Integrating the Technology Acceptance Model (TAM) into the Supply Chain of India's Passenger Car Industry: Mitigating Technical Uncertainties

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Abstract:
This study explores the application of the Technology Acceptance Model (TAM) in the context of the Indian passenger car industry's supply chain, with a specific focus on addressing technical uncertainties. The research aims to investigate how TAM can be leveraged to enhance the adoption and utilization of advanced technologies, thereby improving supply chain efficiency and resilience.
The Indian passenger car industry is experiencing rapid growth, driven by increasing demand and technological advancements. However, technical uncertainties pose significant challenges to supply chain management. The Technology Acceptance Model (TAM) offers a valuable framework for understanding the factors influencing technology adoption. This study integrates TAM into the supply chain of the Indian passenger car industry to identify key drivers and barriers to technology acceptance.

Research Questions:
1. What are the technical uncertainties faced by the Indian passenger car industry's supply chain?
2. How can TAM be applied to address these technical uncertainties?
3. What are the key factors influencing technology acceptance among supply chain stakeholders?

Theoretical Framework:
The Technology Acceptance Model (TAM) posits that two primary factors influence technology acceptance: Perceived Usefulness (PU) and Perceived Ease of Use (PEU). This study extends TAM to incorporate supply chain-specific variables, including:
1. Technical uncertainty
2. Supply chain complexity
3. Stakeholder collaboration
4. Organizational readiness

Methodology:
A mixed-methods approach will be employed, combining:
1. Survey research: Questionnaires will be administered to supply chain stakeholders (OEMs, tier-1 suppliers, logistics providers) to gather data on TAM constructs.
2. Case studies: In-depth analyses of select passenger car manufacturers will provide insights into TAM's application.

Expected Outcomes:
This study aims to:
1. Identify technical uncertainties faced by the Indian passenger car industry's supply chain.
2. Develop a TAM-based framework for addressing technical uncertainties.

3. Provide recommendations for enhancing technology acceptance and supply chain efficiency.

Implications:
The findings of this study will contribute to the development of effective strategies for managing technical uncertainties in the Indian passenger car industry's supply chain. By integrating TAM, organizations can improve technology adoption, reduce uncertainty, and enhance overall supply chain resilience.

Keywords: Technology Acceptance Model (TAM), Supply Chain Management, Technical Uncertainties, Indian Passenger Car Industry, Supply Chain Resilience.

INTRODUCTION:

Innovation and introduction of technologies are recently found to have vast impact on the automotive industries. These impacts are not only due to the design and manufacturing of the vehicle functionalities, at the same time it is also for a result of digitalization of the logistics processes altogether. The technological interventions are also found essential for the internal management of the stakeholders. The stakeholders are identified to involve in the production as well as in the part of supply chain management, too. Therefore, the giant automobile manufacturers and their suppliers need to adapt to the markets, and also to consumer's demand accordingly. For these noticed changes and at the same time it is being required to become adjusted with the newly introduced trends in the markets, there arise some urgencies. These urgencies are basically for the adoption of faster and more efficient technology and also for a generalized process management. Moreover, the effect of globalization over the economy and the off shoring of businesses has resulted the need to be connected with any business anywhere in the world. This demand and necessity mentioned in the previous few lines, of today's market is termed as "Industry 4.0" or "Intelligent Business". This term is being referred as the advances and adaptations of businesses in production level. The idea is also found useful for conversion of an ordinary business to an intelligent business one, in the perspective of design, manufacturing, logistics, distribution and sales or in an integrated effect of all. This digital transformation is marked for its competitive advantages in the businesses sectors in connection with the concept of automation and real-time monitoring of processes, too.

This paper is now considered as an important step of a research work in the limelight of the above-mentioned specifications. The paper is drafted to propose a conceptual supply chain management framework leading to a conceptual model for the Automobile Industry, especially in the passenger car manufacturing sector in Indian context. The framework and model are being used to accept the Technology Adoption Model (TAM) for this digital transformation of Automobile Supply Chain in Indian Territory.

MOTIVATION OF THE RESEARCH:

Based on some recent the literature reviews it has been observed that the sales of passenger cars dropped during economic slowdown. It has been also observed that at time of supply chain disruptions due to force majeure reasons or supplier failures, the sales of cars are affected. Research in the supply chain management domain of passenger cars, especially in the Indian context, considering a number of uncertainties *viz.* customer's choice perspectives, economic upheavals, suppliers' inability to supply of raw materials etc. hampering the smoothness of the supply chain of passenger car. One of those before said uncertainties the technological interventions is also found an important one. The technological factors is one of the PESTEL factors known as external factors affecting the supply chain node, that cannot be controlled or influenced. Therefore, a framework is being proposed in this paper considering the concept of Technology Adoption Model (TAM) for this digital transformation of Automobile Supply Chain in Indian Territory. The framework is expected to lead to a derivation of business intelligence and outcomes will enable decision makers to enrich their decision-making capabilities.

RESEARCH OBJECTIVE(S):

The target of this research paper is to propose a framework along with a conceptual model those help to identify the key factors and dimensions are affecting the adoption of technological advancement in the Indian Automobile Sector and accordingly to design a Supply Chain Management Framework along with a model by using the concept of 'Technology Acceptance Model (TAM)". This conceptual model will help to implement a disruption free Intelligent Supply Chain Management System for the Indian passenger car sector. Moreover, the model will also be beneficial for the policy makers to decide how to convert their business into a "Smart Business" without hampering the supply chain, considering all the technical uncertainties (External factor affecting the Supply Chain Nodes).

RESEARCH METHODOLOGY:

The research methodology applied here is a two (2) steps process.

1. First the literature survey is done and next based on these surveys the problems identified, research gap is enlisted and accordingly a conceptual framework with a conceptual model is constructed.
2. The conceptual model proposed in this paper is extended and illustrated more through the incorporation of the influential factors, supply chain technology adoption drivers and challenges for adopting the same.

Literature Survey-

I. Technology Adoption Model – A Brief Overview-

The Technology Acceptance Model (TAM) is known by the information systems theory that it is basically a model is being used for user's understanding that how to accept and use a technology for their own business. The model can also be used as a suggestion for the users of the newest technologies. A number of factors are found to be influenced to the users, while making the decision about how and when TAM should be used.

Luaren and Lin (2005) used the technology acceptance model in an effort to understand customer intention to use technology. Pedersen (2005) used the decomposed theory of planned behavior in his study based on the effect Internet usage. He further points out that there exist few studies based on information systems theories applied to supply chain technology. On the other hand, Lauren and Lin (2005) employed the technology acceptance model in his study because he views technology as an innovation for organizations.

According to Yan et al (2009), the Technology Acceptance Model (TAM) is considered as one of the widely used models in information system field. He presented a theoretical contribution for understanding of the concept of technology acceptance. TAM is actually used to provide an explanation for the determinants of the technology acceptance. The determinants of TAM are generally capable of explaining user's behavior across a broad range of technologies. Therefore, the user's populations are being both economically and theoretically justified (Davis et al., 1989).

TAM is found to focus on the attitudinal explanations and at the same time the intention to use specific technology is also highlighted (Nysveen et al 2005). Five important variables are included in TAM are mentioned below:

- Perceived usefulness,
- Perceived ease of use,
- Attitude towards using,
- Behavioral intention and
- Actual use.

From the above-mentioned variables, the two specific variables mainly the perceived ease of use and perceived usefulness are hypothesized to be the fundamental determinants of user acceptance (Davis, 1989). Perceived usefulness is defined as the expectation that the technology will enhance job performance and service delivery and perceived ease of use is defined as the belief that using technology will be free of effort (Davis 1989).

