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## A framework development

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# Achieving sustainable development goals through identifying and analyzing barriers to industrial sharing economy: A framework development


## Abstract

Various sustainable development goals (SDG's) that have been achieved with current economic business models initiated the new socioeconomic system known as the "sharing economy." This collaborative economy system shares resources among communities and further assists to reduce both negative environmental and societal impacts and to reduce costs. The importance of this endeavor urges researchers to investigate the sharing economy more fully through different applications, primarily including transportation and customer service. However, these studies fail to attempt to explore the perspectives of the sharing economy through industrial applications. Industrial sectors are more prone towards negative sustainability; hence, it is necessary to address strategies to promote and to implement the sharing economy with an industrial perspective. Hence, this study seeks to identify the barriers of sharing economy implementation in industries, particularly with small and medium scale enterprises (SME) located in India. Common barriers are identified through the combined assistance of literature review and experts' opinions. These common barriers are shortlisted through Best Worst Method (BWM) and further analyzed through proposed solution methodology, DEMATEL, with the support of case industrial managers. Among 15 shortlisted barriers of sharing economy, "Lack of trust" was identified as the most influential and "Capital cost" was identified as the least influential barriers. This study contributes to both academic and practitioner levels by identifying the most common barriers of the industrial sharing economy. Further, we present strategies so practitioners can evade such barriers through customized practices instead of providing a generic treatment. In addition, this study provides a new approach to the literature; insight into the 'industrial sharing economy' could be a scientific breakthrough for upcoming studies. Finally, the study concludes with various useful recommendations and suggestions on the implementation of sharing economy in industries, particularly with SMEs. These recommendations shed light into various key research areas, which can be examined more fully in future studies.



Keywords: Industrial sharing economy; Best Worst Method; DEMATEL; Barriers; SDG's


## 1. Background

In recent years, a great deal of interest has been paid to the concepts of the sharing economy worldwide, which including researchers, practitioners, decision makers, the media, and others. This interest grew rapidly due to the success of two sharing economy platforms, Airbnb and Uber. Airbnb offers lodging space for tourists, in which landlords rent out their unused space to guests through Airbnb; the company serves as an intermediator and trust builder. Likewise, Uber shares the same business model, in which transportation, via personally owned cars, is shared under the Uber platform and brand. These startups began with the simple idea of sharing; now, they are international companies with share values of multi billion dollars within five years of their creation (Lashinsky, 2015; Konrad and Mac, 2014; Martin, 2016). These success stories further inspired many companies, even big brands, to rethink their business models built around the sharing economy perspective.

In addition, the idea that underscores the sharing economy serves all three pillars of sustainability, including the economy, the environment, and society. This increased attention is the result of the significant economic success of the sharing economy business model, which offers quality service with lower costs and diversified options compared to previous business structures (Mohlmann, 2015). A major advantage of the sharing economy rests on the redistribution of goods and services which helps to lower carbon emissions and waste instead of constant production of new products or services (Botsman & Rogers, 2011). Sharing the services of a single occupied vehicle can reduce its overall personal footprint and encourages less traffic with affordable cost without compromising conveniences (Cohen and Kietzmann, 2014). For instance, if the car sharing example has been considered, according to Martin and Shaheen (2011), the implementation of sharing economy replaced maximum of 11 personal vehicles to one, which further results in emission reductions of about 482,170 tons per year. Besides boosting the environment, the sharing economy also serves as a tool for societal development: it encourages more people to earn money through their unused resources, and some accrue regular paychecks through sharing platforms. These numbers expect to increase even more in upcoming years due to the development of smart technologies. Hence, most researchers and practitioners approach the sharing economy business model as a benefit of sustainability along with customization advantages (Philip et al., 2015). Even in a developing context, the sharing economy plays a significant role on various value propositions. For instance, in China, the sharing economy market reached the size of 490.05 billion yuan as reported in the 2018 China's State Information Centre (Li et al., 2019). With these success stories, sharing economy business models have begun to be integrated in different fields of applications, including food supply chain

(Asian et al., 2019), fashion (Yuan and Shen, 2019), hospitality (Cheng et al., 2019), and tourism (Gossling and Michael Hall, 2019).

While research on the sharing economy became popular and many studies emerged with different concepts, there is no standard definition of the sharing economy. Existing studies define sharing economy based on their practice applications; however, such applications are often complicated with overlapping concepts like gig economy, collaborative consumption, access-based consumption, product service systems, and collaborative economy (Botsman and Rogers, 2011; Bardhi and Eckhardt, 2012; Mont, 2002). One renowned definition is given by Prothero et al. (2011): "By shifting the paradigm away from individual ownership to collectivity and sharing, less demand for consumer goods may give way to a new economy that could help take on problems such as pollution and excessive energy usage" (Prothero et al., 2011, p. 36). Based on the definition, the sharing economy can be constructed on the three pillars of the access economy, platform economy, and community-based economy (Acquier et al., 2017). The access economy is designed to access unused or underutilized resources, the platform economy offers exchanges among peers through digital platforms, and the community-based economy encourages community engagement of particular projects, interaction of work performance, and so on. Recent sharing economy business models are striving hard to incorporate all three pillars in order to reap the full potential of this emerging concept.

