



Green Technology Acceptance Model and Green Logistics Operations: “To See Which Way the Wind Is Blowing”

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The study provides a new insight to extend traditional technology acceptance model (TAM) in to energy-augmented TAM (EA-TAM) model in order to analyze the micro and macro perspectives of green enterprise technology to ensure eco-friendly products. The critical review would enhance analytical abilities to understand the main determinants of the TAM model at both firms' and industry perspective. The study proposed micro and macro enterprise energy-augmented TAM models and found that microenterprise EA-TAM associated with green investment decision that increases the use of renewable energy demand to improve logistics performance, export capabilities, technology advancement, resource inputs, and competitiveness. These factors would largely support to green product innovation, which is fueled by green R&D expenditures. The green supply chain process would develop an attitude and behavioral intention toward the use of technology and green products, which ultimately would bond with green system use. The macro perspective of EA-TAM shows that green factors including green supplier selection, industrial green engineering, green procurement, green consumerism, green product recovery, and green innovation would increase green purchase decisions that convert into perceived ease of green products usage. The eco-product choice faced three compelling issues that could negatively affect the use of green products attitude and intentions, i.e., political constraints, carbon pricing, and consumer willingness-to-pay for public goods. The study concludes that the need for green policies is imperative to regulate firms and the industrial decision to go-for eco-friendly production. The use of renewable energy, carbon pricing and willingness-to-pay for public goods would be recommended for long-term sustainable development.

Keywords: green technology acceptance model, green logistics, renewable energy demand, green investment decision, green innovation, green system use

AN OVERVIEW OF TECHNOLOGY ACCEPTANCE MODEL (TAM)

Technology Acceptance Model (TAM) is basically an individual's acceptance of certain information technology and information system (Davis, 1989). The two most important factors of TAM model are: perceived usefulness—that shows the importance and subjective capabilities of individuals to use computer base applications in a way to derive maximum utility of his/her work to perform

in an efficient manner. The perceived ease of use—it is related to how an individual feel easiness and capable to use computer base applications with quite low efforts. It was quite obvious that both the factors influenced by the number of external factors through which the end-use of the actual system could be halted for a while. The previous studies largely presented the numerous external factors that affect the use of the actual system, including social factors, cultural factors, and political factors (Davis, 1989; Ajzen, 1991; Taylor and Todd, 1995; Surendran, 2012; Dwivedi et al., 2019; Schmidhuber et al., 2020, etc.). The actual Davis–TAM model is presented in **Figure 1** for ready reference.

Venkatesh and Bala (2008) presented the TAM model in the two different versions, i.e., TAM-2 and TAM-3, by introducing numerous exogenous factors of perceived usefulness (Venkatesh, 2000) and perceived ease of use (Venkatesh and Bala, 2008). The perceived usefulness introduced with four component items, i.e., individual standing (image) in a social circle by using technology, technology-related with his/her job requirement, improve quality of work, and end task outcome is satisfactory, while there are six component items for perceived ease of use, including, computer proficiency, an external control system for technology support, fear of technology use, computer playfulness, perceived enjoyment of technology use, and objective usability. TAM-2 and TAM-3 both qualify the utility maximization principle to improve the outcome of the end-user system. **Figure 2** shows the Venkatesh and Bala–TAM models for ready reference.

In a similar connection, Kim et al. (2008) developed a TAM model for travelers and included mobile technology in information technology and system to perceived tourist's acceptability in terms of usefulness and ease of use, which becomes an integral part of the information acquiring about seeking tourism destinations, auto navigator, hotels location, flight reservation, and other travel information. TAM model includes technology experience and leisure trip experience in order to access an actual use of mobile technology in the pleasure-seeking destination. **Figure 3** shows the Kim–TAM model for ready reference.

Table 1 shows the current strikes of literature on TAM in different sectors.