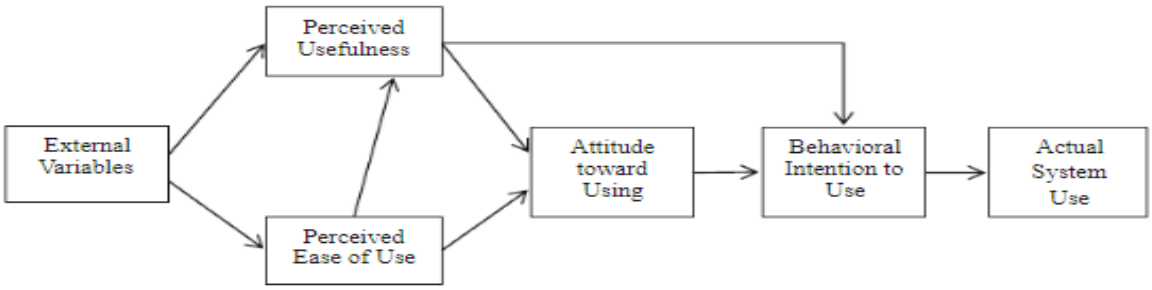

Figure-1: Technology Acceptance Model (Davis et al. 1989)

The TAM proposed by Davis et al, 1989 afterwards extended as TAM augmented to create the Automation Acceptance Model (AAM), as illustrated through Figure-2, below-

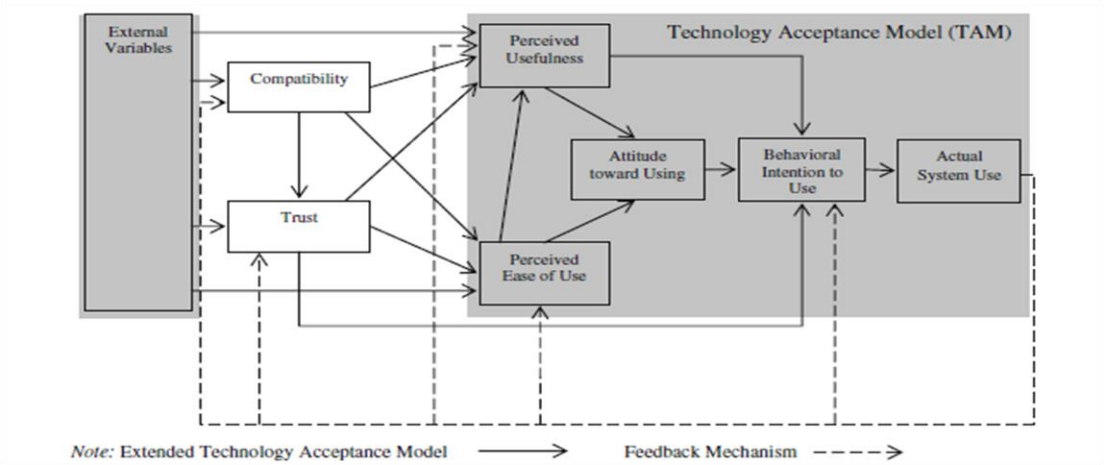

Fig. 2 TAM augmented to create the Automation Acceptance Model (AAM). Solid arrow represents Extended Technology Acceptance Model,
and dashed arrow represents feedback mechanism

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Figure-2: TAM augmented to create the Automation Acceptance Model (AAM). Solid arrow represents Extended Technology Acceptance Model, and dashed arrow represents feedback mechanism

II. Impact of Technology Adoption in Supply Chain -

Tippins and Sohi, (2003) proposed that the technology adoption in supply chain can be defined as an extent through which a firm can adopt the most advanced and available technologies. Not only this the adopted technologies can also be implemented as a proactive adoption of the state of art of IT. This should be helpful also to build new technical solutions for a supply chain. Moreover, the supply chain technology incorporates the degree of diffusion of information technology intermingled with a firm's own activities, too. It was also stated by them that the supply chain technology adoption is a distinctive concept in comparison with the information technology. It is also clear from their opinion that the supply chain technology is found enable for a firm to adopt new technologies in front of competitors.

The points mentioned by Barney (2004), stated that the supply chain technology adoption is basically used to cultivate the organizational capabilities. This phenomenon is required to enable the firm to perform better than their competitors. Moreover, it is evident that the adoption of information technology alone probably not be a source of competitive advantage. This is because of the wide availability of technologies in the competitor's market. It will

be expected to offer sustainable benefits only when the information technology is embedded into organizational process e.g., strategy making, etc.

It is also found out from an extensive literature review that the increasing role of supply chain technology is identified for the evolution of the competitive supply chain management. The points raised by Regan and Song (2001), that some mentionable trends are very much evident in the consequences of the impact in case of technology adoption in supply chain management. Not only this, they are found very much effective also for the development of new services, new functions, formation of new alliances and many more.

One of the very prominent visible effects associated with the increasing dissemination of supply chain technology especially in service industries is the integration of traditional services (e.g., transportation and warehousing) with information-based services like booking, freight rate computation, routing and scheduling, too.

Since last few years the aforesaid companies had made significant progress in the adoption of new technologies, particularly those linked with the Internet. In today's scenario, many transport and logistics service firms are found able to provide a variety of information through the Internet. This firms are also found able to perform secure transactions online with their customers through their web sites, pointed out by Ellinger et al., 2004.

The distribution of supply chain technology has opened up new opportunities. It should have utmost requirement for the development of the firm and also for the playing of a new roles in the supply chain. Those are actually used to give added value to the existing supply chain functions through the incorporation of greater efficiencies along with information transparency. Those are being run through Internet portals helping to bring together numerous members of the supply chain from any corner of the World (UNCTAD, 2000).

One more feature is identified as an emerging feature along with the vast scale use of Internet and supply chain technology, is that the creation of a new category of service provider. These service providers are popularly known as Fourth Party Logistics (4PLs). According to Bade et al., 1999, a 4PL is considered as a supply chain integrator. The role of the 4PL is to assemble and manage the resources, capabilities and technology of an organization. With the help of those complementary service providers the organizations are found to deliver a comprehensive supply chain solution. The 4PLs solutions are also used to make the customers enable to outsource the management of the entire logistics network to a single organization and ultimately to re-engineer supply chain processes. Often 4PLs are found to set up through alliances. The alliances are basically having been formed with n integration of management consulting companies, financial service companies and technology service providers.

Regan and Song (2001) highlighted that with the emergence of 4PLs, there is a continuing trend in the logistics service industry to form such alliances with certain firms operating in other industries.

III. Factors Influencing Supply Chain Technology Adoption-

From the literature surveys it has been noticed there are three important external factors i.e. organizational structure, supply chain member pressure, organizational size as well as organizational complexity influencing more in an existing supply chain management system These factors are also can be specified in reference to the manufacturing sector, for adoption of a new technology model.

IV. Challenges in Supply Chain Technology Adoption-

It is very much evident that the adoption of a new technology should require new infrastructure and promising skills. Those are beyond individual control. Therefore, it becomes necessary for the researchers to investigate the factors more and more that affect technology adoption for an entire organization.

Russell and Hoag (2004) cited that organizational complexity i.e. the size and decentralize organizational structure, is also very much influential in case of adoption of a new technology. Moreover, SCT adoption encompasses the implementation of the technologies. So, the implementation also refers to the application or degree of the extent of the usage of the SCT in the supply chain activities altogether.

The above discussion is summarized through the identifications of some problem statements as follows-

Problem Statement(s)-

Problem Statement-1-

One of the major problems found often in adoption of supply chain technology in SCM is that the inadequate implementation IT knowledge in SCM organizations ultimately resulted into substantial difficulties is felt during the implementation stage (Sohal and Singh, 2002).

Problem Statement-2-

The, organizations adopting SCT are found that they do not use the SCT on regular basis. For example, some firms that had purchased SCTs e.g., Enterprise Resource Planning (ERP) software but the staffs in the firm do not use it in a regular basis. This indicating that the firm has adopted SCT (ERP) but they are not implementing or using it (Ngai, 2004).

Research Gap Identified-

Supply chain technology and supply chain management have attracted attention from many researchers since a long. Those two are basically two separate research areas, though few researchers have combined those (Shen et al., 2004). It has been found that a considerable number of studies have been done in the area of supply chain technology, but very few of those focused on the identification of the factors that affect the adoption supply technology in Indian Automobile Sector. Therefore, this study is required to throw light of this important gap in research area. To accomplish the intended objectives, the study is wanted to get specific answers of the following questions, i.e.

i. What are the main drivers required for the supply chain technology adoption?
ii. What are the challenges to be faced by the adoption of supply chain technology?
iii. Does supply chain technology adoption surely having impacts on manufacturing organizations' performance?

Research Design-

This study in this paper adopted an exploratory research design here. Kothari (2003) stated that an exploratory research design is one of the flexible designs that allow the researcher to consider many different aspects of a problem. This type of research design is found as a help the researcher to gain new insights and ideas about a problem. According to Saunder et al (2003) exploratory research is used principally to gain a deeper understanding of something. In this paper the research design is based on the research work of Kamariah et al (2008) who had been used such an exploratory design in his study on supply chain technology adoption in the Malaysian automotive sector.

Conceptual Framework-

At the time of SCT implementation firms began to initiate the adoption and at the same time they start to give pressures on other organizations to adopt it in their supply chain management process. The nature of the pressures are mimetic pressure, coercive pressure and normative pressure respectively, found to play a significant role on adoption of SCT systems in India.

This scheme was undertaken basically in order to standardize the data format and improve the coordination and communication within and between organization's supply chains. Based on the aforesaid concepts, other SCT started to adopt the data format etc. that had been already standardized as because they became interested to enhance information sharing. That TAM sort of models was adopted by the organizations influenced from partners in their supply chain in order to streamline the transactions and also to improve inter-firm communication.

It was theorized then, that the larger the organizations should have sufficient the financial and technological resources to invest in new technologies more, and so that they the associated risks are being absorbed by them (Teo et al., 2003).

In the contrary, smaller companies, often due to lack of their financial resources, identified to be more innovative, flexible, responsive, and less bureaucratic. Accordingly, their found greater incentive to adopt SCT by them (Iskandar et al., 2001).

The above discussion is found very useful while constructing the conceptual model and the conceptual framework that should be considered while adopting TAM in automobile supply chain to remove the technological uncertainties of an existing supply chain is depicted below (Figure-3)

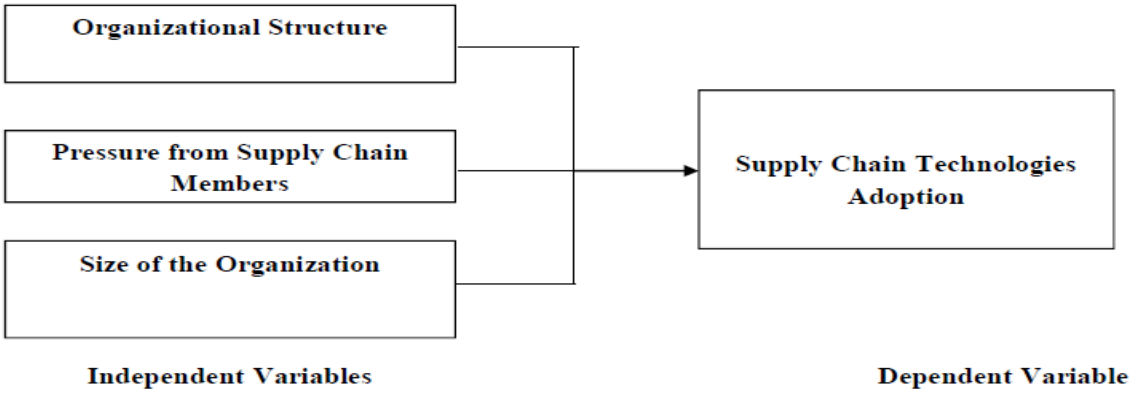

Figure-3: The Conceptual Framework for Adopting TAM in Automobile Supply Chain

Conceptual Model-

The above-mentioned conceptual framework now can be used to propose a simple linear regression model to analyze the relationship between extent of supply chain technology adoption and performance of manufacturing organizations. The analytical model will be then used to demonstrate that how the dependent variable (performance) is affected by any changes in the independent variable (supply chain technology adoption). The equation to be used was as follows:

$Y= \beta_0+\beta_1 X_1 +\varepsilon$

Where,

Y – Performance of manufacturing organizations

β_0 – constant variable

X_1 – Supply chain technology adoption

ε – Error term

Therefore, to proceed with this conceptual model of Technology Acceptance by the Passenger Car Manufacturer's in their existing supply chain, first it is required to list down the factors and drivers required for this kind of adoption. The factors are in their turn influencing and the drivers in their turn affecting the proposed independent variable i.e., the aforesaid supply chain technology adoption or X_1 in various ways.

Factors Influencing the uptake of Supply Chain Technology-

The study is required to establish the factors influencing the uptake of Supply Chain Technology. According to Raymond, (2005), technology plays an increasingly critical role in businesses large and small. Techno savvy firms are at an advantage. Research in the past has shown a positive impact on technology adoption on small businesses, by helping firms enhance their operational efficiency. Technology adoption drives business growth and integrates business' operations with strategies (Roger 2003). The factors are as follows-

- Availability of Technology and innovation
- To gain competitive advantage
- To increase efficiency and effectiveness
- Reduce wastage and lead times
- The need to coordinate and integrate information flow and activities within and/or between firm boundaries
- To generate effective and efficient business transactions

- To enable quick access to information and records
- To allow better customer service
- Reduce paperwork, allow better communication
- The desire to increase productivity and savings
- To bridge the limitation in the ability to work with global partners e.g. language barriers and time differences
- To enable members of the supply chain co-ordinate their production and logistics activities
- The desire by the organization for cost-cutting and increase efficiency across the extended supply chain
- Proliferation of globally sourced products
- Rapid technological change
- To reduce transaction costs
- The organizations desire to move towards self-service approach and integrated supplier management
- To improve customer segmentation, up-sell, and limit or eliminate risk
- To improve communication and productivity between suppliers, partners and customers
- The need to enhance the speed time-to-market and speed delivery times.
- To improve order management and decision making

Drivers Affecting the Supply Chain Technology Adoption-

The influential factors are in their turn are subject to the integrated effect of certain drivers. The drivers are classified as both External and Internal, of which the Internal Drivers can be controlled and regulated whereas the Externals are beyond control and regulations. Through this absence of control or regulations the uncertainties arise in the supply chain leads to a disruption in the performance. The drivers those are identified from literature surveys are as follows-

Internal Drivers-

Those include the organizational related controllable drivers are stated below-

- Organizational structure
- Size of the organizations
- The organization's ability to develop the risk management
- Cooperation with suppliers
- The level of the personnel commitment
- Quality enhancement

External Drivers-

Those uncontrollable drivers are as follows:

- Government regulations,
- Customers,
- Competitors,
- Suppliers,
- Society
- Some international standards

Challenges To Be Faced by the Adoption of Supply Chain Technology-

The main challenges are identified from literature surveys are as follows-

1. New infrastructure and
2. Nascent skills

Those are beyond individual control. Thereafter many more obstacles are also identified for this type of adoption, listed below-

Internal Obstacles-

- **Costs-** Consumers are always asking for lower prices, thus this require the cost incurred to be low enough to be able to offer low prices.
- **Lack of knowledge-** Lack of knowledge obviously appears to be a common hindrance for establishing a sustainable supply chain approach.
- **Lack of Training Referring-** to Bowen, Cousins, Lamming & Faruk (2001), employees should be motivated enough in order to take this sustainability approach more serious and to work hard to achieve it.
- **Lack of Integration-** of IT system in the study done by Dashore & Sohani (2013), they consider the integration of IT system into the green supply chain approach is a major necessity for this new concept to be adopted successfully.
- **Poor Organizational Structure-** This can be emphasized from the poor top management commitment. Some organizations management has poor commitment practices. People in such organization are considered impassioned regarding the issues of the external environment.

External Obstacles-

- **Regulations-** Government regulations are a major driver as discussed before; however, in some cases they can also serve as one of the barriers for the sustainable supply chain implementation. Environmental regulations might restrain innovation and creativity by stipulating some required techniques that are considered more reasonable.
- **Poor Supplier Commitment-** As discussed in the drivers' part, suppliers have a low driving force for the sustainable supply chain management. However, when it comes to the obstacles part, supplier involvement is highly important
- **Competition and Uncertainty-** According to Yu Lin & Hui Ho. (2008): "market competition and uncertainty is high due to global competitiveness and varying customer's requirement".
- Customers' unawareness of sustainable green products In some industries, lack of customers' awareness regarding the green supply chain approach is a major obstacle that obstructs the quick implementation.
- **Lack of Green Practitioners-** Some areas have a lack in well-trained and well experienced green specialists. This includes green architects, contractors, consultants and developers. For a sustainable supply chain to be well implemented there should be sufficient green specialists that can do their job well.

After identification of all those drivers, challenges, and obstacles, too now, the conceptual framework can further be extended as illustrated through Figure-4 below:

Extended Framework-

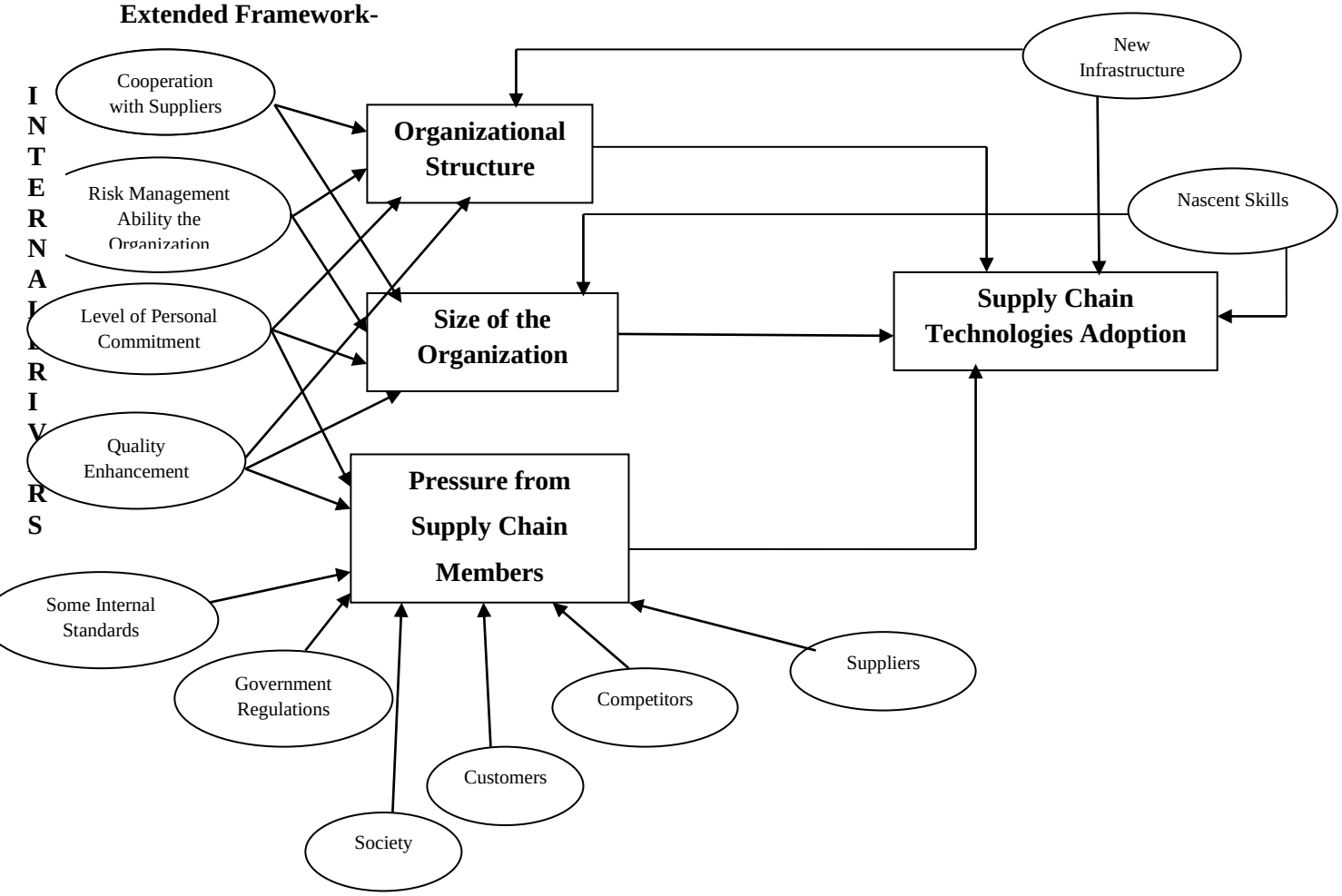

Figure-4: The Extended Conceptual Framework for Adopting TAM in Automobile Supply Chain

Based on the above-mentioned conceptual framework, now the model can also be extended further as discussed below:

Extended Model-

In the proposed analytical model, the dependent variable Performance of the manufacturing Organizations is affected by any changes in the independent variable i.e. supply chain technology adoption. The equation to be used was as follows:

$Y = \beta_0 + \beta_1 X_1 + \varepsilon$ …… (i).

Where,

Y – Performance of manufacturing organizations

β_0 – constant variable

X_1 – Supply chain technology adoption

ε – Error term

Now the simple regression model can be decomposed further as-

$Y_1 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$ …….(ii).

Where,

Y_1 – Supply chain technology adoption (dependent variable now)

β_0 – constant variable

X_1 – Organizational Structure

X_2 – Organizational Size
X_3 – Pressure from Supply Chain Members
ε – Error term
It is now becoming a multiple regression model
Substituting X_1 from equation (i), now the model will be as –
$Y= \beta_0+\beta_1(\beta_0+\beta_1X_1 + \beta_2X_2 + \beta_3X_3 +\varepsilon) +\varepsilon$ …… (iii).

Interpretation-

Therefore, altogether the performance of a supply chain can be affected by each unit of minimum changes of organizational structure, organizational size and various other pressures of the supply chain participants both inside and outside or the organizations. Those three independent factors actually in integration giving the opinion of acceptance or rejection of supply chain adoption model in an existing supply chain for its digital transformation.

The organizational structure, performance and pressures from supply chain members are affected in each of their turn by several internal and external drivers, of which some are controllable, some are regulatory while some are not.

They are also being affected by some of the obstacles too along with some existing challenges to resist.

Moreover, the entire model is subjected to a number of qualitative drivers, too that cannot be included in empirical studies but also found to be influenced on the adoption of the technology in an existing supply chain.

Hence, the model fitness can be tested based on the concept of an Augmented Tam (as discussed in Figure-2) by individually analysis of all or some external variables identified along with qualitative factors considered in the shaded area of Figure-2, and ultimately it can be stated the adoption model is suited for removing the technological uncertainties r not.

The entire model is also dependent on the customer's trust and model computability with the existing supply chain system, too.

CONCLUSION:

The proposed framework and established conceptual model revealed that applying the technology Acceptance Model in case of the improving performance and sustainability of a passenger car's supply chain processes is expensive and require a big amount of money to be invested. Moreover, the lack of knowledge evidently found to be a common hindrance for establishing a sustainable supply chain approach. Employees are not perfectly equipped with the needed and sufficient knowledge to flawlessly implement a disruption free supply chain practice.

Therefore, the proposed framework and conceptual model can be enhanced further by the policy maker to establish a dynamic supply chain model. The model is further proposed to concentrate more on those mentioned hazards and technology related uncertainties. So, that the uncertainties can be minimized as soon as possible and digital transformation of passenger car's supply chain will be exaggerated.

FUTURE SCOPE:

The proposed conceptual supply chain technology adoption model demonstrated in this paper is a subject of interests for the future researchers. Using this conceptual framework and model they are able to construct a real-life dynamic supply chain model for the passenger car industry in India, without the presence of any technology related uncertainty and henceforth the supply chain will be totally disruption free for such a promising sector in Indian economy, contributing more and more GDP enhancement in near future.

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