the EV segment amongst BRICS countries. It analyses the growth in EV technologies in these countries for a period of ten years, *i.e.*, from 2012 to 2022, and tried to understand the role of the intellectual property (IP) regime mainly patents in the development of EV technologies. By performing a comparative analysis of the national patent laws of BRICS country's role of patents and relevant provisions affecting the faster promotion, development, and diffusion of EV technologies has been identified. Study shows that IP is an essential component in accelerating green growth in the EV segment and a conducive patent regime promoting green inventions with supporting administrative processes is needed for BRICS countries.

**Keywords:** Sustainable Development Goals, Green Technology, Green Patents, Green Innovation, Electric Vehicles, Intellectual Property, Innovation in BRICS

The development of green technologies is one of the crucial aspects for Sustainable Development Goals (SDG). The terms green technology, clean technology, rational technology, and Environmentally Sound Technology (ESTs) are synonymously used for the technologies that are more environmentally acceptable, cause less pollution and protect the environment by using resources in a sustainable manner.<sup>1</sup> Among the different categories of green technologies, Electric Vehicle (EV) technologies are one of the fastest-growing segments which play a vital role towards stabilizing atmospheric concentrations of Greenhouse Gases (GHG).<sup>2</sup> The United Nations Conference on Environment and Development (UNCED) of 1992, followed by other international environmental agreements, opened the pathways for EV development. As a part of the Nationally Determined Contribution (NDC) set by countries in the Paris Agreement in 2015, many countries have pledged “to phase out Internal Combustion Engines (ICE) or have ambitious vehicle electrification targets for the coming eras.” Very recently, the importance and urgency of adoption of EVs has been acknowledged in COP26 held at Glasgow in

2021. Interestingly, not only environmental concerns but other concerns like COVID-19 and international politics have also led to an increase in the adoption of EVs. As per the recent report by the International Energy Agency (IEA), more than 10 million electric cars were sold in 2022 worldwide and the EV segment is predicted to grow by 17 million in 2024.<sup>3</sup>

The role of developing nations, particularly emerging economies, towards climate change mitigation and green technology development is very critical.<sup>4</sup> BRICS (Brazil, Russia, India, China, and South Africa) nations are fast-growing developing countries and have a greater impact on the environment.<sup>5</sup> Their dependence on fossil fuels for energy production and imports has led to a steady increase in greenhouse gas emissions over time. With the combined population accounting for nearly half of the total world population, the BRICS countries possess high influence worldwide, including its contribution to the global carbon emission level.<sup>6</sup> According to the IEA 2018 report, among BRICS nations, China had the highest 10.06 gigatons of carbon emissions in 2017-18 accounting for nearly 29% of the global emissions. India and Russia followed the list with 3<sup>rd</sup> and 4<sup>th</sup> rank globally with approximately 3 gigatons of carbon

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emissions per year. Similarly, Brazil and South Africa were in the 13<sup>th</sup> and 14<sup>th</sup> rank globally and produced almost 2 gigatons of CO<sub>2</sub> emissions in 2017– 2018.<sup>7</sup> Overall, it has been observed that between 2010-2020, there has been a continuous and fast surge in the emission of GHG by the transport sector in BRICS countries (Fig. 1).

Post Paris Agreement in 2015, BRICS nations have committed to avoid dangerous climate change impacts by limiting global warming below 2°C. This clearly necessitates the need for the development of green and sustainable technologies in those countries. Towards this, EVs are the significant technology that decarbonises the road transport sector which accounts for nearly one-sixth of the total pollution. In addition to addressing environmental concerns, EVs reduce energy dependence and foster economic growth. Therefore, BRICS nations have started taking concrete steps toward their communicated NDC by promoting green technologies and formulating policies for the development, promotion, and adoption of EVs.<sup>8</sup> EVs

embrace a wide range of technologies and effective policies are very much required to protect and promote the advancement of these technologies. The growth of the EV segment in a given country is affected by many factors. Technology, infrastructure, market, accessibility, affordability, perception, incentives, etc., shape the EV segment in a region (Fig. 2). Among all the above-mentioned factors, the promotion and protection of EV technology is one of the key challenges for the EV ecosystem. An enabling policy to promote technology development and dissemination is crucial for EV growth.

For green energy sector, Intellectual Property (IP) protection enables creation, adaptation, and distribution of such technologies. Particularly, the role of patents is very important in the protection and promotion of green technologies. Patents are considered an indicator of technological growth<sup>9</sup> and have a significant role in enhancing innovation and in developing green technologies.<sup>10</sup> They protect the novel invention in terms of its originality and utility and work as a value signal

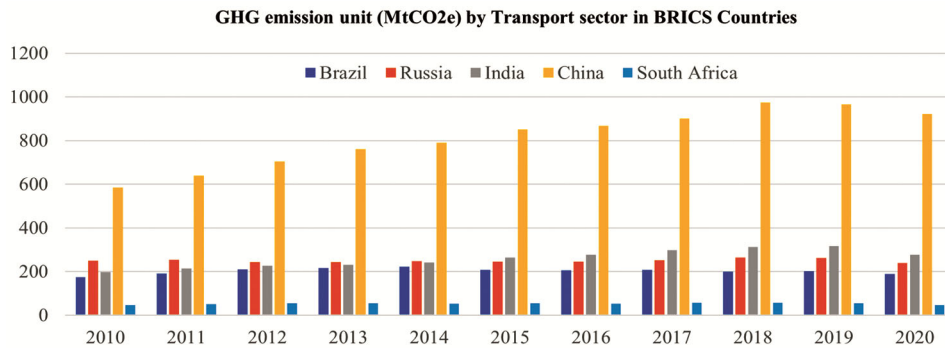


Fig. 1 — GHG emission in BRICS countries by transport Sector  
Data Source: Data Explorer, Climate Watch

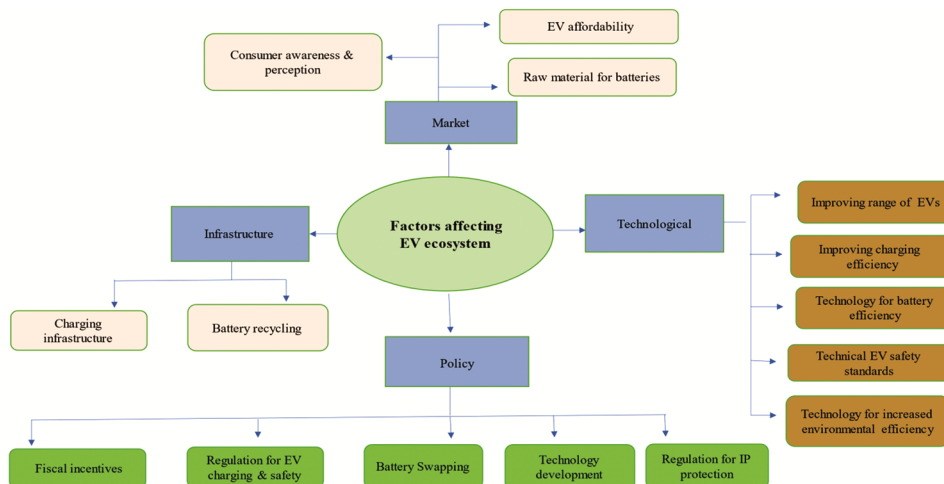


Fig. 2 — Factors affecting EV ecosystem

generator widening the scope of potential technology collaboration aiding in the development and diffusion of technology.<sup>11</sup> Further, technological advancement is a key factor in promoting the diffusion of low-carbon technologies.<sup>12</sup> Patents, as an IP can be used to analyse the history of advancement of industrial technology, development models, characteristics, and trends.<sup>13</sup>

According to a report by the International Council on Clean Transportation (ICCT) in 2021, EV-related patents have increased significantly over the years. Patents as indicators of technological progress illuminate shifts in this burgeoning industry. There are country-specific studies on patenting aspects of EVs which provide a subtle idea on the growth of EV technologies.<sup>14</sup> However, a holistic representation from the developing countries or BRICS perspective is not prevalent in the literature. Given the important role of BRICS in the global economy, it will be interesting to understand how the EV segment is proliferating in such emerging economies. In this context, the current paper aims to present an analytical picture of the growth in EV technologies in emerging nations like BRICS from the perspective of patents. The work involves a two-pronged strategy. In the first part, the authors have analysed the EV technology growth by studying EV patenting trends for 10 years from the year 2012-2022. In the second part, the authors have tried to analyse the role of national patent regimes in promoting the development and diffusion of EV technologies in BRICS countries. This study aims to provide a deeper insight into the EV industry in the BRICS nation through the lenses of patent and technology dimensions.

### Methodology

To achieve the objective of understanding the growth in EV technologies in BRICS, a study on patent trend was conducted by using the Questel Orbit Intelligence (version 2) software to uncover growth, innovation insights, and patterns. A patent search was carried out for a period of ten years, *i.e.*, from 2012 to 2022 to understand the recent developments in EV technologies. A strategic patent search technique involving combination and iterative search method was adopted to retrieve relevant patent information. A combination of keyword and classification-based search was used to enhance the comprehensiveness, precision, and flexibility of the search (Fig. 3). This approach ensures that we capture a broad spectrum of relevant patents while maintaining a high degree

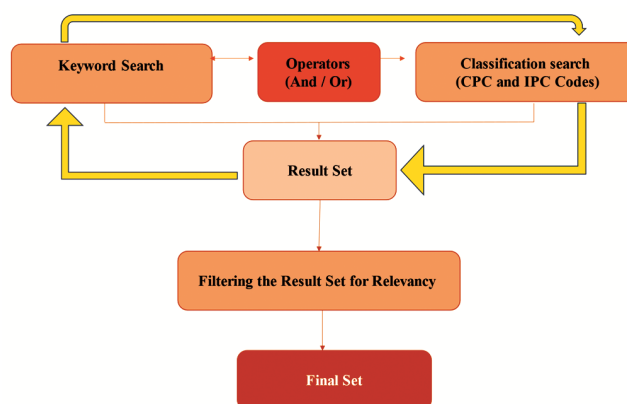


Fig. 3 — Graphical representation of search conducted for patent analysis

of relevance to our research objectives. By using appropriate search strings containing a word or set of words that describe or relate to the relevant technology the patent information on the underlying concepts was gathered. Subsequently, patent classification search was conducted which worked as a filter in the search process. Though there exist different classification schemes maintained by respective patenting authorities, we have considered the two main classification schemes *i.e.* Cooperative Patent Classification (CPC) codes and the International Patent Classification (IPC) for subsequent refinement of the patent dataset. The CPC scheme offers better granularity in terms of identification of relevant technological fields compared to the IPC scheme, while the IPC scheme offers a wider coverage in terms of patenting authorities using it. EV technology constitutes various classifications. There are practical limitations in considering all classification codes together, therefore in the present study authors have selected five relevant codes. The most relevant codes selected by the authors were G05D (patents related to EV control systems), H01M (patents related to battery technologies,) Y02E60/10 (patents related to electric powertrains or electric propulsion systems in vehicles), Y02T (technologies aiming at mitigating climate change in transportation, including EVs) and, B60L (electric propulsion systems, charging infrastructure, battery-swapping technologies, and EV components). The combination of the above two searches resulted in the final patent set, which was then saved, filtered for relevancy and analysed. This search strategy was repeated to get respective patent datasets from each BRICS country. Then these final patent sets were used for further analysis in terms of growth trends, and technological landscape etc. for respective countries.

For the second part of the study, a doctrinal method has been adopted. The role of national patent regime in promoting the development and diffusion of EV technologies in BRICS countries is studied by performing a comparative analysis of the patent laws and policies of respective countries. The relevant provisions affecting the faster development of EV technologies were also identified and studied to understand the EV growth in BRICS.

**Patenting Trends of EVs in BRICS Countries**

The increasing eminence of EVs as a sustainable transportation solution has resulted in an amplified focus on patenting in the EV technology domain. The increase in patenting of EV technologies indicates the importance of the role of Intellectual Property Rights (IPRs) in a particular sector.<sup>15</sup> The EV industry has experienced significant growth and development in

recent years. This has been reflected in the patenting trends, with a substantial increase in the number of EV-related patents filed worldwide. Our study shows that numerous companies, academic researchers, and innovators have been actively filing patents to protect their innovations in this field. However, patenting activities in the EV sector are not evenly distributed globally. Among BRICS countries, China has the maximum share of patents in EV technologies (97%), and the rest are held by India, Brazil, Russia, and South Africa (Fig. 4).

Our result shows that China, with around 4,79,264 patents, has emerged as a significant contributor in recent years, both in terms of domestic and international patent filings. There is a huge difference in the number of patents filed in China and the rest of the BRICS nations. The reason for such a huge disparity may be attributed to China’s utility model patent policy. It protects relatively minor advancements over existing technology.<sup>16</sup> Utility model patents are a powerful weapon to patentees since they are quick and easy to obtain and yet carry the same remedies as invention patents, including monetary and injunctive reliefs.<sup>17</sup>

Representation in Fig. 5 below indicates the chronological distribution of EV patent applications in BRICS countries from 2012 to 2022. A year-wise analysis reveals that there is a steady growth in the patent filing for EVs from 2012- 2020 in China and India. The maximum patent filing was observed from 2017-2020 in these jurisdictions. However, jurisdictions like Brazil, Russia, and South Africa reflects fluctuating growth throughout, which can be due to low R&D or to the political and economic condition of that particular country at that point in time. Post 2019, the decline in the number of patents can be related to the impact of COVID-19. The patent data for 2021 and 2022 is considered a grey area because it

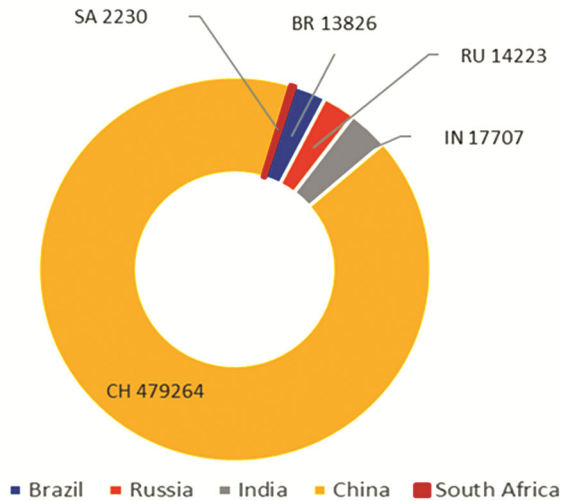


Fig. 4 — Distribution of EV Patents in BRICS countries from 2012-2022

Source: Questel Orbit Intelligence Database

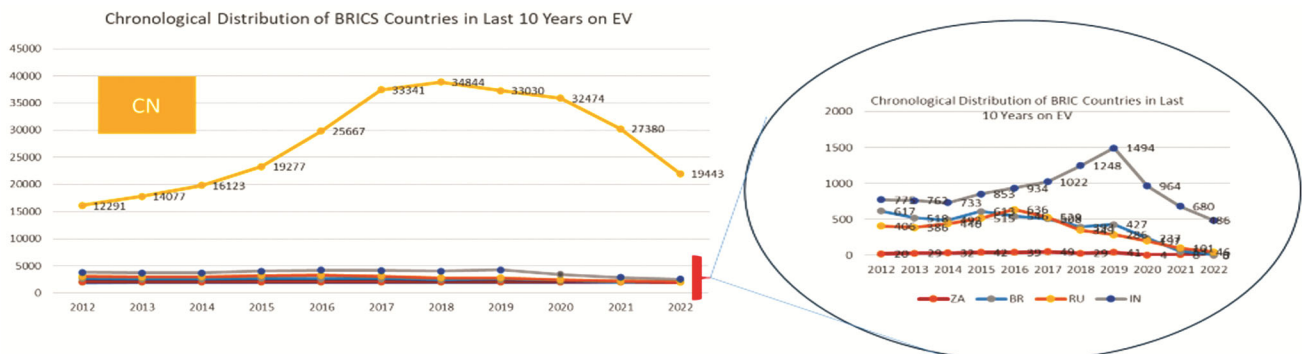


Fig. 5 — Chronological distribution of EV patenting in BRICS countries

Source: Questel Orbit Intelligence Database

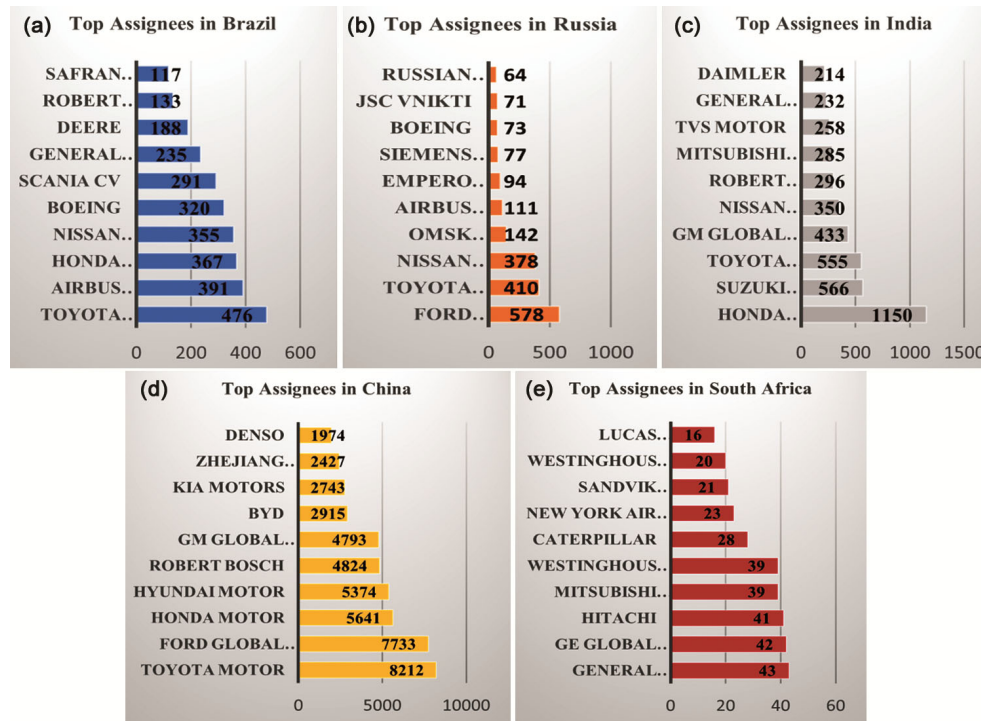


Fig. 6 — Top 10 EV Assignees in BRICS  
 Source: Questel Orbit Intelligence Database

reflects only published applications and does not include applications in the 18-month pre-grant publication period of patent applications.

Figure 6 (a-e) indicates that the major players in the particular segment are the big giants from developed nations like the USA and Japan. Toyota Motors, Ford Global, General Electrics, Nissan Motors, and Hyundai Motors are the leading players in the EV segment and have a presence in BRICS nations. Many Chinese assignee have also marked their presence in other jurisdictions. Local or indigenous manufacturers from the respective countries are also paving their presence in the given segment. Both startups and established giants are thriving in this fertile ground of innovation.

The analysis for EV technology cluster in BRICS countries helps to identify the possible technology clusters protected by the players in the particular country (Fig. 7 (a-e)). This technology cluster is gathered by analysing the last five years patent data (2017-2022) for Brazil, Russia, India, and South Africa. In the case of China, the cluster data is represented by taking into account the patent data between 2020-2022, as the Questel orbit software had limitations in processing the huge data for five years. China has the largest EV market, and it is thriving with

growing New Energy Vehicles (NEV). With more than 600000 existing NEV enterprises, the technological progress in China is remarkable. The cluster data for two years also reveals the growing innovations in the areas of battery charging, power management, electrical steering, etc. From the study it is apparent that in India, Russia, and Brazil, EV technologies are also developing faster in different domains. However, in South Africa, the EV technology growth has been observed in a few pockets marking a lot more future possibilities for R&D. The study suggests that China and India have many patented areas with strong overlap which indicate consolidation of the portfolio on the given segment. It signifies the growth of the given technology segment and the presence of more licensing and collaborative opportunities. Areas with low overlap are either the opportunities for the new development or portfolios to be sold. It marks the white space in the technology domain and thus can be taken as future areas for R&D.

Further, an analysis was made to understand the major areas of research through patent classification codes. Figure 8(a-e) below illustrates the top ten IPC and CPC codes in the EV domain in BRICS countries. This classification indicates the technology spread in the EV ecosystem in the BRICS countries. Y02T,

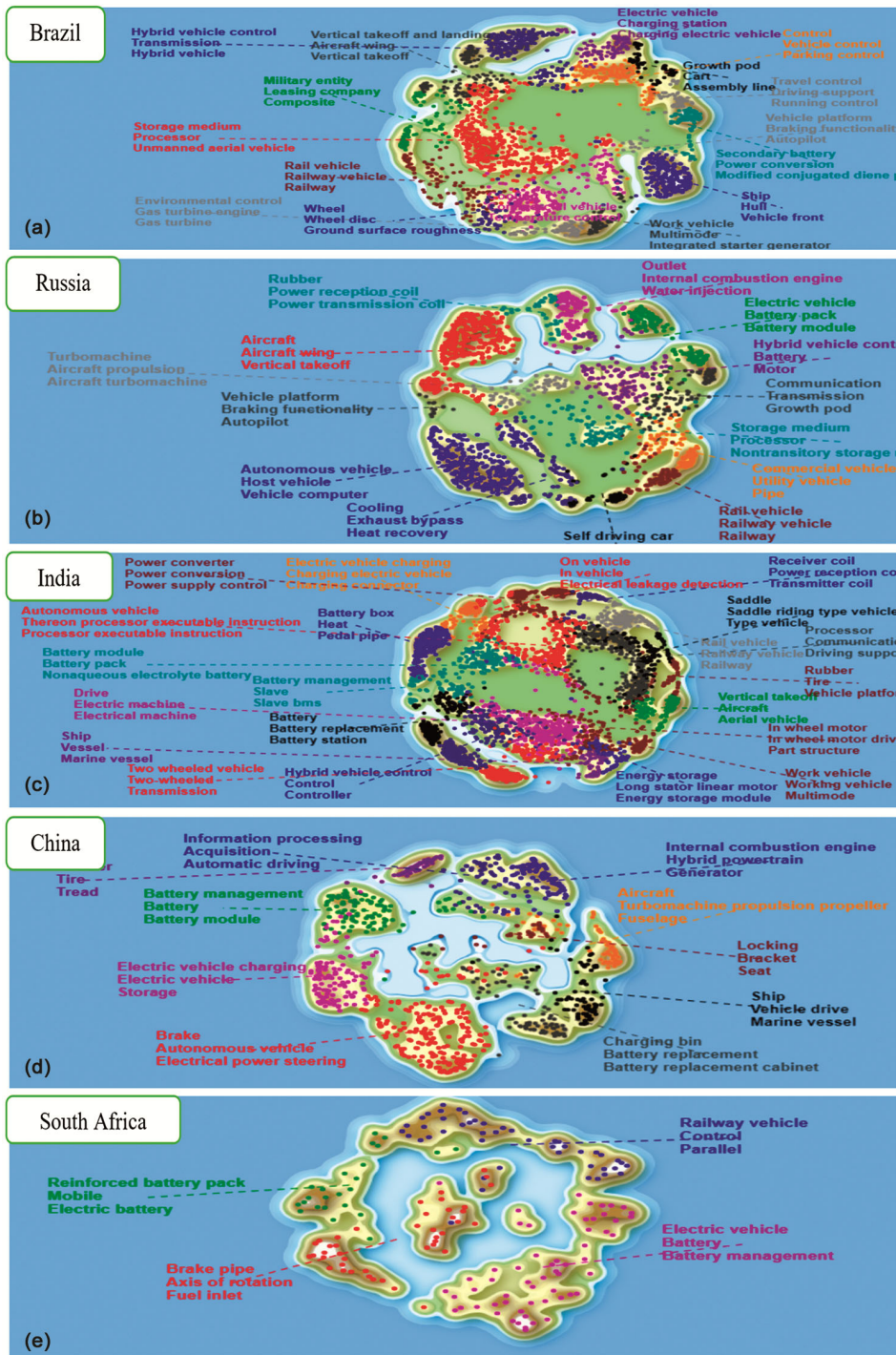


Fig.7 — EV Technology cluster description in BRICS  
 Source: *Questel Orbit Intelligence Database*

B60L, B60K, B60W, G05D, and H01M are the most common classification codes in which patents have been filed in BRICS countries and the most common inventions classification codes are elaborated in Table 1.

Filing of patents in different jurisdictions is a good indicator of the markets that need to be protected. Figure 9(a-e) below identifies the number of alive patents protected in the various national offices in BRICS countries. The analysis for the

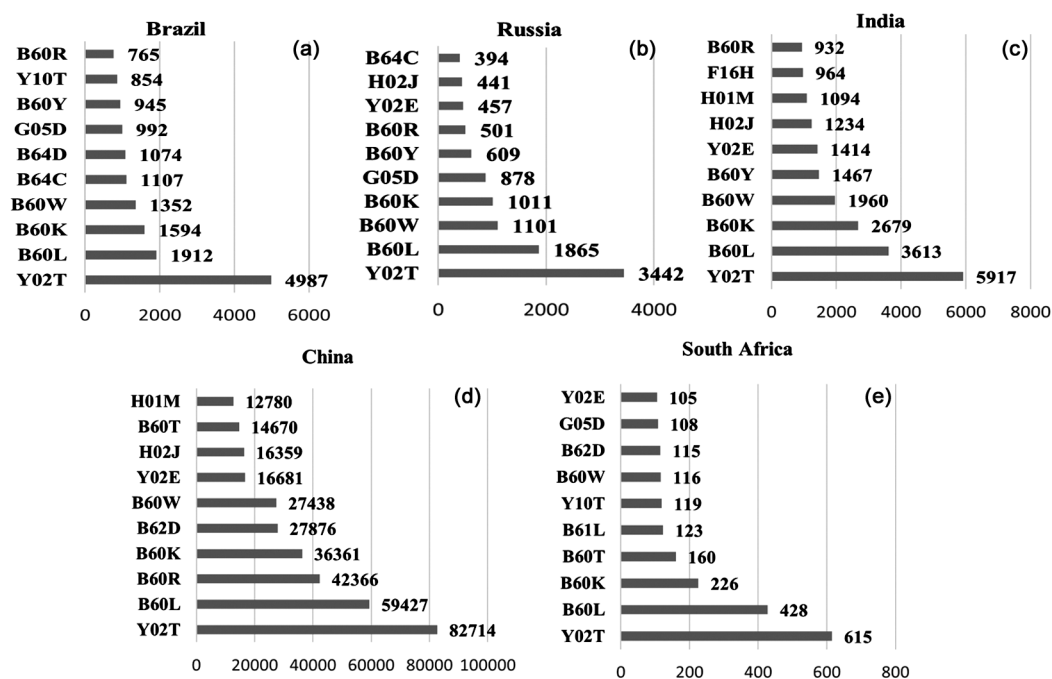


Fig. 8 — Top 10 classification codes in BRICS countries  
 Source: *Questel Orbit Intelligence Database, Compiled by author*

Table 1 — Description of top IPC/CPC codes for EV patents in BRICS countries

Codes	Description
Y02T	Technologies aimed at mitigating climate change in transportation. Inventions related to energy efficiency, emissions reduction, renewable energy integration, smart grid applications, and sustainable transportation systems.
B60L	Pertains specifically to electric equipment or propulsion systems of electrically-propelled vehicles, including EVs. It encompasses inventions related to electric propulsion systems, charging infrastructure, battery-swapping technologies, and EV components
B60K	Arrangement or Mounting of Propulsion units or transmissions in vehicles including EVs.
B60W	Conjoint control of vehicle sub-units of different types or different functions for propulsion of purely electrically-propelled vehicles with power supplied within the vehicle.
H01M	Inventions related to battery technologies. It covers advancements in battery chemistries, electrode materials, cell designs, charging methods, thermal management systems, and safety features.
G05D	Patents related to the control of various aspects of EVs, including power distribution, energy management, charging, regenerative braking, and vehicle performance optimization
H02J	Circuit arrangements or systems for supplying or distributing electric power; systems for storing electric energy.
B60R	Vehicles, vehicle fittings, or vehicle parts including- arrangement of batteries, using electric means, e.g. electric motors, for carrying-off electrostatic charges, etc.
B60Y	Indexing scheme relating to aspects cross-cutting of EV technology.

Source: IPC green inventory

global spread of patents by BRICS was performed by identifying the patent family distribution. It highlights the strategy of the applicant and identifies targeted markets for the innovators. The analysis shows that the US is the top destination for filing of the application (apart from the country of origin) for all the BRICS countries except China. This is followed by some EU countries as the major choice for filing applications. The faster adoption of EVs in

the US, EU, and China also echoes the findings about the acceptability of EV technologies in those countries and more growth in the EV market. Interestingly, the analysis further reveals that apart from the home country the inventors have tried to protect the inventions in other BRICS member countries. This signifies the cumulative potential of BRICS in EV technology in the near future.

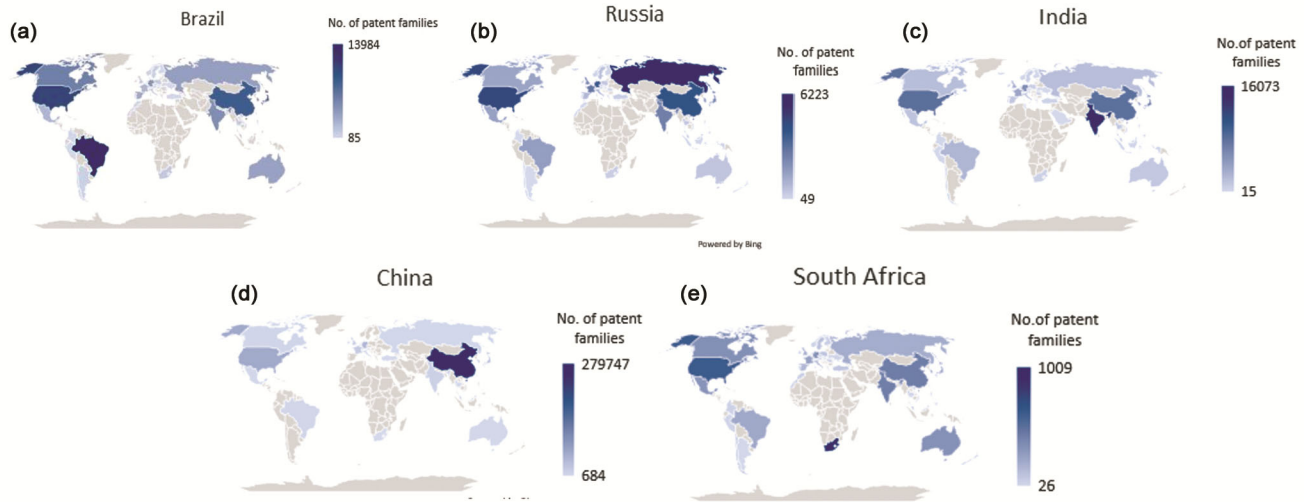


Fig. 9 — Protection countries for EV technologies in BRICS countries  
 Source: Questel Orbit Intelligence Database

Table 2 — Exclusion provision of non-green technologies from patenting in BRICS nation

Countries	Provision	Exclusion criteria
Brazil	Article 18 of Law No. 9,279 of 1996, Regulating Rights and Obligations related to Industrial Property Rights	Technology against moral, good moral principles, public security, order, and health.
Russia	Article 4 (3) of Russia Patents Law, 3517-I of September 23, 1992.	Technology contrary to the public interest, humanitarian principles, or morality.
India	Section 3 (b) of Patents Act, 1970	Technology prejudice to human, animal, plant life, health, or the environment.
China	Article 5 of China’s Patent Law	Technology that impairs public interests.
South Africa	Section 25 (4) (a) of Patents Act, 1978	Technology expected to encourage offensive or immoral behaviour.

**Role of Patent Regime in EV Technology Growth**

A strong IP system coupled with government initiatives and commercialization approaches provides an efficient framework for patenting green technologies, including EV technologies. IP system further works as a vehicle for the dissemination and implementation of such efficient technologies, particularly in emerging markets. The various facets of patenting system such as the patenting criteria, the green patent application examination process, mechanisms for promoting patents, and licensing of green technologies, etc., decide a country’s capability in green energy. Therefore, in this section, the authors have given a deeper insight into the patenting regime of BRICS nations to understand their progress and competence in developing more EV technologies.

**Patentability Requirements for EVs**

Patenting activities in EV-related technologies have developed at a faster pace in the past few years. For any invention to get a patent, it must meet the minimum standard of patentability as specified by the

national patent law. Generally, green patents are promoted by restricting non-green patent applications, through the patent object exception system, which stems from the TRIPS (Trade-Related Aspects of Intellectual Property Right) Agreement.<sup>18</sup> It provides some exemptions from patentability under the grounds of protecting public order or morality, protecting human, animal, or plant life, or health, or to avoid serious *prejudice to the environment*.<sup>19</sup> Towards achieving TRIPS compliance, the BRICS countries have also incorporated the provisions for the exemption of technologies, not benefitting the environment in their respective national IP laws (Table 2). They have clearly excluded the patentability of any technology that causes harm to the environment or has conducive interest or incremental effect in society. For example, India’s Patents Act of 1970, under Section 3(b), mentions that- “no patent right shall be granted for an invention the primary or intended use or commercial exploitation of which could be contrary to public order or morality, or which causes serious prejudice to human, animal or plant life or health or to the

*environment.*” This provision can be extrapolated to assume that non-green inventions or technology are not patentable under this Act.<sup>20</sup> In China, Article 5 of Patent Law provides that no patent right shall be granted for inventions, that violate laws, social morals or impair public interests and the non-green technologies are not conducive to the environment or the public interest.<sup>21</sup> The prevalent law in Brazil is Law No. 9,279, that regulates rights and obligations related to industrial property rights in Brazil. Section 18 of this Act deals with the non-patentable inventions and utility models wherein it provides that- “*No patent right shall be granted for whatever is against moral, good moral principles and public security, order and health.*” Russia Patents Law 3517-I of 1992, under Section 4, states that proposals that are contrary to public interest, humanitarian principles, or morality shall not be deemed patentable under the present Law.<sup>22</sup> Also, Article 5(3) of the Russia Patents Law provides conditions for the patentability of utility models with the same line. In South Africa, Section 25(4)(a) of the Patents Act, 1978 provides that “*the publication or exploitation of which, would be generally expected to encourage offensive or immoral behaviour*” shall not be patentable under the Act. Therefore, through these provisions, it can be put forth that BRICS countries have restricted non-green technologies and encouraged more green and sustainable technologies.

#### **Accelerating the Patentability Procedure for EVs**

Generally, examination and granting of patent applications is a lengthy process. However, green technologies being *global public goods*, should be allowed to come into the market timely so that the manufacturer or the inventor can exploit them, thus benefitting society.<sup>23</sup> To overcome the processing delay different mechanisms are developed to accelerate the examination procedure at the international level. For example, the Patent Cooperation Treaty (PCT) Patent Prosecution Highway (PCT-PPH) originated as a collaborative concept between different patent offices to promote work sharing and accelerated processing. Similarly, Global Patent Prosecution Highway (Global PPH) is another platform through which the acceleration of patent examination can take place.<sup>24</sup> It is a pilot program where requests for accelerated processing can be made at any participating office based on work products, including PCT work products, from any one of the other participating offices under unified criteria.

Among BRICS countries, except South Africa, all the other nations are part of some accelerated prosecution program. The Russian Patent Office (Rospatent- Russian Federation) is a participant in the Global PPH. China is part of the IP5 Patent Prosecution Highway (IP5 PPH) launched in 2014, where the patent offices of the European Union (EU), United States (US), Japan, Korea, and China are participating offices.<sup>25</sup> National Institute of Industrial Property of Brazil (INPI), has PCT-PPH bilateral agreements with Japan. Other participating countries also have PPH bilateral agreements with Brazil. In 2019, a bilateral PPH pilot program commenced between the Indian Patent Office (IPO) and the Japan Patent Office (JPO).

In addition to existing international mechanisms, national IP offices have also put in place measures to fast-track “green” patent applications. It can reduce the time needed to obtain a patent from several years to just a few months.<sup>26</sup> The adoption of accelerated examination of green patents was not accidental. It was a sort of move to encourage green patenting and to mark the role and importance of IPRs, particularly patents in green technologies. It was adopted in 2009 before the start of the highly contentious United Nations Climate Change Conference in Copenhagen, Denmark.<sup>27</sup> The developed nations adopted it early, and the United Kingdom was the first country to establish this accelerated program, “*Green Channel*” in 2009, to allow applicants to request accelerated processing of their patent applications having some environmental benefit.<sup>28</sup> The USPTO also announced the “*Green Technology Pilot Program*” in November 2009, which aimed at fast-track examination of patent applications pertaining to environmental quality, energy conservation, development of renewable energy resources, or greenhouse gas emission reduction.

In the same line as developed nations, emerging economies like Brazil and China also adopted the green patents fast track system in 2012. Brazil was the first emerging economy to launch a pilot program to accelerate the green patent application. On April 17, 2012, Brazil’s patent office (INPI - Instituto Nacional da Propriedade Industrial) designed the “*Green Patents Program*” to reduce the time spent in examining technologies that have less environmental impact and contribute in fighting climate change. Inventions related to alternative energy generation technologies, transportation, energy conservation, waste management, and sustainable agriculture were covered in this. As of now, INPI offers priority examination of green technologies applications as a

Table 3 — BRICS status in Fast track application &amp; PPH

Country	National Fast Track Application	PPH
Brazil	√	√
Russia	×	√
India	√	√
China	√	√
South Africa	×	×

standalone service.<sup>29</sup> From January 2020 to March 2021, the INPI received 118 requests for accelerated examination involving green technologies. Of these, 32 applications have already been decided, with an approval rate of 65%. The average time from the request for accelerated examination to the grant of the patent can be 7-8 months.

China's State Intellectual Property Office (SIPO) was the last patent office to launch a green patent fast-track program in August 2012.<sup>30</sup> China's State IPO released its Administrative Measures on Prioritized Examination of Patent Applications, which allows for expedited examinations of various types of patents, including green patents, from August 1, 2012.

Though India does not have a specific fast-track mechanism for green patents, the Patents Rule, 2003, Rule 24C allows applicants from different categories to file a request for expedited examination of the patent application. Recently, vide Patent (Amendment) Rules, 2021 Rule, 24C(k), "*eligible educational institution*" can also file for a request for expedited examination.<sup>31</sup> Interestingly, in India, the National IPR Policy, 2016, under its objective 2 para 18, provides "*special incentives for the creation of IPRs in green technologies and manufacture of energy-efficient equipment.*"<sup>32</sup> However, till date, no direct supportive measure from IP Office specifically for IPR generation, technology transfer, and commercialization of green technologies in India has been made. Table 3 below summarises the position of BRICS countries with respect to national fast-track applications for green technologies as well as participation in PPH.

## Discussion

IPRs in particular to patents have an integral role in promoting economic as well as the social growth of a country. It encourages R&D, facilitating global commerce having a positive impact on gross domestic product (GDP) of the particular country.<sup>33</sup> It analyses the technological history, its development and the trends. Thus, as an indicator of technological progress understanding the patent landscape for a given technology is important.

EV technologies per se involve many subject areas and are the complex industrial product as the technological advancement in each segment is closely associated and are interlinked with each other, requiring continuous and strong technological innovation through and encouraging patenting. Developed nations like the US and the EU have already marked their presence in EV technologies, but the position of the developing world with respect to EV technology development and adaptation is always a matter of investigation.<sup>34</sup> The larger population and need for a sustainable transportation system have made BRICS a favourable destination for EVs. However, constraints like access to standard technologies, lack of technical skills, infrastructure, and high pricing are some of the critical factors that impede the growth of the EV sector in BRICS nations.<sup>35</sup> However, this study with respect to the patenting trend in the EV domain spreads some positive light and clearly suggests that the BRICS nations are coming out as research hubs for EV-related inventions. The EV growth experienced in the recent years is gradual and continuous, in line with the Net Zero Emissions targets set by countries.

Our study demonstrates that numerous companies, academic researchers, and innovators have been actively filing patents to protect their innovations in this field. However, patenting activities in the EV sector are not evenly distributed globally. As per our analysis among BRICS countries, China has the maximum share of patents in EV technologies, followed by India, Brazil, Russia, and South Africa, making it a global leader in EV technology. The trend for China is the same over the years as presented in different studies.<sup>36</sup> The technological growth in each of the countries may be attributed to their patent regime. A strengthened patent system always promotes trade, investment and licensing opportunities.<sup>37</sup> The substantial growth in China can be attributable primarily to its utility patent model, which offers a simplified and cost-effective patenting process enabling inventors to obtain patents quickly, at a lower cost compared to other patent models, by relaxing the inventive steps requirements and allowing incremental innovations to be patented for EV technologies. This process incentivizes inventors and companies to protect their innovations, which in turn fosters technological growth. Therefore, by adopting and acclimatizing the patent utility model like China, other BRICS countries can potentially stimulate the patenting of EVs. Alternatively, countries may think of an appropriate national strategy to strengthen patent system based on country's unique requirements and priorities and thus

promote innovation, technology transfer, and economic growth.

The regulatory policies and administrative measures adopted for EVs also play a crucial role in promoting the growth of EV technologies.<sup>38</sup> Patent exemption object criteria, green fast-track patents, and PPH are a few of the major factors that have affected the growth of EV technologies among countries. Countries have different priorities for faster examination of green patents, including patents related to EVs. However, every country should have the objective to encourage green innovations and bringing new products to the marketplace more quickly. Fast-track systems for green technologies and accelerated examination procedures are the key positive initiatives toward EVs as adopted by many countries. The beneficial effect of patent on innovation is well established particularly for high end technology sector. So, by strengthening the patent regime in BRICS country the organization of EV industry can be strengthened, by allowing trade in knowledge and allowing vertical disintegration of knowledge-based industries.<sup>39</sup>

The focus of research always depends on the nature of the market, the country's ability to invest in R&D and policy supporting EV supply chain, and its geopolitical situation. Accordingly, the countries have crafted their niche research areas. The recent trends, as illustrated in the study, show the concentrated growth in the areas of alternative energy sources, battery management, alternative battery chemistry, etc., which is in continuity with earlier works.<sup>40</sup> But the adoption of EVs has been slow in BRICS countries, (except China) due to various economic and technological reasons, including the high upfront purchase cost mainly due to the high cost of batteries, the limited driving range, and the need for charging infrastructure, inherent and perceived uncertainty about the quality of the new EV technologies. Nevertheless, the motivation to innovate and well-drafted cooperative measures among the technology developers and potential takers will help in bringing in more stabilized growth in the EV domain. Enhancing patent cooperation and patent pools among the transnational companies to facilitate technical cooperation can promote technical spillover, resulting an increase in R&D of EV technology and boost the adoption of EVs in BRICS.

## Conclusion

Sustainable and affordable technology is the key to the growth of the EV sector. Also, the role of IPRs in the development and dissemination of green technologies is

integral. IPR not only serves as an instrument to protect innovations but also is a critical factor in deciding the entry of new players, particularly in emerging markets. Patents are facilitators for the effective development, and dissemination of ESTs. Patenting activities in the EV segment highlight positive growth among the BRICS countries. IP regulatory framework of most jurisdictions acknowledges the importance and urgency of green technologies and is proactively focusing on facilitating its protection, promotion, and dissemination. As green technologies are rational technologies, their need and requirements vary from country to country. Being a global public good, the diffusion of these technologies as per the needs and requirements is essential. Patents facilitate the effective transfer of green technologies among countries and give protection to the inventor. Innovation and collaboration are critical to this industry. The role of national policies in the development and deployment of EVs is undoubtedly important. However, efforts are also taken internationally to properly develop, promote, protect, and diffuse these technologies. The role of TRIPS and WIPO green inventory in the identification and diffusion of technology among countries is undeniable. While governmental policy, R&D funding, manpower, and other resources have a direct impact on green innovation, a proper IPR regime facilitating the protection of such innovations and proper dissemination channels will help in achieving the sustainable development goal of ensuring affordable and clean energy.

Despite of the contribution, the research on this topic has two limitations, which offer encouragement for future research on the topic. First, not all technical data with respect to EVs are covered here. The analysis is based on patent information retrieved by specific patent search methods involving few major relevant classification codes. There is a practical limitation in considering all codes together, therefore in this paper, we have considered only 5 major relevant classification codes like G05D, H01M, Y02E60/10, Y02T, and B60L. Second, the discussion in this paper is restricted mainly to patenting trends and patent regimes. The discussion on the impact of other factors affecting the EV market is not in the scope of this paper.

Specific research into the collaborative aspect of EV technology development among BRICS and other developed nations will be an interesting study. Understanding the practical barriers in technology

dissemination will be helpful in shaping the EV domain across countries.

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