Contribution of the Study

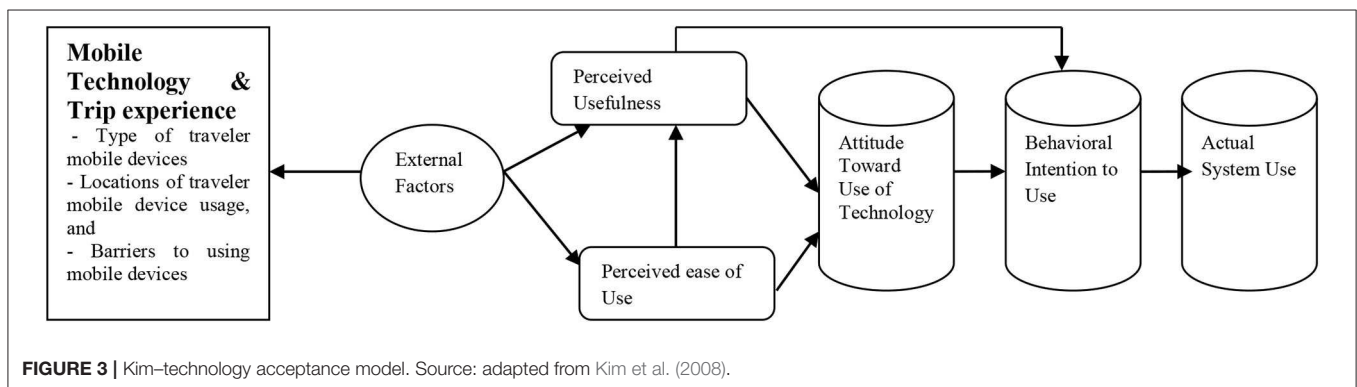
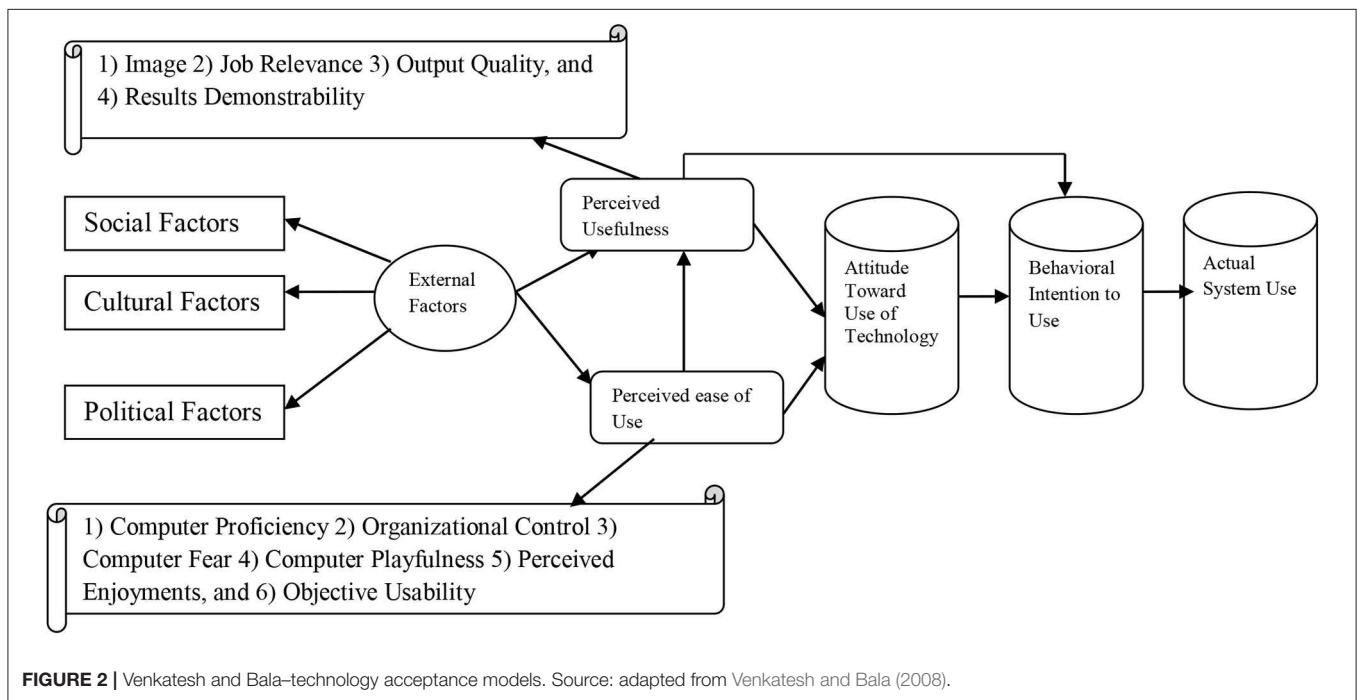
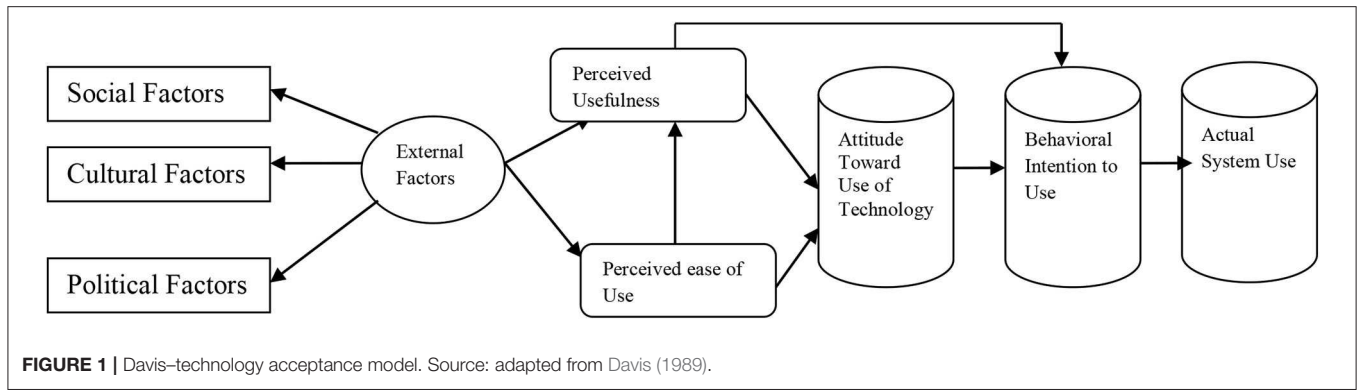
The study has a novel contribution in the existing literature for three different ways; firstly, it's focused on extensive review of past literature on green technology acceptance model that is linked with renewable energy demand. The green energy is vital for operating logistics operations that helpful to reduce carbon emissions and achieved sustainable supply chain management practices, both at firm and industry level. The previous studies extensively worked on green TAM, however, these studies are mainly limited to firm-level study, which is partially address to respond country's call for global warming to reduce the global average temperature $<2^{\circ}\text{C}$ (see McKinnon, 2010; Chaabane et al., 2011; Rezaee et al., 2017; Chelly et al., 2019, etc.). Secondly, the investment in energy infrastructure would enable logistics activities to increase exports capabilities, which would be helpful to develop an attitude toward the use of green products and make them green profit. The earlier studies moderately supported