Successful evidence of the sharing economy exists, but some studies claim that the economic benefits of the sharing economy are still unclear. For instance, studies by Morozov (2013) and Martin (2016) claim that the sharing economy is a form of neoliberal capitalism. In addition, there are many negative criticisms on the sharing economy business model due to their unregulated peer-to-peer marketplaces and businesses. In contrast, several studies (Ma et al., 2019) correlate the benefits of sharing economy with sustainability through sustainable consumption. These debates start from the initialization of the concept of sharing economy. Many businesspersons do not agree with this new business model due to several limitations of the model, including safety concern, lack of regulations, uncertain future, unstable benefits, and so on. Further, this sharing economy model is often overlapped with servitization concepts. Without clear understanding, most companies started with sharing economy concepts but ended up with servitization concepts. Sharing economy is sharing of unused or underutilized resources, whereas servitization refers to service as a business in which the company offers service not business. From these discussions, there is still ample room on sharing economy to consult literature perspectives regarding these concepts. Researchers are urged to explore

the sharing economy with different areas of applications where the sharing economy has been less frequently explored.

One of the less explored areas of sharing economy is industrial manufacturing sectors. The industrial manufacturing sector plays a vital role in the global economy regardless of which nation it inhabits. In addition, existing sharing models do not fit manufacturing applications due to their own complexities. The major concern on manufacturing sector's sharing economy is the sharing involved between two parties who are competitors in nature; hence, it is difficult to have a mutual agreement for sharing. Further, data among industrial manufacturing companies are not transparent, which makes a more clumsy approach to sharing economy. On the other hand, customers pressure manufacturers to produce specialized and/or customized products with short lead times. This demand and supply problem can be mitigated through the proper implementation of sharing economy through the advantage of recent technologies and flexible production systems (Tseng and Hu, 2014). With this concern, this study proposes a novel business model, 'industrial sharing economy,' defined as "an economic system in which assets (man, machine, materials) and/or services are shared between industries (two or more), with the mutual consent with the means of technology." The traditional sharing economy has been exhibited successfully through tourism and hospitality models (Airbnb and Uber). However, the same model cannot work with industrial sectors, in which industries might be in competition with one another. Hence, there is a need for a different business model for the industrial sharing economy. Implementing this new business model can have a huge impact on various levels, including all pillars of sustainability.

Despite the recent prolific research on the sharing economy, no previous study has explored the industrial manufacturing sector through the sharing economy lens. Many studies (Becker and Stern, 2016; Li et al., 2018) repeatedly claim that there is a huge opportunity which, despite its potential, has not yet attracted sufficient attention from researchers. With this concern, this study interlinks sharing economy concepts with an industrial perspective and extends the knowledge deeper with analyzing the barriers. However, for the implementation of sharing economy in manufacturing sectors, the existing barriers needs to be identified and then relevant practices should be followed to eradicate those barriers for effective implementation of sharing economy. For better understanding of the root cause, this study continues to explore the barriers of industrial sharing economy implementation in Indian context. The Indian context is still new with strategies including green manufacturing, sustainable manufacturing and so on; however, in order to compete with global competitors, India has no choice but to engage with novel techniques that may satisfy their clients

with their sustainable activities. In addition, this study acts only as a pilot study which can underline the challenges involved in the implementation of industrial sharing economy. The challenge of addressing current practices is not in this work's focus; however, this study might be an initial point of a larger future analysis.

Unlike developed nations, developing nations more often struggle with the implementation of new strategies, especially with sustainable advantages. Those struggles are based on various reasons, including high population (like India and China), lack of knowledge and education, lack of regulation, lack of transparency, and so on. As with other strategies, it is not easy to implement sharing economy in a developing nation like India. Although some successful strategies, such as Airbnb and OLA cabs, have succeeded in the Indian context, trust among the people using the services is not as high when compared to developed nations. India's Airbnb has more horror stories as compared to similar models in developed nations, so many users don't want to explore the new opportunities. Demographically, younger people (below age 35) show more interest in sharing platforms. Another major drawback in Indian context is the understanding of the business model. OLA, a company that initially started like Uber, advertised that personal vehicles registered with their platform can be available for customer service in their unused time. Now, all taxi owners, who are already working as taxi drivers, have joined OLA to reduce wasting time waiting in taxi stands. The sharing economy business model becomes a conventional business model with a digital platform. Another example, Zoomcar, a company best known for self-driving cars, allows car owners to let their car for rental when it is unused, similar to OLA. But here too, travel agencies have registered their vehicles in the business model, defying the sharing model. From this it can be clearly understood that, initially, self-driving cars started as a sharing economy business model (personal cars for rent) but it has turned into a servitization model (travel agencies' cars for rent). Because of the potential income to be generated, both taxis and travel agencies have violated the sharing economy model of self-driving Zoomcars and, instead, changed their platform to digital but still provide the same old services with an intermediate. This kind of unchanged business model did not affect ride prices due to the travel agencies involved. For well-known applications, since the Indian context faces various troubles, the industrial sharing economy is far behind. Hence, to nurture the pioneering work, this study considers India as a case context to explore the barriers of industrial sharing economy.

### 1.1 Gap analysis and research objectives

Without a doubt, the sharing economy exhibits many advantages over existing business models, but the applications are limited to certain segments such as transportation, logistics, and space. Most application sectors are left unattended from the perspective of the sharing economy due to the lack of original studies, pilot projects, or exploratory initiatives that analyze the hindrances. This study took the responsibility to explore the barriers of implementing sharing economy with specific applications on industries. Despite an abundance of studies on industrial sectors, to the best of our knowledge, no work in the literature has proposed an assessment of the sharing economy. There is a term – sharing manufacturing – present in the literature (He et al., 2019; Brandt, 1990), but its objective to assist small scale industries, in which the resources are shared, to less financially capable companies. The current proposed industrial sharing economy model is totally different from what previous studies claim and, regardless of the level of financial ability, this model could assist industries within a sharing environment. