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DRIVING SUSTAINABILITY, ECO-EFFICIENCY OF FINANCE, TRADE AND TRANSPORT ENERGY DIVERSITY

Impulsionando a sustentabilidade, a ecoeficiência das finanças, o comércio e a diversidade energética dos transportes

Muhammad Naveed Jamil, Abdul Rasheed
Khwaja Fareed University of Engineering and Information Technology, Institute of Business Administration, Rahim yar Khan, Pakistan
Email: abdul.rasheed@kfueit.edu.pk, mnaveedknp@gmail.com

ABSTRACT
Eco-efficiency is a lively concept toward clean production and biggest universal challenge. Carbon dioxide (CO_2) is a primary greenhouse gas and transport accounts for a third of world CO_2 emissions unprecedented accelerating of global warming. A wide range of clean energy production initiatives contribute to prevent damages the environment. This study sought to introduce first-hand knowledge and researchers/practitioners debate on energy diversity and identifying the best ways of clean energy production contribute to achieve United Nation sustainable development targets. An adequate response to this challenge intent study model was designed to summarize time series data of four major energy consumed, potential trade and high clusters populated Asian countries period from 2001 to 2022 and three data analysis methods were used; first, past and future analysis, second card analysis and third Regression, GMM, and Robust measurement underscore the effect of transport energy diversity on eco-efficiency and sustainability. Study trends result indication for world high fuel dependency. Transport Oil energy consumption source China on top, while Gas and electric transport energy consumption Japan at leading technology initiates toward green transportation, but country's still away from Paris Agreement-Target-2050. Graphical card investigation indicate Eco-efficiency and energy consumption in transportation sector have inverse relationship. Regression and GMM result point out the transport, Oil, Gas and Electric power motion positive highly significance effect on eco-efficiency and Sustainable Development Goals, moreover indicate Oil is one of the most common energy source and one point clean energy production biggest impact on world environment toward sustainability, as electric less CO_2 emission source, Trade negative, FDI and ODA are positive significant impact on eco-efficiency, ODS, Foreign trade and FDI positive, Environmental development, Human Index negative and economic development positive impact on SDGs. The robust outcomes indicate the validity and the sustainability of data and results. Study implication and recommendation are cleared; transportation-oriented systems should be designed as environmentally friendly systems. The government should create policies to encourage people to give up gasoline and diesel as means of transportation until modern technology becomes more efficient. Electric energy suggests suitable substitute of fossil fuel toward clean energy production UN Agenda Sustainable Development Goals.
Keywords: Transport Energy Diversity, Eco-efficiency, Central Asia Future Sustainability
Highlight. The best eco-power is determined by using a three-way analysis of the effects of oil, gas, and electricity on eco-efficiency. Trends results indicate world high fuel dependency and Japan Eco-efficiency policy is better. Graphical card indicates inverse relationship. When fossil consumption is high Eco-efficiency is going down. Regression and GMM result point out Oil biggest utilization energy source and electric less CO_2 emission source. One fourth CO_2 emission produces by World Transport. Transport Cargo and trade system must be designed with environmental considerations.
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IMPULSIONANDO A SUSTENTABILIDADE, A ECOEFICIÊNCIA DAS FINANÇAS, O COMÉRCIO E A DIVERSIDADE ENERGÉTICA DOS TRANSPORTES

Driving sustainability, eco-efficiency of finance, trade and transport energy diversity

Muhammad Naveed Jamil, Abdul Rasheed
Khwaja Fareed University of Engineering and Information Technology, Institute of Business Administration, Rahim yar Khan, Pakistan
Email: abdul.rasheed@kfueit.edu.pk, mnaveedknp@gmail.com

RESUMO
A ecoeficiência é um conceito vivo em direção à produção limpa e o maior desafio universal. O dióxido de carbono (CO_2) é um gás de efeito estufa primário e o transporte é responsável por um terço das emissões mundiais de CO_2, uma aceleração sem precedentes do aquecimento global. Uma ampla gama de iniciativas de produção de energia limpa contribui para evitar danos ao meio ambiente. Este estudo buscou introduzir em primeira mão o conhecimento e o debate de pesquisadores/profissionais sobre diversidade energética e identificar as melhores formas de produção de energia limpa contribuir para atingir as metas de desenvolvimento sustentável das Nações Unidas. Uma resposta adequada a este modelo de estudo de intenção de desafio foi projetada para resumir dados de séries temporais de quatro principais países asiáticos consumidos, comércio potencial e altos clusters de 2001 a 2022 e três métodos de análise de dados foram usados; a primeira, a análise passada e futura, a segunda análise de cartão e a terceira medição de regressão, GMM e robusta ressaltam o efeito da diversidade energética do transporte na ecoeficiência e sustentabilidade. Tendências do estudo resultam de indicação para alta dependência mundial de combustível. Transporte Fonte de consumo de energia de petróleo China no topo, enquanto Consumo de energia de transporte de gás e elétrico O Japão em tecnologia líder inicia em direção ao transporte verde, mas o país ainda está longe do Acordo de Paris-Meta-2050. A investigação da placa gráfica indica que a ecoeficiência e o consumo de energia no setor de transporte têm relação inversa. A regressão e o resultado do GMM apontam o efeito positivo do movimento de transporte, petróleo, gás e energia elétrica altamente significativo na ecoeficiência e nos Objetivos de Desenvolvimento Sustentável, além disso, indicam que o petróleo é uma das fontes de energia mais comuns e um ponto de maior impacto na produção de energia limpa no meio ambiente mundial em direção à sustentabilidade, como fonte de emissão de CO_2 menos elétrica, comércio negativo, IED e ODA são impacto positivo significativo na ecoeficiência, ODS, comércio exterior e IED positivo, desenvolvimento ambiental, índice humano negativo e desenvolvimento econômico impacto positivo nos ODS. Os resultados robustos indicam a validade e a sustentabilidade dos dados e resultados. A implicação e a recomendação do estudo são esclarecidas; Os sistemas orientados para o transporte devem ser projetados como sistemas ecologicamente corretos. O governo deve criar políticas para incentivar as pessoas a desistir da gasolina e do diesel como meio de transporte até que a tecnologia moderna se torne mais eficiente. A energia elétrica sugere um substituto adequado do combustível fóssil para a produção de energia limpa, Objetivos de Desenvolvimento Sustentável da Agenda da ONU.
Palavras-chave: Diversidade de Energia de Transporte, Ecoeficiência, Ásia Central Sustentabilidade Futura
Destacar. A melhor ecopotência é determinada usando uma análise de três vias dos efeitos do petróleo, gás e eletricidade na ecoeficiência. Os resultados das tendências indicam que a alta dependência mundial de combustível e a política de ecoeficiência do Japão é melhor. A placa gráfica indica a relação inversa. Quando o consumo fóssil é alto, a ecoeficiência está diminuindo. O resultado da regressão e do GMM aponta a fonte de energia de maior

utilização do petróleo e a fonte elétrica de menor emissão de CO_2. Um quarto da emissão de CO_2 produzida pelo World Transport. O sistema de transporte de carga e comércio deve ser projetado com considerações ambientais.

INTRODUCTION

Emissions of carbon dioxide into the atmosphere are not limited to those created by burning fossil fuels in homes or businesses; they also result from energy consumption related to economic growth. Therefore, such emissions have been connection with social, economic and environmental activities and the several dimensions including conventional energy and alternative energy source (Adedoyin, Alola, & Bekun, 2021). One of the largest problems is greenhouse gas emissions, with one-fourth of the global transportation sector producing CO_2 emissions. While all sectors are working to minimize CO_2 emissions, the transportation industry must also transmit power-motion and diversity (Kjellén & Tasala Gradin, 2020). Transportation is an essential part of today's world, promoting social development, promoting economic prosperity and ultimately ensuring the welfare of people everywhere (Momber, 2015). However, Transportation was accounted a remarkable carbon emission, while increasing waste soil recycling through technology initiates green transportation (Peng et al., 2024). While traditional Climate action remained unfit loss and damage wider climate and financing (Naylor & Ford, 2023). Further alternative framework climate change was warranted (Harrould-Kolieb, 2019). Therefore United Nations climate diplomacy resulted shortcomings Paris agreement on climate action by all countries (Obergassel et al., 2015). The United Nations agreement on climate cleans production action and international response to our plant's environment changes (L. A. Greene, 2000). The 2015 Paris Climate Agreement is the most successful global agreement and aims to establish targets to achieve eco-environmental efficiency and reduce CO_2 emission (Dimitrov, 2016). In short, automotive technology advancement can able to succeed the highest CO_2 emission reduction potential and meet the United Nations climate agreement and road development requirements (Kubik, Turoń, Folęga, & Chen, 2023). The concept of Zero impact emission was significant improving air quality, while technologies reduce pollutant emissions (Maurer, Kossioris, Sterlepper, Günther, & Pischinger, 2023). Despite the fact that global supply chains and the world economy depend heavily on transportation. Every economy is based on its transportation vehicles, freight conveyance, ships, and ports (Notteboom, van der Lugt, van Saase, Sel, & Neyens, 2020). Fossil fuel transportation results in greenhouse gas emissions, and air pollution externalities (Höök & Tang, 2013), Greenhouse gas emissions have a relations with public health (Lelieveld et al., 2019). Transport would be largely demanded for decarburization while hydropower and sediment transport major consequences for transport clean energy production roadmap 2050 (Pang, Mörtberg, & Brown, 2014). In order to reach the De carbonization targets as outlined in Road-Map 2050, the EU and Central Asian will have to bear the related costs of transport power motion system diversification (Knopf et al., 2013).

The 2050 aim of 80% reduction in GHG emissions (Yang, McCollum, McCarthy, & Leighty, 2009), transportation 80 % GHC emission reduction target for 2050 (Yang et al., 2009), Hong Kong target to achieve zero carbon emission in 2050 (Dong & Zhang, 2023), for the purpose of assessing global transportation energy and climate, the following energy-economy models are frequently used worldwide: Gains, GEM-E3, Green-X, NEMESIS, Primes, Times-Pan-EU, and World Scan (Capros et al., 2014). Energy system, technical efficiency using various methodologies, and alternate de-carbonization pathways (Williams et al., 2012), pricing strategy (Camporeale, Caggiani, Fonzone, & Ottomanelli, 2019), while transportation energy cost, and future sustainability of macroeconomic implications were factors in alternate de-carbonization pathways (Onat, Kucukvar, Aboushaqrah, & Jabbar, 2019). Emissions can be reduced 75% through current technology (Bouman, Lindstad, Rialland, & Strømman, 2017). Greenhouse gas emissions effect on energy optimization, Energy efficiency is of fattening farmhouses in order to separate efficient; indication for greenhouse gas emission reduction with optimum energy consumption (Hosseinzadeh-Bandbafha, Safarzadeh, Ahmadi, Nabavi-Pelesaraei, & Hosseinzadeh-Bandbafha, 2017). The industrial revolution was accelerated by marine transportation, which also raised emissions and environmental stress (Andersson et al., 2016). The right combination of technologies can help meet the challenge of eco-friendly CO_2 emissions. Different energy scenarios indicated natural gas and electric vehicles can fully displaced oil consumption in transportation sector due to reduce carbon emission over 20% compared to gasoline transport (Orsi, Muratori, Rocco, Colombo, & Rizzoni, 2016). GHG emission decline when steel was replaced with aluminum (Lewis, Kelly, & Keoleian, 2014). Transport and storage could comprise 35% of overall carbon emission footprint (Hren et al., 2023). Conventional System increases energy consumption, damage resource, ecosystem and human health. In economic term modern technological of LED equipped vertical system LVS enhance 24% more consumption efficiency and profit (Moosavi-Nezhad, Salehi, Aliniaeifard, Winans, & Nabavi-Pelesaraei, 2022).

Eco-efficiency is key thought encompassing environmental, sustainability and economic development aspects to promote more efficient use of resources and CO_2 emissions (Belucio, Rodrigues, Antunes, Freire, & Dias, 2021). Eco-efficiency has been future to change un-sustainable development to sustainable development, eco-efficiency also indicators as tool for regional sustainability policy (Mickwitz, Melanen, Rosenström, & Seppälä, 2006). The definition of eco-efficiency indicate the roots of the business world (Mickwitz et al., 2006). However, currently, eco-efficiency sought by people, family, private-public institutes, economic development and even country sustainability. Countries seek the optimum across-point their economic growth, natural resource consumption with minimum the pollution (Stern, 2004). Eco-efficiency was an ability to create more goods and services with less consumption of natural resources with less impact on environment. Eco-efficiency was initially calculation by using approached with simple indicators of GDP to CO_2 emissions reduction at macro-level (Picazo-Tadeo, Beltrán-Esteve, & Gómez-Limón, 2012). Explore the literature of Eco-efficiency and generally define to create value by General Goal while decreasing environmental impact. In simple word, the eco-efficiency was a ratio between environmental element and production value (Huppes & Ishikawa, 2005). Environmental intensity metrics of CO_2 emissions was widely used for eco-efficiency measurement studies. Eco-efficiency can play vital role and useful for policymakers in decisions, in achieving long-term sustainable development goals (Camarero, Castillo, Picazo-Tadeo, & Tamarit, 2013). Therefore, eco-efficiency measurement patterns can be important to possible to identify most eco-efficient country in world, supportive for policies and strategies maker that made them more eco-efficient (Belucio et al., 2021).

Modern intensive agriculture production causing enhances the environmental and economic pressures and hinders sustainable development. Reduction in energy consumption was due to inefficient and high cost energy source. Life cycle assessment and life cycle cost commonly used for production and eco-environment assessment. The eco-efficiency rate are high during production of irrigated production as compare to dry farming (Nabavi-Pelesaraei & Damgaard, 2023). Life cycle assessments were optimizing energy consumption and mitigate impact on environment (Nabavi-Pelesaraei, Saber, Mostashari-Rad, Ghasemi-Mobtaker, & Chau, 2021). Technical and economic management of production energy efficiency and decreasing the production cost. Better results produced during data involvement analysis in energy and economic sections (Saeidi, Dehkordi, & Nabavi-Pelesaraei, 2022).

Principal arguments on problem scenario, study justification, and valuable output key significance of study; in recent decade's problem of environmental pollution become more and more serious, and general concept raise economic growth cannot fulfill the environment requirement; therefore, sustainable development has become aspiration of entire human. Sustainable motives to enhance production with less consumption and environmental impairment. In previous study focus eco-efficiency measure with degree of sustainable development and get more attention, energy consumption, trade and finance central role in eco-efficiency, sustainable development and modern Social-economic development (Ferrer & Thomé, 2023). Energy source diversity with trade, and finance role in eco-efficiency, sustainable development and Social-economic development is deficiency in literature (Zubedi et al., 2018). Transportation was an economic activity that interacts with the environment, while sustainable development has a global priority, performance of global transportation with respect to sustainability issues (Bojković, Anić, & Pejčić-Tarle, 2010). Green economy to promote improvement in eco-efficiency and role of energy source diversity in various regions are not the same for development, and eco-efficiency impact also differs (R. Wang, Zhao, & Zhang, 2022). Carbon emission reduction also differs under transport diversity scenarios (Jiang et al., 2024).

Developmental challenges for world, two global scale initiatives for world problem; one was Millennium Development Goals (2000-2015) and second was Sustainable development Goals Paris agreement UN Agenda-2030 (Patel, Joseph, Shrestha, & Foint, 2019). World leaders pledged to improve the social, economic and environmental condition of world. Goal 7D of the MDGs and SDGs 11.1 were foreign finance significant effect till 2020 in live standard (Traverso & Nangah Mankaa, 2023). There goals were put the international community to make effort and there foreign financing key role toward capacity building and human indexing (Gibberd, 2022). For instance, Executive Director of UN-habitat highlights the importance of foreign direct investment for development, planning, policies, financial and legal system, while low carbon transportation concentrated in capital cities green initiative for carbon capture and gaining momentum in urban various cities (Abubakar & Alshammari, 2023). In addition, Official development Assistance (ODA & Aid) was another key factor toward sustainability, and donors, financial organization award the world target and approved multi-project of technology enhancement, technical assistance toward social, economic and environmental sustainability (Acharya, 2003). ODA promoted social structure change, energy efficiency and technological progress (Q. Wang, Guo, & Dong, 2021). International trade was in today global economy and transport services that greatest scope to create the trade surplus (Malkowska & Malkowski, 2021). In similar sustainable transport main driver of economic development of any country while pollution implications. However, trade the sum of import, export of goods and services was key factor for investment and financial sustainability (Mačiulis, Vasiliauskas, & Jakubauskas, 2009). Trade is a most energy usage and major source of currency movement in-outside of countries, and enhance human living standard index (Sipahutar, Syahfitri, Sagura, Matondang, & Indrani, 2022).

The policy of reducing carbon dioxide emissions by 50% in 2050, announced at the 72nd meeting of the Marine Environment Protection Committee in April 2018, is an important step towards the adoption of environmentally friendly greenhouse gas emissions agreement (Psaraftis & Kontovas, 2020a, 2020b). The Transportation De carbonization initiate strategy (Doelle & Chircop, 2019). International Maritime Organization adopted strategy toward GDG emission reduction in ships (Earsom & Delreux, 2021). Define energy system, decarburization and technological development of transportation (Dorotić et al., 2019). Transport technology initiative (Kraciuk, Kacperska, Łukasiewicz, & Pietrzak, 2022). Oil and Gas transport energy consumption, carbon footprint and technological improvement (X. Chen et al., 2023). Electricity, hydrogen, fuels and renewable fuels are collectively known as transportation energy (Jorgensen, 2008). Therefore, Study research Gap to Investigating the difference between targets and diversity of energy transport consisting of oil, gas and electricity and determines the optimum energy supply that generates power for transport lead to meet the Paris CO_2 emissions agreement and research Gap having justification through empirical literature matched research objective decarburization of transportation toward SDGs, research significant of transport Energy such as traditional energy resources i.e., Gas and Oil are limited and have a high percentage of CO_2 emission which hurt to environment extremely, however have to necessary a suitable substitute (Armin Razmjoo, Sumper, & Davarpanah, 2020). On the other hand, technical transportation systems actually improve sustainability and the efficiency of the environment, whereas de-growth air transportation is a gateway to economic stability (Köves & Bajmócy, 2022). In modern technology and electric vehicles, it is used to provide electric motors with all or part of the energy produced for transportation, while reducing CO_2 emissions (Delgado, Moura, & de Almeida, 2021). The world's eco-efficiency aim is seriously challenged by the nearly 80% growth in transport CO_2 emissions between 1990 and 2019. Modify the transportation sector's growth and energy consumption sources to reduce emissions (Dai, Alvarado, Ali, Ahmed, & Meo, 2023). The main aim of this study is to analyze the impact of transportation on different energy sources (e.g. oil, gas and electricity) on reducing CO_2 emissions and to determine the best clean energy production for the development goals of the United Nations. Moreover, the empirical data can be further expanded; challenges, transporting energy, the goal of doing good in the world, and changing development. Energy various sources may direct influence on environmental. Study initiate the answer the several questions: What are transport energy research questions and studied contributions? What roles of energy source diversity in achieving Environment toward sustainability? Why the Transport energy source topic is important? Why energy source diversity influenced by Environment? Why purpose this particular method and various types of energy, such as Oil, Gas, and Electric influence on eco-efficiency? How does energy source diversity impact on Environment? When does energy source diversity influence on Environment?

Empirical evidence indicates energy consumption produce economic development and sustainability may implication for environment. Study applied the following research methodology for indication of results and policy recommendation. First we define the variable; second we develop hypothetical arguments, why various types of energy e.g. Oil, Electric, and Gas, can influence on eco-efficiency. Third we develop a strategy and Datasets used for examine the hypotheses, fourth we applied test for analysis the variable and hypothesis examination, fifth section discus present and empirical results, finally conclusion section comprises and a brief discussion on policy, research contributions, recommendation and implication of this study.

Experience from many countries shows that international trade is a good way to reduce CO_2 emissions from international transport, while charges of emission are an effective way for governments to influence environmental protection (Burchell, Ison, Enoch, & Budd, 2019). Globally emission trade was absence of cooperative climate (Carbone, Helm, & Rutherford, 2009). Universal carbon emissions trading were mitigates the costs, while without emission trading reduced the global welfare loss and burden (Fujimori et al., 2016). Transport road freight volume effective promotion shift alternative reduction emission modes (Gomez & Vassallo, 2020). In addition, Transport Fee-charging policies to reduced carbon emission (H. Wang, Shi, Xue, He, & Liu, 2022). Similarly emission trading contributed toward reduction in economic losses while associated technological assumptions with climate mitigation (Fujimori, Masui, & Matsuoka, 2015). High abatement cost reduced economy loss and emission trading schemes also redistributed in clean energy production (X. Zhang, Qi, Ou, & Zhang, 2017). Carbon market price erratically consumers decide to change road fuel transport vehicles (Li, Gao, Hu, Jia, & Wang, 2023). Road environment linked capital resources allocation toward lower cost efficiency for pollution reduction as well as marginal cost, energy consumption cost permit importer's intensive production, permit opposite economic and environment impact. To encourage consumption and clean manufacturing, importers are granted permission to transfer funds (Qi & Weng, 2016). Government and market forces had a vital role in encouraging investment and lowering emissions (Hu, Qi, & Chen, 2023).

A combination of environmental transport and economic policy can mitigate trade and economic shocks. Efficient utilization of natural resources by means of affordable economic and transportation methods, parking levies, traffic congestion mitigation, and road congestion pricing (Maruyama & Sumalee, 2007). Social impacts transport road pricing (Perkins, Wagner, & Leung, 2018). Achieving social climate goals needed rapid greenhouse gas reduction in transportation (Naumov, Keith, & Sterman, 2023). In order to attain economic success, the sustainable Development Goals require modern transportation systems, and SDGs may achieving through adoption of hydrogen fuel cell in transport vehicle's (Harichandan, Kar, Bansal, & Mishra, 2023). Innovation in technology for the environment and SDGs, as well as the sustainable development of renewable energy (L. Xing, Udemba, Tosun, Abdallah, & Boukhris, 2023). More important alternative fuels key factor toward greenhouse gas reduction in transport and promotion of UN Agenda of SDGs (Rony et al., 2023). Oil and Gas at central Asian and Gulf region countries tend to lower emission compared by inversions, while carbon fluxes from lateral carbon transport (Deng et al., 2021). Climate and environmental technologies at North-South key tools significant improvement toward Paris Climate agreement (Herman, 2022). Global climate progress depends on annual CO_2 emissions from Chinese and American companies. As part of the Paris agreement, China and the United states set a target for the United States to reduce carbon dioxide emissions by about 50% between 2005 and 2030, while china committed to trading and transporting carbon dioxide emissions by 2060. Emission neutrality, the Asian region consisting of Pakistan, India, China and Japan; Oil, gas and electricity transportation is greatly affected in terms of eco-efficiency and development goals (JAMIL, RASHEED, & MUKHTAR, 2023).

The real challenge is to reach an environment goal where unconventional fuels can be recovered and transported. Oil companies are showing great interest in unconventional oil as an alternative to energy use (Santos, Loh, Bannwart, & Trevisan, 2014). Pipelines may require integrated technologies to reduce costs and transportation (Martínez-Palou et al., 2011). Different types of fuel can be produced, including bio-diesel and hydro processing. Improved emissions of bio-diesel and hydro processing technologies have a positive impact on the production, efficiency and reduction of CO_2 emissions of recycled materials (Sonthalia & Kumar, 2019). A UK study shows that while fuel consumption depends on income, the estimated cost of fuel consumption is important. CO_2 emission policies are based on transportation, future energy needs and the environment (Broadstock & Hunt, 2010). Oil production to receive energy dynamic emission in the company (S. Greene, Jia, & Rubio-Domingo, 2020). While transport have De-carbonization potential (L. Wang, Xue, Zhao, Wang, & Zeng, 2020).

Oil reservoirs can produce negative impacts and carbon monoxide emissions with high activity (Etemad, Kantzas, & Bryant, 2020). De carbonization potentials in transportation (L. Wang et al., 2020). Diesel fuel usages are high impact on environment and health of people due to high rate of utilization in agriculture section; industrial manufacturing and transportation sector almost 50 % contributors in ecosystems (Hatim, Majidian, Tahmasebi, & Nabavi-Pelesaraei, 2023). Energy categories of diesel fuel and compost are causing damaging of human health, ecosystem due to direction emission effect (Nabavi-Pelesaraei et al., 2023). An empirical study was conducted on gasoline vehicles, vehicle market and its effectiveness and failure in improving the performance of gasoline vehicles in twelve countries (Khan, 2017). FCA invested in CNG-Powered vehicles in the 1990s and became a leader in transportation. While road transport is still 65% powered by natural gas, and electric hybrid vehicles are gradually being added. Modern oil technology should be efficient by eliminating the use of conventional oil (Ferrera, 2017). The main characteristics of gasoline as a transportation fuel are emission performance, safety and economy, while competition between electric transportation, gasoline and diesel, moreover CNG has many advantages that can reduce costs and reduce emissions (Khan, Yasmin, & Shakoor, 2015). Carbon monoxide is an energy carrier and an optimization problem in transportation (Ríos-Mercado & Borraz-Sánchez, 2015). De carbonizing transportation is a complex issue involving the population, environment, technology and economy. While, hybrid power system that reduces co2 emissions explores the de carbonization potential of efficient transportation (L. Wang, Zhao, Wang, & Xue, 2021).

The modernization of electric vehicles has great potential for De carbonizing the transport sector. Plug-in hybrid electric vehicle powertrains promise to reduce carbon emissions (Blumsack, Samaras, & Hines, 2008). Nanomaterial was a considerable application for environmental engineering (Maklavany, Rouzitalab, Bazmi, Askarieh, & Nabavi-Pelesaraei, 2023). Electron paramagnetic resonance spectroscopy and Nano phase magnetic particles, corn plant effect the efficiency of machines (Nasibova, 2023). Adsorbent Heavy metals effects onto bio adsorbent efficiently and environmental. Removing toxic heavy metals usages a novel and challenged (Ziarati et al., 2023). Silver nanoparticles sizes are important synthesized silver nanoparticles represented by Ag and AGCL. Standardized Silver nanoparticles are 22.9 nm and Ag 64.6 nm and AGCL 75.7 nm (Gunashova, Ahmadova, & Khalilov, 2021). Plug-in hybrid and modern electric vehicles can provide 50% energy efficiency compared to other modes of transportation. CO_2 emissions in transportation can also vary depending on when and where electricity is generated. Therefore, the power to move through electric transmission is the benefit of environment supporting electric vehicles (Y. Chen et al., 2018). Increase in carbon dioxide emissions from electric vehicles. Research based in china, the USA and European Union shows that electric vehicles are harmful to carbon dioxide. Carbon dioxide emissions reduction target of 671 million tons, 280 tons and 143 million tons, respectively, by 2050 (Gan, Wang, Lu, & Kelly, 2021). The traditional transportation increases pollution and therefore, the need for green transportation. Electric vehicles power stands out as the future of world vehicles. This uses the bidirectional power flow of the electric vehicle battery to both charge the car and control the electrical load (Ismail et al., 2022). The use go electric public transportation can reduce carbon dioxide emissions and passenger deaths (Pan et al., 2023). India, with its large population, with fossil emissions, but over the years, its policies have shifted towards decarbonizing transportation sector (Pradhan, 2021) and set the target of electric transportation by 2023 (Raugei & Winfield, 2019).

Greenhouse gases are the biggest problem of our time. One third the world' a transportation sector produces carbon dioxide, almost all sectors will reduce their dependence on fossil energy, but the transportation sector is still based on fossil energy. The government should create policies that encourage people to stop using gasoline and fossil transport driving (Kjellén & Tasala Gradin, 2020). Electrical energy can replace fossil energy to reduce carbon dioxide (Momber, 2015).

This research inspires the above valuable motivations, need and significance; to address these clear critical gaps and produce notable's evidence on energy diversity in achievement of Eco-efficiency toward sustainability in major four high populated clusters and energy consumed Asian countries.

Figure 1 - Model Structure

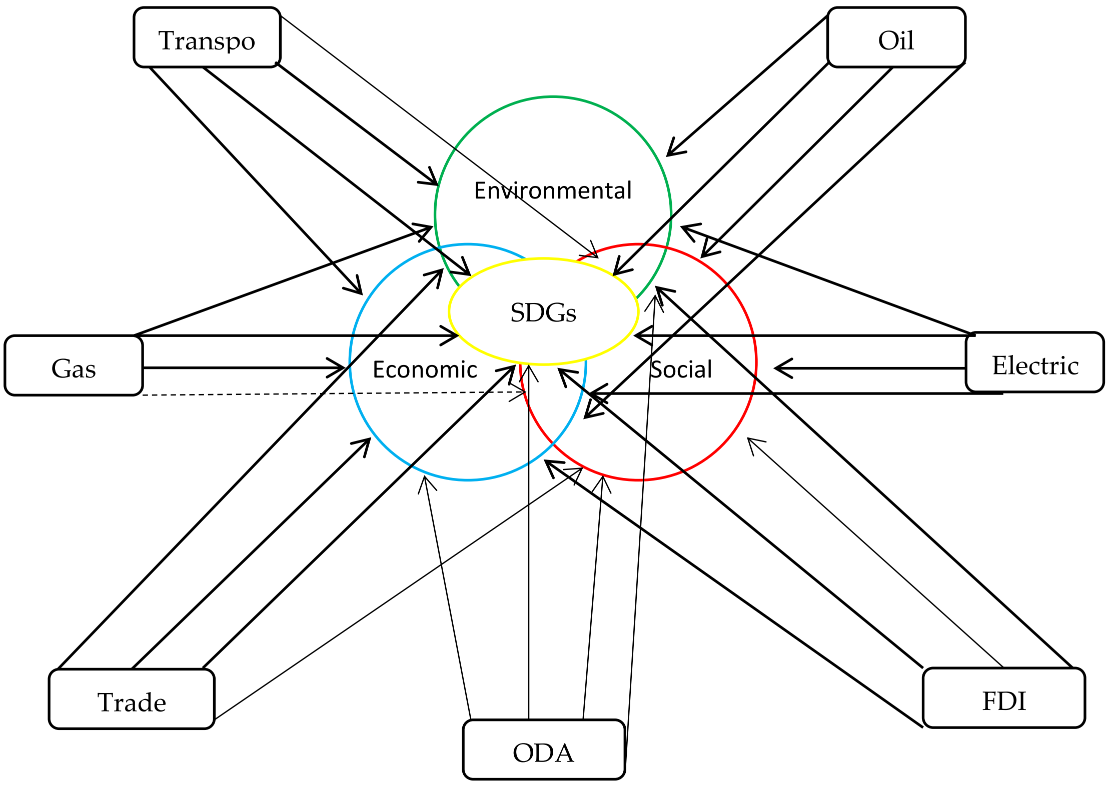


Table 1 - Variable Description

Variables	Measurement Units	Source
Eco-efficiency	The relationship between eco-element and production value was called eco-efficiency. Eco-efficiency refers to measure GDP per capita / CO_2 emissions per capita.	WDI
SDGs	Sustainable Development Goals (SDGs) refer to SDGs UN Agenda-2030 measure through average of SDGs ranking which was indicator to identify the degree of SDGs practiced and performance.	SDR Index Ranking
Transportation	The percentage of fuel burned during transportation is used to calculate the transport CO_2 emission.	WDI
Oil	The percentage of oil fuel consumed (kt) in the transportation sector is used to calculate the CO_2 emission from transport Oil power motion.	WDI
Gas	The percentage of total gaseous fuel consumption (kt) in the transportation sector is used to measure CO_2 emissions.	WDI
Electric	The transportation sector's overall electricity consumption (kWh) is used to calculate CO_2 emissions.	WDI
ODA	Technological and Employees Skill Development Assistance Measured by Official Development Assistance.	WDI
Trade	Trade the sum of import, export of goods and services was key factor for investment and financial sustainability.	WDI
FDI	Foreign Direct Investment (FDI) measured through net inflows (% of GDP).	WDI

HDI	Human Development Index (HDI) measured through GDP per Capita.	UNDP
Economic Development	Economic Development measured through the GDP Annual Growth.	WDI
Environmental Development	Environmental development measured through CO_2 emission (Metric tons per capita)	WDI

CO_2 emissions in transport are measured as a percentage of all transport vehicles burned. Covers all fuel combustion for all means of transportation; road, rail and pipe-line transport while only international marine oil and international aviation. Transportation CO_2 emissions from gasoline-powered movements are measured as a percentage (in kilotons) of all gasoline consumption in the transportation sector. In another world we can say carbon dioxide emissions in transportation are measured as a percentage of the total fuel (kilotons) use in transportation. CO_2 emissions from fossil fuel use mean that transportation is mostly powered by natural gas. Transportation CO_2 emissions are measured as a percentage of total transportation electricity consumption (kWh). Energy efficiency refers to the total energy consumption in transportation; heating, charging of batteries and other various ways of energy production in transportations. The measurement of transport eco-efficiency is; Eco-efficiency = Environmental cost / Economic output ~ transport eco-efficiency ~ transport CO_2 emissions (% of total) / Transport GDP share (% of total GDP). This study examines the impact of transportation carbon dioxide emissions on eco-efficiency in three ways. First, "pie chart" is used to analyze the policy trend impact of four Asian countries (Japan, China, India and Pakistan) on the 2050 Paris Agreement. Secondly, the line graphic is used to estimate performance of four Asian countries (Pakistan, India, China and Japan), and measure carbon dioxide emission between 0 and 40. Third, estimate the impact through Panel-GMM, while robustness applied for sustainability and efficiency estimation, the impact of transport diversity on eco-efficiency and sustainable development has been studied in four Asian countries of Pakistan, India, China and Japan and period 2021 to 2022. Therefore equations of transportation energy study as;

Transport CO_2 emission factor equations as

$$\text{Tranport Eco} \sim \text{efficiency efficiency}_t = f(C_{it}, O_{it}, G_{it}, E_{it}, A_{it}, F_{it}, T_{it}, S_{it}, Y_{it}, P_{it}) \sim \ldots\ldots\ldots 1$$

$$\text{Transport Eco} - \text{efficiency efficiency}_{it} = \beta_0 + \beta_1 C_{it} + \beta_2 O_{it} + \beta_3 G_{it} + \beta_4 E_{it} + \beta_5 A_{it} + \beta_6 F_{it} + \beta_7 T_{it} + \beta_8 S_{it} + \beta_9 Y_{it} + \beta_{10} P_{it} + \mathcal{E} \ldots\ldots\ldots 2$$

$$\text{SDGs}_t = \beta_0 + \beta_1 C_{it} + \beta_2 O_{it} + \beta_3 G_{it} + \beta_4 E_{it} + \beta_5 A_{it} + \beta_6 F_{it} + \beta_7 T_{it} + \beta_8 CO_{it} + \beta_9 Y_{it} + \beta_{10} P_{it} + \mathcal{E} \ldots\ldots\ldots 3$$

The above formula $_i$ represents the four Asian countries of Pakistan, India, China and Japan, $_t$ represents time, C represents fuel consumption, and O represents transportation Oil consumption, G representing gasoline consumption, E representing electric consumption in transportation. A represents Services; ODA & Official aid, T stand for trade, F stand for Financial Investment, S stands for Sustainable development Goals ~ average score of countries in the region. Co for environmental development, Y for GDP growth and GDP per capita P stands for human development. Although most evidence suggests that the difference between EE (b1>0) for good results (Sarkodie & Strezov, 2019).

$$P(\text{Trend}_i > j) = g(X_i \beta j) = \frac{\exp(aj + X_i \beta j)}{1 + \exp(aj + X_i \beta j)} \quad j = 1, 2, 3, 4 \ldots\ldots\ldots\ldots\ldots 4$$

Where $_i$ is represents four countries in Asia; Pakistan, India, China and Japan. While X_i applied for vector predictor variables estimation ~ representing the eco-efficiency, performance of countries measured as between 0 and 40, indicating the trending (Anyanwu & Yameogo, 2015).

1 RESULTS

Past and Future Trend of Climate policies and Significance toward Target 2050.

Figure 2

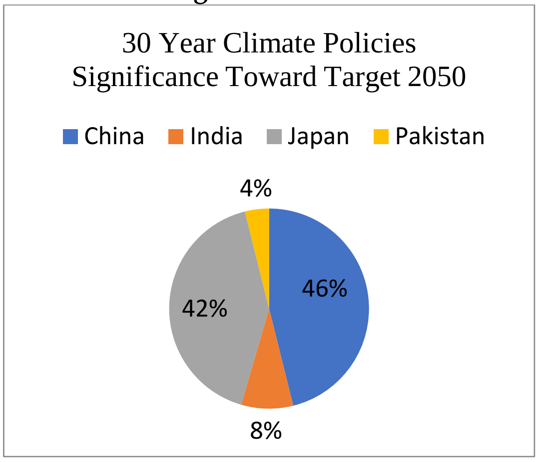


Figure 3

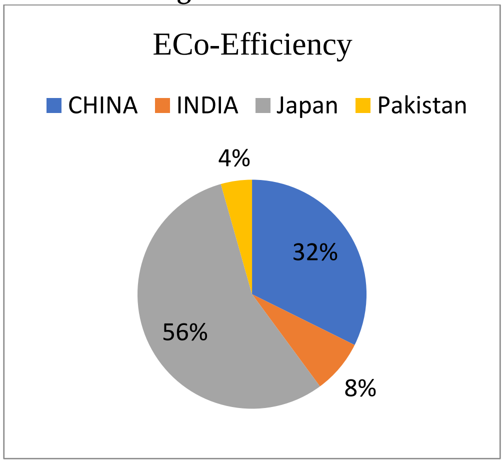


Figure 3 shows four Asian countries consisting of Pakistan, India, China and Japan the individual climate polices effort trend and significance toward target 2050. China on top 46% need to priority policies to forward Eco-efficiency because share of CO_2 emission big and policy on climate direct impact on world eco-system. Japan is on 2nd place 42 % toward policy implication toward target 2050. Trade between Japan and China is important for the world, but never environment cost. Transportation-oriented systems should be designed as environment friendly. India and Pakistan also goes on same pattern as policy implication less impacting world but his own country need to meet population and world standard. Figure 3 showing result from 2001 to 2022 data base the percentage of fuel used for transportation in total is used to determine transport eco-efficiency/ transport GDP share (% of total GDP). On average of 4 countries, Japan Eco-efficiency is 56%, China 32%, India 8% and Pakistan 4% shows the energy power motion of transport, carbon emission and its sum of the manufacturing transport unit, production and rail-road and air transport mode.

Transport Power Diversity (Eco-efficiency Share)

Figure 4

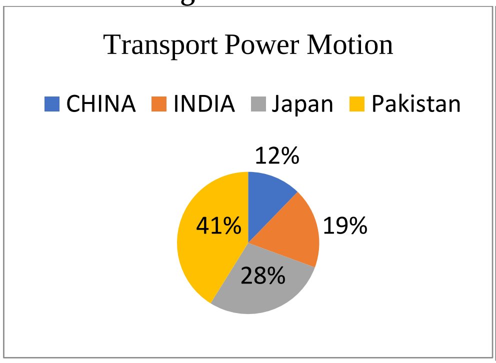


Figure 5

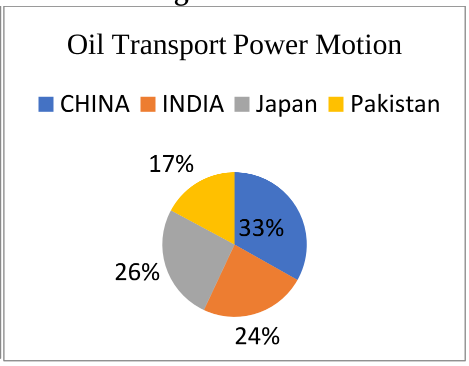


Figure 6

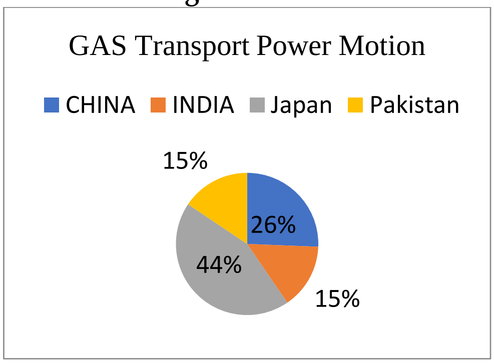


Figure 7

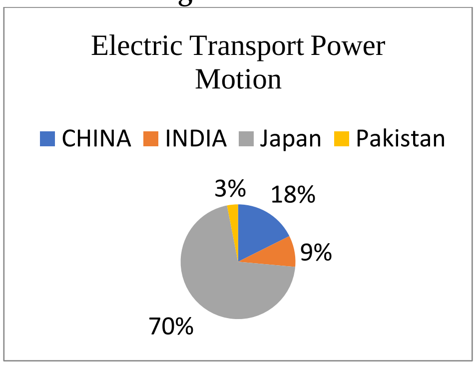
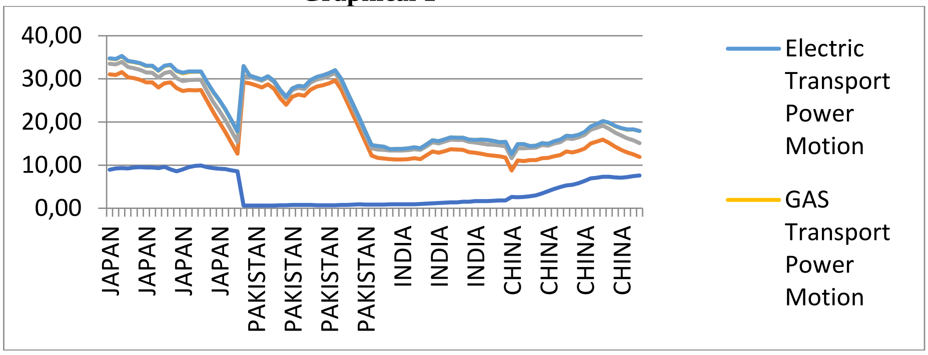


Figure 4 shows results from data 2001 to 2022 and CO_2 emission in transportation are measured by the average of all transportation costs. In terms of transport CO_2 emission fuel consumption of china 41%, 28% in Japan, 19% in India and 12% in Pakistan. Figure 5 showing result Oil Consumption in transportation sector. Oil consumption is almost equally each country because world trade cargo mostly base on Oil energy power motion system. Although on average of 4 countries, China Oil transports consumption on top with 33%, second 26% consumption in Japan, 24% in India and 17% in Pakistan. Gas utilization japan on top in transportation with 44%, second 26% in China, India and Pakistan 15% equality consumption ratio of Gas. While electric transportation average of 4 countries is real difference of four countries. Japan highly utilized electric power motion energy source country with 70%, second 18% in China, and third 9% in India and 3% in Pakistan electric transport using countries.

Graphical 1



Graphical table showing result from 2001 to 2022 data base Transport Power Diversity energy utilization sources and Eco-efficiency indication is very cleared, when fuel and energy consumption is high Eco-efficiency is go down, while when energy consumption is low down Eco-efficiency bust-up. Eco-efficiency and energy consumption in transportation sector have inverse relationship.

Table 2 - Descriptive Statistic

Descriptive Statistic	Eco-Efficiency	Transport	Oil	Gas	Electric	ODA	Trade	FDI	SDGs	Human Index	Economic Development
Mean	4.16	15.06	2.33	1.00	0.03	0.41	37.19	1.53	63.86	3.40	4.45
Median	2.15	11.85	2.33	0.75	0.01	0.19	35.51	1.10	61.91	3.08	4.78
Maximum	9.91	28.93	3.31	2.78	0.09	2.52	64.48	4.55	79.56	13.64	14.23
Minimum	0.62	4.10	1.49	0.28	0.00	-0.01	19.56	-0.05	51.60	-8.20	-7.30
Std. Dev.	3.60	7.50	0.56	0.65	0.03	0.55	10.46	1.28	9.68	4.10	4.19

Table 2 is Descriptive statistic of four major trades and population cluster Asian Nations; China, India, Pakistan, and Japan and showing how each variable have the ability to affect the environment period 2001 to 2022. Eco efficiency dependent potential effects mean 4.16, standard deviation 3.60. Independent potential oil mean 2.33, standard deviation 0.56 showing highest impact factor in transport power motion, while Gas mean 1.00, standard deviation 0.65 at second largest source of energy. Electric energy is on 3rd place and continuously increases the share in that region. ODA ~ official development assistance mean 0.41 and standard deviation 0.55, trade 37.19 and 10.46, FDI 1.53 and 1.28, GDP growth was 4.45 percent and 4.19 percent, per capita GDP growth was 3.40 and 4.10 percent, and sustainable development targets were 63.86 percent and 9.68 percent, respectively potential to effect on environment quality.

Table 3 - Eco-efficiency - Regression

Variables	Coefficient.	t-Statistic	Prob.
Transport Power Motion	0.04060*	1.790291	0.0773
Oil Transport Power Motion	2.7083***	5.987897	0.0000
Gas Transport Power Motion	0.017027	0.087209	0.9307
Electric Transport Power Motion	103.18***	7.647052	0.0000
Official Development Assistance	0.308967	1.377919	0.1722
Foreign Trade	-0.0373***	-3.663222	0.0005
Foreign Direct Investment	0.20769*	2.133359	0.0360
Sustainable Development Goals	-0.06907*	-2.515179	0.0140
Human Index	0.445867	1.271610	0.2073
Economic Development	-0.400030	-1.149833	0.2537

R-squared	0.974560	Mean dependent var	4.159784
Adjusted R-squared	0.971625	S.D. dependent var	3.603880
S.E. of regression	0.607074	Akaike info criterion	1.946313
Sum squared resid	28.74605	Schwarz criterion	2.227829
Log likelihood	-75.63779	Hannan-Quinn criter.	2.059729
Durbin-Watson stat	0.354905		

Table 3 shows the impact of transport on eco-efficiency energy power motion in four Asian countries (Pakistan, India, China and Japan). Overall transport power motion 0.04060*, Oil transport power motion 2.7083***, and Electric power motion 103.18*** indicating positive highly significance and important for Eco-efficiency, while Gas power motion 0.017027 showing less impact on Eco-efficiency. Results point-out significance of the Oil and electric energy towards eco-efficiency. Moreover, other indicators i.e., Trade -0.0373***, and Sustainable development Goal of UN-Target 2050 -0.06907* are highly significant, negative impact on Eco-efficiency; showing high importance of foreign trade, SDGs for eco-efficiency. As Foreign Direct Investment 0.20769*, Official development assistance 0.308967, Human Index 0.445867 positive and economic development -0.400030 negative relationships exist. Concluding remarks are Transport power diversity and their resources are an important factor in eco-efficiency and can increase efficiency and productivity.

Table 4 - Eco-efficiency - GMM

Variables	Coefficient.	t-Statistic	Prob.
Transport Power Motion	0.04060*	1.790291	0.0773
Oil Transport Power Motion	2.7083***	5.987897	0.0000
Gas Transport Power Motion	0.017027	0.087209	0.9307
Electric Transport Power Motion	103.18***	7.647051	0.0000
Official Development Assistance	0.308967	1.377919	0.1722
Foreign Trade	-0.0373***	-3.663222	0.0005
Foreign Direct Investment	0.20769*	2.133359	0.0360
Sustainable Development Goals	-0.06907*	-2.515179	0.0140
Human Index	0.445867	1.271610	0.2073
Economic Development	-0.400030	-1.149833	0.2537

R-squared	0.974560	Mean dependent var	4.159784
Adjusted R-squared	0.971625	S.D. dependent var	3.603880
S.E. of regression	0.607074	Sum squared resid	28.74605
Durbin-Watson stat	0.354905	J-statistic	34.216***
Instrument rank	11	Prob(J-statistic)	0.000000

Table 4 shows the eco-efficiency impact of transport sources diversity in four Asian countries (Pakistan, India, China and Japan). GMM refer to generalized method of movements applied for penal data correct assessment. It is recommended to use GMM estimation when the co-efficient of the dependent variable is close to 0.87. Overall transport power motion 0.04060*, Oil transport power motion 2.7083***, and Electric power motion 103.18*** indicating positive highly significance and important for Eco-efficiency, while Gas power motion 0.017027 showing less impact on Eco-efficiency. Moreover, other indicators i.e., Foreign Trade -0.0373*** and SDGs is -0.0697* highly significant, negative impact on Eco-efficiency. As FDI 0.20769*, Human Index 0.445867 positive and economic development -0.400030 negative relationships exist. The generalized method of movements' assessment concluding remarks are transportation with electric power is important for eco-efficiency, increasing efficiency and performance.

Table 5 - Eco-efficiency – Robustness Least Squares Method

Variables	Coefficient.	z-Statistic	Prob.
Transport Power Motion	0.04520*	1.848894	0.0645
Oil Transport Power Motion	2.5123***	5.152341	0.0000
Gas Transport Power Motion	0.121013	0.574929	0.5653
Electric Transport Power Motion	95.793***	6.585071	0.0000
Official Development Assistance	0.310999	1.286523	0.1983
Foreign Trade	-0.0425***	-3.874565	0.0001
Foreign Direct Investment	0.26529*	2.527594	0.0115
Sustainable Development Goals	-0.05709*	-1.928480	0.0538
Human Index	0.64275*	1.700367	0.0891
Economic Development	-0.584422	-1.558170	0.1192

Robust Statistics

R-squared	0.704830	Adjusted R-squared	0.670772
Rw-squared	0.980893	Adjust Rw-squared	0.980893
Akaike info criterion	120.4375	Schwarz criterion	145.2255
Deviance	24.19561	Scale	0.490782
Rn-squared statistic	6173.2***	Prob (Rn-squared stat.)	0.000000

Non-robust Statistics

Mean dependent var	4.159784	S.D. dependent var	3.603880
S.E. of regression	0.613826	Sum squared resid	29.38898

Table 5 above shows robust least squares method results that demonstrate the long-term validity and sustainability of the results. Transport power motion 0.04520*, Oil power motion 2.51*** and Electric power motion 95.73*** are positive highly important for CO_2 emission reduction. Gas is 0.121013 less impact factor for Eco-efficiency. Foreign Trade -.0425*** and Sustainable Development Goal UN-Target-2050 is –0.05709* highly significant negative impact on CO_2 emission reduction. FDI 0.26529* and Human Index 0.64275* are positive and Economic Development -0.584422 negative effecting factor for Eco-efficiency. Rn-squared statistic indicated 6173.2*** the Robustness assessment test data and results sustainability concluding; transportation with electric power is important for eco-efficiency, increasing efficiency and performance.

Table 6 - Sustainable Development Goals - Regression

Variables	Coefficient.	t-Statistic	Prob.
Transport Power Motion	0.2762***	3.202091	0.0020

Oil Transport Power Motion	16.705***	15.80463	0.0000
Gas Transport Power Motion	0.784361	1.019843	0.3110
Electric Transport Power Motion	478.69***	10.51818	0.0000
Official Development Assistance	0.088565	0.098425	0.9218
Foreign Trade	0.08094*	1.893181	0.0620
Foreign Direct Investment	0.66342*	1.701192	0.0929
Environmental Development	-1.0860**	-2.515179	0.0140
Human Index	-7.559***	-6.787654	0.0000
Economic Development	7.394***	6.655690	0.0000

R-squared	0.944576	Mean dependent var	63.85795
Adjusted R-squared	0.938181	S.D. dependent var	9.681756
S.E. of regression	2.407212	Akaike info criterion	4.701460
Sum squared resid	451.9842	Schwarz criterion	4.982976
Log likelihood	-196.8642	Hannan-Quinn criter.	4.814876
Durbin-Watson stat	0.281245		

Table 6 shows the impact of transport energy source diversity on sustainable development goals in four Asian countries: Pakistan, India, China and Japan. Overall transport power motion 0.2762***, Oil transport power motion 16.705***, and Electric power motion 478.69*** indicating positive highly significance and important for Sustainable Development Goals, while Gas power motion 0.784361 showing less impact on Sustainable Development Goals. Result point out the energy clean production of Oil and Electric energy motion efficiency toward Sustainable Development Goals. Moreover other indicators i.e., Trade 0.0894*, FDI 0.66342* and Official development assistance 0.088565 are positive significant impact on SDGs, moreover Sustainable development Goal of UN-Target 2050 specific indicator of Environmental development -1.0860**, Human Index -7.559*** negative economic development 7.394*** positive relationships exist. Concluding remarks are Transport power diversity and sources are an important factor for social economic and environmental development toward sustainable development leads to increasing efficiency and performance.

Table 7 - Sustainable Development Goals - GMM

Variables	Coefficient.	t-Statistic	Prob.
Transport Power Motion	0.2762***	3.202091	0.0020
Oil Transport Power Motion	16.705***	15.80463	0.0000
Gas Transport Power Motion	0.784361	1.019843	0.3110
Electric Transport Power Motion	478.69***	10.51818	0.0000
Official Development Assistance	0.088565	0.098425	0.9218
Foreign Trade	0.08094*	1.893181	0.0620
Foreign Direct Investment	0.66342*	1.701192	0.0929
Environmental Development	-1.0860**	-2.515179	0.0140
Human Index	-7.559***	-6.787654	0.0000
Economic Development	7.394***	6.655690	0.0000

R-squared	0.944576	Mean dependent var	63.85795
Adjusted R-squared	0.938181	S.D. dependent var	9.681756
S.E. of regression	2.407212	Sum squared resid	451.9842
Durbin-Watson stat	0.281245	J-statistic	41.046***
Instrument rank	11	Prob(J-statistic)	0.000000

Table 7 shows the impact of transport energy sources diversity on sustainable development goals in four Asian countries: Pakistan, India, China and Japan. GMM refer to generalized method of movement applied for penal data estimation. Therefore, when the co-efficient of the dependent variable is close to 0.87, it's recommended to use for accurate estimate through GMM estimation. Overall transport power motion 0.2762***, Oil transport power motion 16.705***, and Electric power motion 478.69*** indicating positive highly significance and important for Sustainable Development Goals, while Gas power motion 0.784361 showing less impact. Energy Result point-out the clean production of Electric and Oil energy efficiency toward SDGs. Moreover others indicator i.e., ODA 0.088565, Trade 0.08094*, and FDI 0.66342* have positive impact on Sustainable development Goal of UN-Target. More specific SDGs target indicator, environmental development -1.0860**, Human Index -7.559*** negative and economic development 7.394*** positive effect on SDGs. The GMM estimation concluding remarks are Transport power motion is an important and significant factor for social, economic and environmental development toward SDGs UN Agenda-2030 and enhances the efficiency and performance.

Table 8 - Sustainable Development Goals – Robustness Least Squares Method

Variable	Coefficient	z-Statistic	Prob.
Transport Power Motion	0.4528***	9.052479	0.0000
Oil Transport Power Motion	17.582***	28.68026	0.0000
Gas Transport Power Motion	0.95876*	2.149398	0.0316
Electric Transport Power Motion	478.08***	18.11236	0.0000
Official Development Assistance	0.793991	1.521420	0.1282
Foreign Trade	0.0727***	2.934651	0.0033
Foreign Direct Investment	0.7820***	3.457759	0.0005
Environmental Development	-1.6894***	-6.746023	0.0000
Human Index	-4.0301***	-6.239097	0.0000
Economic Development	4.0156***	6.231935	0.0000

Robust Statistics

R-squared	0.790570	Adjusted R-squared	0.766405
Rw-squared	0.985718	Adjust Rw-squared	0.985718
Akaike info criterion	99.92540	Schwarz criterion	133.0526
Deviance	193.3785	Scale	1.480045
Rn-squared statistic	185549***	Prob. (Rn - Squared stat.)	0.000000

Non-robust. Statistics

Mean dep. var	63.84795	S.D. dep. var	9.680756
S.E. of reg.	2.714220	Sum squared resid.	574.6253

Table 8 shows SDGs results through estimation the robust least squares method that validate the data and research sustainability. Transport power motion 0.4528***, Oil power motion 17.582*** Gas 0.95876* and Electric power motion 478.08*** are positive highly significant effect on Sustainable development Goals target. While other indicator Foreign Trade 0.0727*** and FDI 0.7820*** highly significant positive impact on Sustainable Development Goal UN-Target-2050 while ODA less indicated. Further specified SDGs indicators of Environmental development -1.6894***, Human Index -4.0301*** are high significant negative and Economic Development 4.0156*** positive effecting factor for UN SDGs target. Rn-squared statistic indicated 18554*** the Robustness assessment test data and results highly valuable sustainable; Transport power motion is an important factor for social, economic and environmental development toward SDGs target that enhances the efficiency and performance.

Overall, the results are positive highly significant, reveals and consistent with previous findings. Accordingly, energy consumptions i.e., transport Oil, Gas, and electric produced carbon emissions positively across all estimators at a 1% significant level. The evidence study coincide with that (Jing, Liu, Yu, & He, 2022) and (Amin, Altinoz, & Dogan, 2020) economies indicated linkage between transport energy consumption sources i.e. Oil, Gas, electric with environment disturbance (Sarwar, Chen, & Waheed, 2017). Contribution rate of energy usage 4.22% and sustainable transportation system by promoting eco-efficiency. However conventional energy utilization that is responsible for environment pollutant emission consequently causes environment degradation.

Such economic activity involved transportation and industries activities and many other dimensions (Stevens, 2018). Therefore, emissions have been connection with social, economic and environmental activities and conventional energy sources not fulfill universal requirements, however needed alternative energy source.

CONCLUSIONS AND RECOMMENDATIONS

The main aim of this study is to examine the impact of different modes of transportation energy sources (e.g. Oil, gas and electricity) on reducing CO_2 emissions and to identify the best clean energy sources for transportation to achieve sustainable goals. Greenhouse gases are the biggest challenge in the world, one third of the world transportation sector produces carbon dioxide emissions, the world is focused on reducing dependence on fossil energy trough technology, but transportation sector still dependent on fossil energy. The finding also shows that the worlds have dependency on fossil consumption.

In terms of transport CO_2 emissions and transport fuel consumption, the average fuel consumption in the four Asian countries is 41% in China, 28% in Japan, 19% in India and 12% in Pakistan. China has a share of 33 percent in transportation fuel consumption, Japan is second with 26 percent, and India has a share of 24 percent and Pakistan ha a share of 17 percent. Japan is the country that consumes the most oil with 44 percent, while China ranks second with 26 percent, India and Pakistan rank at third. In electric transportation, Japan has 70 percent, China 18 percent, India percent and Pakistan 3 percent. China and Japan is the world's largest producer, while trade is important to the world, but not at environment cost. Japan's eco-efficiency policy is better and recommended for other three countries and world, because eco-efficiency and transport energy efficiency are still far from the target. Thus, china, India and Pakistan have set their target and continue to improve transportation efficiency and reduce CO_2 emissions.

Moreover, results also highlight the impact of the four Asian countries: Japan, China, India, and Pakistan on transport source of energy toward eco-efficiency, and sustainable development Goals (SDGs) period from 2001 to 2022. Overall transport, Oil, Gas and Electric power motion indicating positive highly significance effect on eco-efficiency and SDGs. Study also sidelight the importance of energy consumption diversity because Oil is one of the largest energy sources in transportation; the eco-efficiency of oil has a significant impact on the environmental development leads to UN-Target of sustainable development goals, as electric less CO_2 emission source toward Eco-efficiency and sustainability. However, other indicators i.e., Trade negative, FDI and ODA has a positive impact on eco-efficiency, meanwhile ODS, Foreign trade and FDI positive more specified SDGs indicator's Environmental development, Human Index negative and economic development positive impact on SDGs. Foreign trade major transport energy usage source and important for world, but never at cost of environment destruction highly significance for social, environment and economic development, while Gas, ODA less impact on eco-efficiency and SDGs.

GMM estimation also similar result predicted electric, oil and gas energy motion diversity positive highly significant effect on Eco-efficiency and sustainability. Robust least squares provide long-term sustainability indications and validate regression and GMM results.

Similar studies; studies have shown that technological progress leads to environmental performance, using 1% investment injection growth will also lead to environment stability. Therefore, energy sector should able to more personal and external participation (L. Zhang, Saydaliev, & Ma, 2022). However, positive effect reveals carbon emission to economic activities and alternative energy source (Saboori, Sapri, & bin Baba, 2014). Energy efficiency is important for Southeast Asian countries; when energy demand increases rapidly, it lowers the temperature and becomes more efficient (Azhgaliyeva, Kapoor, & Liu, 2020). Technology innovations indorsed environmental efficiency in south-east and south-Asian regions (Twum et al., 2021). Electric transport reveals results positive effect promote decarbonized electricity generation and total transport GHG reduced 0.8%-4.4% technological inventions and 5.6 overall GHG emission reductions, while transport GHG emission, Gasoline and diesel Oil consumption by 3%-16.2%, 4.4%-16.1% and 15.8%-34.3% respectably reduced by current positive intervention reveals our study results (Zheng, Li, & Xu, 2019). energy resource efficiency positive exploit effect on clean energy production toward investment, cost, sustainability and performance (Majid et al., 2023). Similar earlier study indication alternative fuel options for low carbon transportation system (H. Xing, Stuart, Spence, & Chen, 2021).

Similar empirical studies validate our result; study has value toward energy diversity positive significant effect on eco-efficiency and SDGs. Transport are currently face enormous soaring energy consumption and greenhouse gas emission, major solution to transportation De-carbonization considerable electric vehicles get more attention from policymakers and our study reveals importance of alternative transport energy source electric vehicle and suggested substitute toward clean energy production in transportation.

Energy power motion implication such as natural energy resources i.e., Gas and Oil are limited and have a high percentage of carbon emission which hurt to environment extremely, however have to needed a suitable substitute.

Therefore, recommendations for research are quite clear that transportation and business should be designed as environment friendly systems. The government needs to create policies to encourage people to stop petrol and diesel consumption in transportation until modern technology becomes more efficient. Electrical power is another way to generate power for transport vehicle and reduce CO_2 emissions.

In sharply overall, the technology advancement can able to deliver the greatest CO_2 reductions and support to meet the United Nations climate agreement. The 2015 Paris climate agreement is the most successful international agreement, needs to set targets to achieve eco-environmental efficiency and reduce CO_2 emissions.

In sharply, technology must be able to achieve the highest CO_2 reduce potential and meet the UN Climate agreement. Paris agreement on climate 2015 was most successful agreement between the advancing global world to set a target to meet eco-environment efficiency and reduce CO_2 emission.

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