the stated argument, as it's fairly less emphasized on energy support prices in the industrial setting that negatively influenced logistics performance and supply chain process (see Degirmenci and Breitner, 2017; Ali et al., 2019; Hua and Wang, 2019, etc.). Finally, the carbon pricing strategy could be used to minimize negative environmental concerns that are less likely to explore in the earlier studies in sustainable supply chain process. The study suggested the need to include carbon taxes in EA-TAM that would be helpful to support GSCM practices across the globe (see Kardooni et al., 2016; Girod et al., 2017; Mejia, 2019, etc.).

UNIFIED THEORY OF ACCEPTANCE OF USE OF TECHNOLOGY (UTAUT) IN SERVICES SECTOR

San Martín and Herrero (2012) extended the unified theory of acceptance of the use of technology (UTAUT) in the services sector where technology is directly used to make hotel bookings/reservation online through company websites. Thus, the internet is the viable information technology factor that connected computer system through the world and get information about the hotel reservation, travel information, weather forecast etc. The UTAUT model encompassed four important factors that derive online purchase intention in rural tourism, i.e., (i) effort expectancy, (ii) social influence, (iii) facilitating conditions, and (iv) consumer innovativeness toward the use of new technology. Tom Dieck and Jung (2018) developed mobile augmented TAM and proposed seven external dimensions through which behavioral intention leads toward the use of technology and its application for visiting urban heritage tourism, i.e., (i) information quality, (ii) system quality, (iii) costs of use, (iv) recommendations, (v) personal innovativeness, (vi) risk, and (vii) facilitating conditions. These external factors influenced the tourist's perceptions and developed differential attitude toward use or not to use this application for visitation in pleasure destinations. **Figure 4** shows Tom Dieck and Jung–TAM for ready reference.

The UTAUT model is further discussed in the domain of sustainable technology products where the emphasis is shifted from e-technology to smart and sustainable technologies. Ahn et al. (2016) extended the UTAUT model by including different external factors related to the adoption of green household technology, including, (i) performance expectancy, (ii) effort expectancy, (iii) compatibleness expectancy, (iv) hedonic expectancy, (v) social pressure, (vi) sustainable innovativeness, and (vii) environmentalism. Thus, these seven exogenous factors influenced behavioral intention to use sustainable household technology. Hsu et al. (2017) argued that green information technology products (e-books) helpful to disseminate environmental concerns that intensify the need to buy e-books to care for the natural environment, thus consumer's knowledge played an important role in UTAUT modeling to publicize environmental friendliness technology for green development. Ma et al. (2017) found that sustainable label reading behavior of the products increase the intention to use sustainable products as compared to the non-label products.



Thus, the technology acceptance model is worked in the domain of environmentalism more than the non-sustainable products, which is imperative to develop a greater attitude toward using sustainable products. **Figure 5** shows the green technology acceptance model for safeguarding the natural environment.

ENERGY-AUGMENTED TECHNOLOGY ACCEPTANCE MODEL (EA-TAM)

The above pictorial review gives a pearl of analytical wisdom to extend the TAM model into energy augmented TAM (EA-TAM).

TABLE 1 | Current literature on TAM.

| References | Technology sector | Country | Participants | Results |
|----------------------------|--|------------------------|-------------------------|---|
| Islam (2020) | Wireless internet service | Malaysia | 285 university students | PEU positively influenced on student's satisfaction in using wireless internet. |
| Lee and Moon (2020) | Didi Chuxing–mobile technology | China | 314 users | Service quality positively influenced to mobile technology, while mobile technology leads to customer's satisfaction. |
| Adepoju and Adeniji (2020) | E-banking | Nigeria | 304 users | PU significantly increases the user intention to use E-banking products. |
| Vahdat et al. (2020) | Mobile app technology | Iran | 777 app users | PEU, SPI, and ITP positively influenced on attitude toward use of mobile apps. |
| Rafique et al. (2020) | TAM library applications | Pakistan | 340 MLA users | PU and PEU both are the strong predictors of the use of MLA. |
| Kamal et al. (2020) | Telemedicine services | Pakistan | 275 users | The intention to acquire telemedicine services influenced with PEU, SPI, PR, trust, and technology resistance. |
| Faustino and Simões (2020) | Technology based teaching and learning process | Bibliometric analysis | Last 10 years studies | The Bibliometric analysis shows that TAM is largely discussed as for student point of view while less talk about for teachers' point of view. Further PU, PEU, and self-efficacy are the main factors of technology acceptance. |
| Elishafey et al. (2020) | Construction industry | 4 developing countries | 58 respondents | The users control over building information and augmented reality, and PEU has the greater influence on actual system use that positively affects their intention to use the system. |
| Winarno and Putra (2020) | Financial reporting system | Indonesia | 73 respondents | PEU positively influenced with respondents' experiences. |
| Sohn and Kwon (2020) | Artificial intelligence | Korea | 378 respondents | PEU, enjoyment, and technical ability largely increase perceived value. |
| Rezaei et al. (2020) | Ecological conservation | Iran | 327 farmers | The intention to use integrated pest management in tomato growers largely explained by farmers' attitude, PU, and PEU that shows the ecological concerns of the farmers in application of pest management. |
| Mousa et al. (2020) | E-learning | Iraq | 450 students | PU and PEU both are the potential factor that positively influenced to students' intention to use E-learning. |
| Ardiansah et al. (2020) | E-commerce | Indonesia | 96 users | E-commerce applications influenced by PEU. |

PU shows perceived use, PEU shows perceived ease of use, SPI shows social and peer influence, ITP shows intention to purchase, MLA shows mobile learning applications, and PR shows perceived risk.

The EA-TAM model shows that technology always remains required more energy in order to perform its functioning ability to gear business activities. Thus, the need for energy demand always plays a pivotal role in economic activity that would be helpful to achieve green development agenda. The technology embodied emissions largely released during the production process, thus the need for green energy is always required for moving toward sustainable development. The role of renewable energy sources in technology-oriented growth is imperative for low emissions growth. Thus, on the basis of the significance of the debate, the study proposed EA-TAM model both in micro and macro perspectives. **Figure 6** shows the EA-TAM Model in micro-perspectives (firms view).

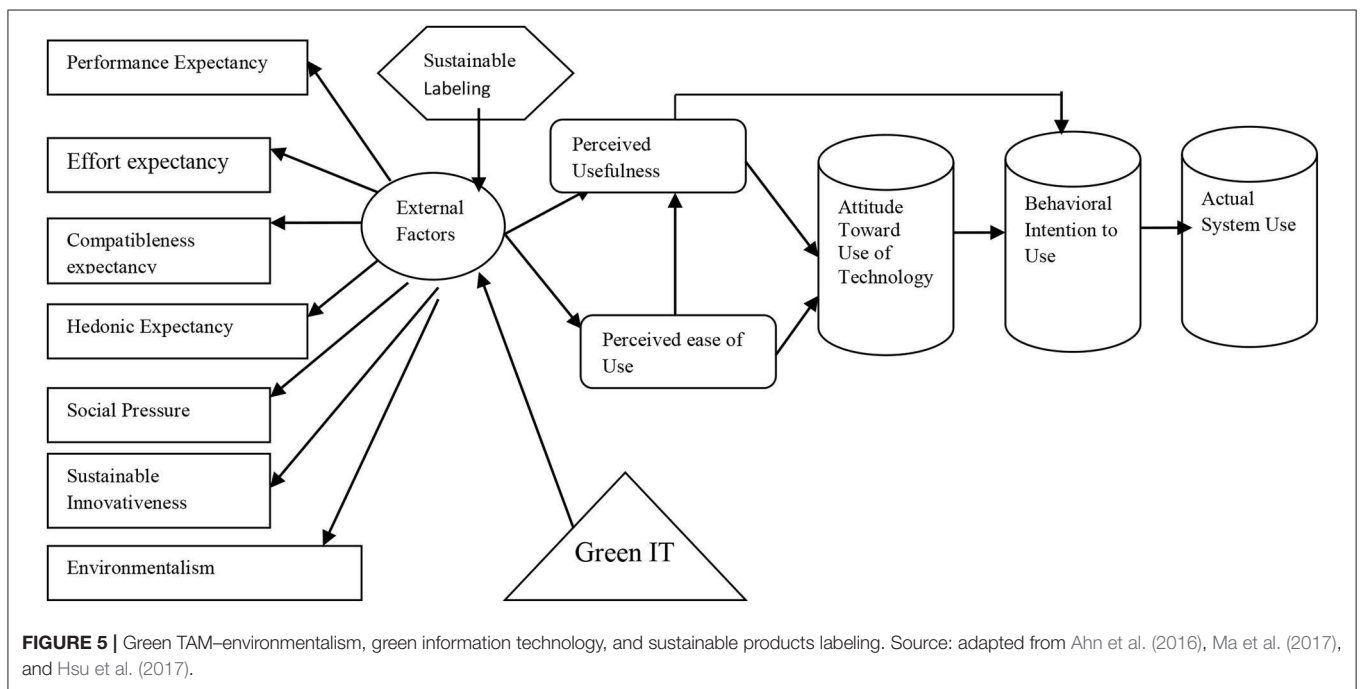
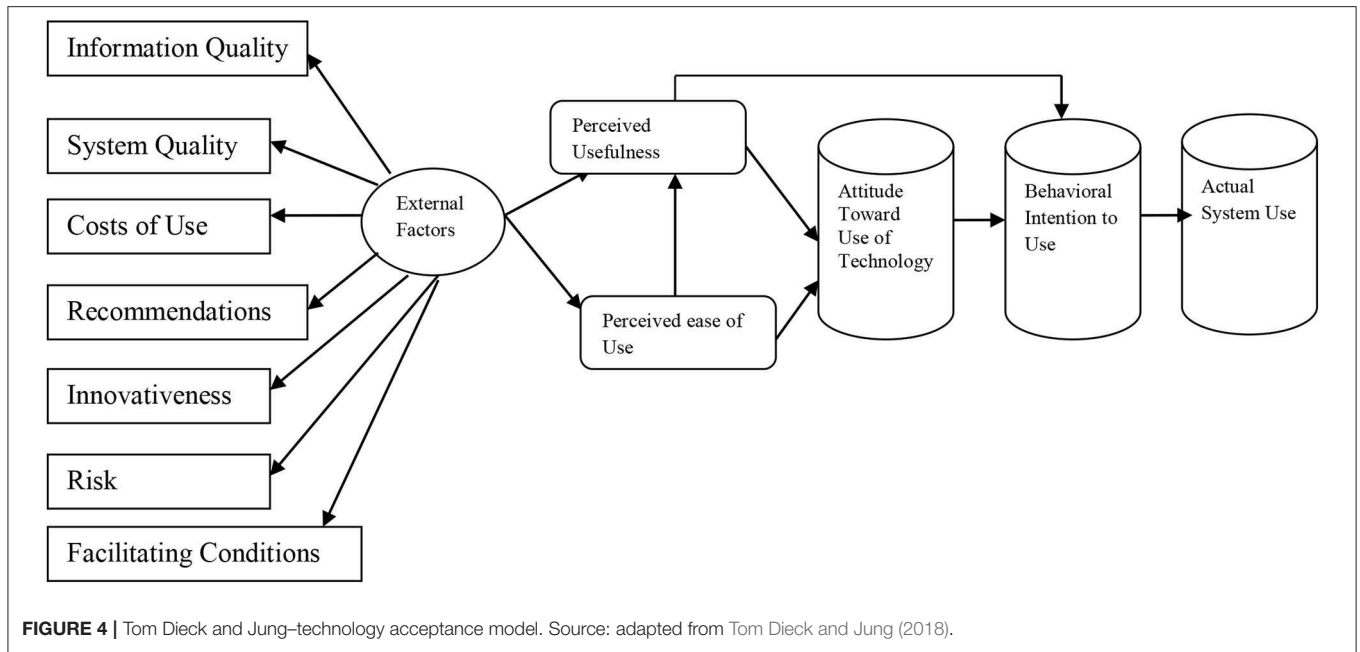
Figure 6 shows the firm's view of energy-augmented TAM model and argued that renewable energy is deemed desirable in order to proceed toward green investment decision, which improves logistics performance, exports capabilities, technology advancement, resource inputs, improves competitiveness, and increase firms' payoff. The green energy demand is further helpful to get product innovations, which need high R&D expenditures in order to develop a green attitude and behavioral intention to use green system use. The firm's view of EA-TAM provides a pragmatic approach that would help to devise firms'

green policies to get green payoffs. **Figure 7** shows the macro perspective of EA-TAM model (industry view).

Figure 7 shows the industry view of EA-TAM and argued that green factors played an important role in green product usage, as green supplier selection would be helpful to make a green purchase intentions, while industrial green engineering, green procurement, green consumerism, green product recovery, and green innovation would be helpful to increase the perceived ease of green product use. There would be a lot of factors that could be cumbersome the process of green innovation including political constraints and high carbon price, which ultimately affect green attitude preferences to use green products. Finally, green preferences would extend eco-product choice that led to increase green product usage. **Table 2** summarized the results of the stated study with the earlier studies for ready reference.

On the basis of significant discussion on the stated topic, it is clear that the subject matter is highly important in order to make EA-TAM proceed for GSCM practices both at micro and macro level. The EA-TAM is different from other green TAM in the literature on the basis of five important distinctions, i.e.,

- (i) Green investment in the energy sector makes them logistic operations greener.



- (ii) Technology advancement in cleaner production could be achieved through the inclusion of renewable energy demand in existing energy portfolios.
- (iii) Exports competitiveness and energy support prices developed an attitude toward the use of green products.
- (iv) The eco-friendly products usage is the subject matter of carbon pricing, and
- (v) Political disinclination makes it difficult to achieve GSCM practices that could be inclined through the development of green protocols.

The view of green TAM model gives greater insights in order to extend conventional TAM model in to energy–augmented TAM model, which would be helpful to the firm’s and industry to go-for-green policies. The logistics operation can be benefited by EA-TAM in a variety of ways, which is not limited to the following factors, i.e.,

- (i) Substantial reduction in energy costs in logistics operations can be achieved through energy efficiency.
- (ii) Vehicles fuel intensity can be increased by subsidizing renewable fuel prices, efficient carbon taxes, provision

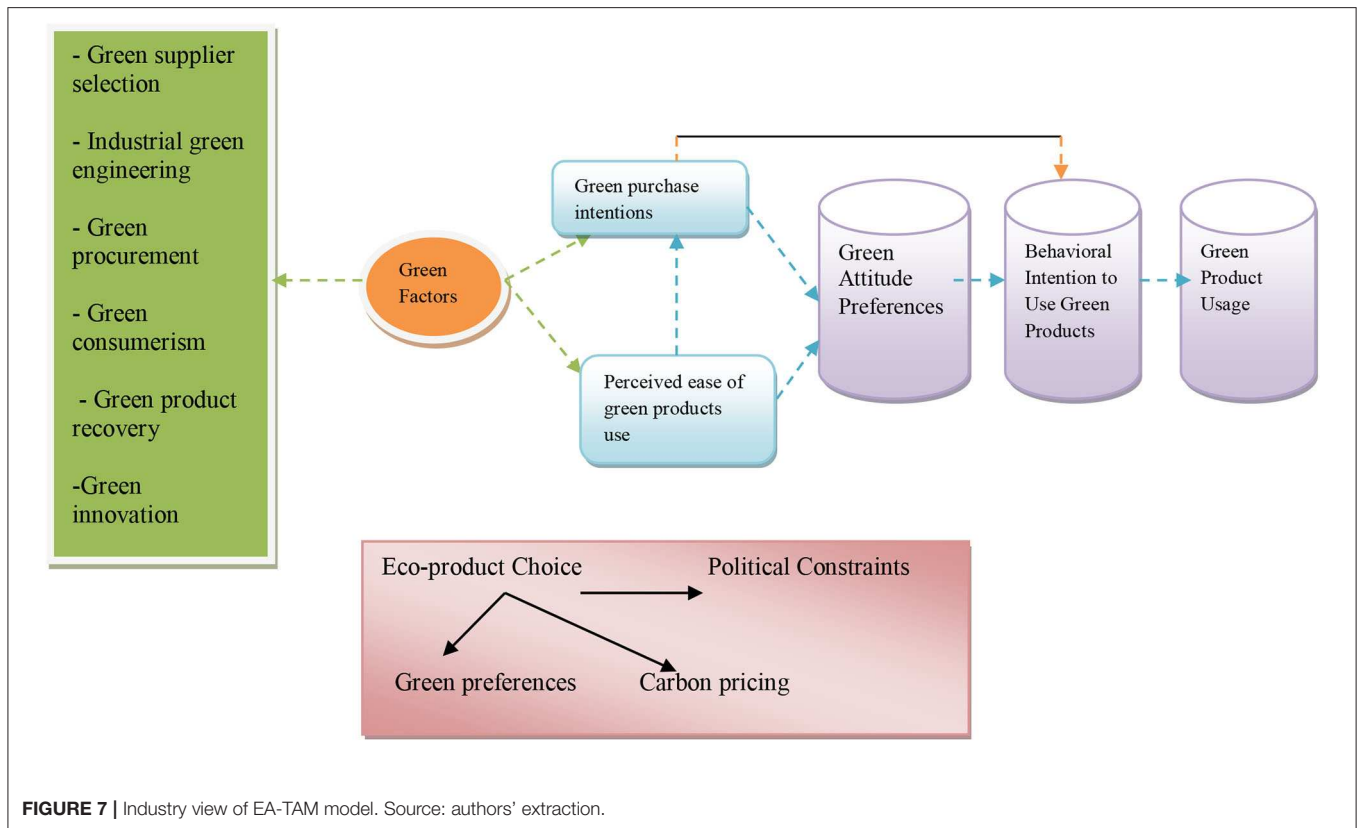
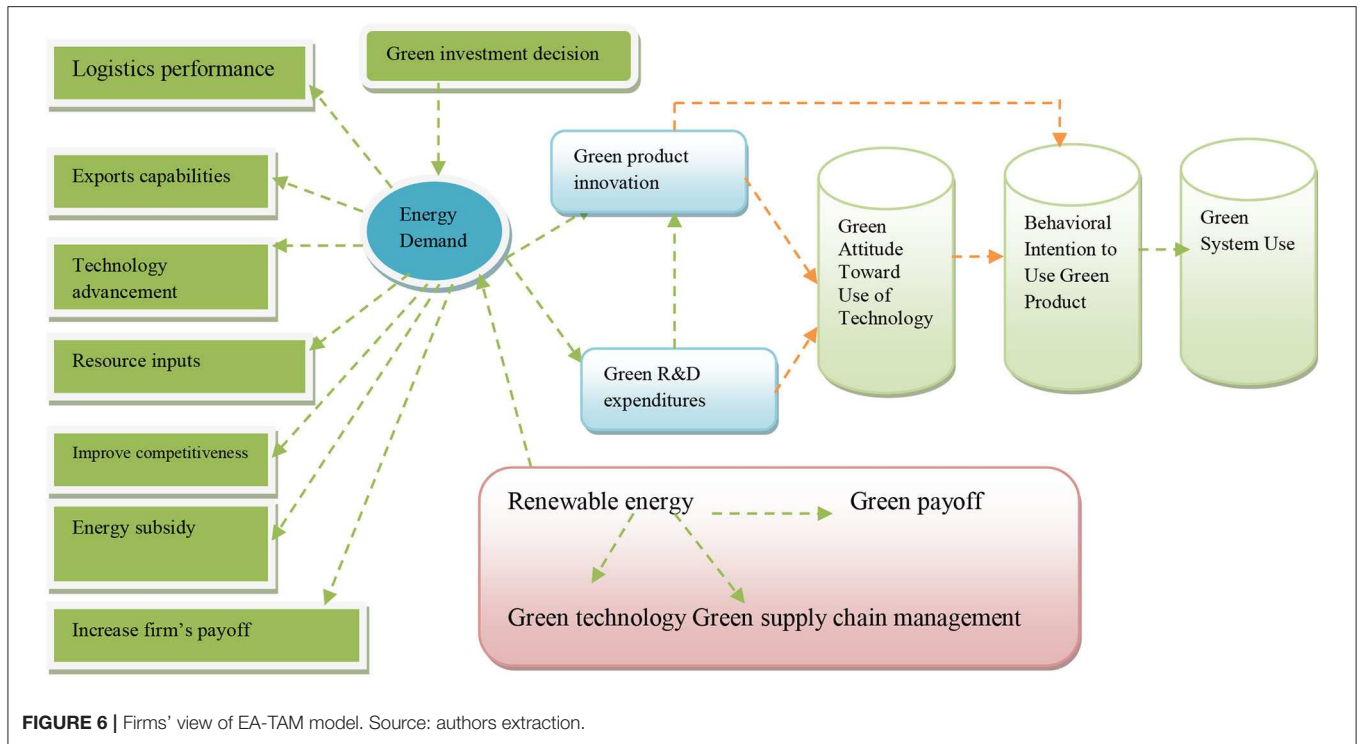


TABLE 2 | Summarized the current work with the existing work.

| Factors | Current work | Existing work |
|--|---|--|
| Novelty | The novel contribution of the study is to extend the original TAM model into energy-augmented TAM both at micro and macro perspectives. | The exiting literature are majorly worked on the services sector and developed a TAM model for micro perspectives (see Kamel and Hassan, 2006; Sang and Lee, 2009; Lee and Song, 2013; Memarzadeh and Anand, 2020; Schmidhuber et al., 2020, etc.), while little work has been done on macroeconomic perspectives that is fairly needed for sound policy implications. |
| Green logistics operations | The study largely emphasized the need to adopt green logistics operations as it is the major component of the supply chain management process. The study highlighted different socio-economic and environmental factors that are attached to renewable demand, green RandD, and carbon pricing. | The existing literature is limited to sustainable innovation and exports competitiveness while it largely lacks carbon pricing instruments, including a carbon tax and emissions-cap modeling, which is deemed desirable to replace fossil fuel combustion with renewable fuels in logistics operations (see Akman and Mishra, 2015; Chen and Lu, 2016; Ibrahim et al., 2019; Zhang et al., 2020, etc.). |
| Advancement in the cleaner production | The current study largely stresses the need to use cleaner production technologies that support to reduce industrial waste and improves a firm's competitiveness. | The few existing studies used micro data to support the given argument, while at a macro level; there is no direct study available to comprehend the statement (see Ibrahim et al., 2017; Biswas and Roy, 2018; Sheen, 2018; Samad et al., 2020, etc.). |
| Eco-products choice | The study accentuates to stabilize political constraints for eco-products choice, as it is mixed with green preferences and carbon pricing. | The existing studies largely discussed eco-products choice through consumer's green preferences while its largely ignored carbon pricing mechanism and political constraints altogether that needed to perform GSCM practices (see Arce Salazar and Oerlemans, 2016; Chuang and Liao, 2018; Qu et al., 2020, etc.). |
| GSCM practices and country's economic growth | The study heightens the need to adopt GSCM practices in order to support a country's economic growth under EA-TAM modeling, as renewable energy demand is the optimized solution to reduce negative environmental externalities and support to green economic development. | The earlier studies generally explored differently firm's level determinants of GSCM practices, while it's less explored the viability of renewable energy demand in economic sectors to supports the country's economic growth (see Rajabian Tabesh et al., 2016; Suryanto et al., 2018; Gardas et al., 2019, etc.). |

of energy fuel subsidy, and vehicle modification through technology upgradation.

- (iii) Environmental regulatory measures would allow transporting competitive goods that helpful to mitigate GHG emissions.
- (iv) Private investment in green energy infrastructure would be helpful to increase sustainable transportation network and
- (v) Clean energy shifts make them shift the logistics business toward green logistics.

The use of renewable energy not only limited to increase exports competency, innovation, and green payoff while it increases green investment decisions to raise green preferences to use eco-friendly goods through green logistics operations.

MANAGERIAL IMPLICATIONS AND INDUSTRIAL BENEFITS

The greater viability in the EA-TAM in logistics operations tend to support corporate profit in a variety of ways, as supply chain managers should require more policy-oriented and strategic wisdom in order to develop corporate environmental policies that make them competitive enough to retain green profit. Eco-design practices are largely lagging behind the success of GSCM practices, managers should be well-versed with technical, regulatory, and environmentally sound to minimize environmental concerns in disposing of manufacturing products. The imposition of carbon taxes on dirty production is imperative to sustained long-term growth, while this also

hold for logistics operations that largely worked in tracking consignments, customs clearance, and delivered products in the stipulated time period. All these activities required more energy to perform their functions efficiently, which leads to environmental degradation. The high dependency on fossil fuel energy leaves many unanswered about product efficiency and corporate policies. The managers should have to develop green corporate policies to replace fossil fuel to rentable fuels in logistics operations and get a competitive advantage on other firms to make a new product line as per see corporate environmental policies.

CONCLUSIONS

The study has a novel contribution in the earlier studies into three different perspectives; firstly, the study proposed micro-enterprise energy-augmented TAM that is associated with the adoption of green technology that leads to go-for-green product innovation. The green investment decision developed an attitude and intention to use a green product, which increases firms' payoffs. Secondly, the study proposed macro enterprise energy-augmented TAM that is linked with the following green factors including green supplier selection, green engineering, procurement, consumerism, product recovery, and green innovation. These stated factors lead to green purchase intentions and ease of green products use that developed an attitude and intention to use eco-friendly products. Finally, the study introduced three compelling factors that could negatively

affect the green product use, including political constraints, carbon pricing, and willingness-to-pay for public goods. The study presented these factors in a simple and pragmatic approach via a pictorial review that increases an analytical ability to understand common problems of enterprise technology adoption both at micro and macro perspectives. The use of renewable energy demand in the TAM model gives more wisdom to devise sustainable development policies on a global scale. The following policy implications have been proposed in a given scenario, i.e.,

- (i) The enterprise TAM should be fueled with green R&D expenditures in the energy sector to reduce negative environmental externalities that take place during the production process.
- (ii) The implementation of carbon pricing on dirty polluting industries would be highly desirable in order to get fruits from the use of green products.
- (iii) The political constraints should be resolved in the adoption of renewable energy in the conventional energy mix, which would help to subsidize the energy market and lowering energy price.
- (iv) Green purchase intention is linked with green product innovation, thus both factors should be under consideration while devising green policies, and
- (v) The green investment decision is important both at the firm and industrial perspective that would be helpful to reduce environmental externalities and improve competitiveness

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and exports capabilities to get involved customers in green system use.

Limitations and Future Extension of the Study

The study is limited to critical reviews of past studies on green logistics policies within the sustainable supply chain management across the globe. The empirical data both at the micro and macro level would be helpful to explore the green determinants of sustainable supply chain management. This study is exploratory in nature and at an initial stage, there is deemed desirable to proposed GSCM model, while at the later stages, the empirical extension of the study would be further added for robust inferences. The future work has been planned to test the given theoretical models by mix methods approach wide across the globe. The proposed model is based upon pragmatic approach and it is well-linked with the exiting studies, thus on the basis of significant discussion, the empirical model would be attractive enough to open new avenues of the future work on the stated theme.

AUTHOR CONTRIBUTIONS

MA: supervision, writing–reviewing and editing, conceptualization, methodology, and supervision. ZY: software and formal analysis. KZ: data curation and validation. All authors contributed to the article and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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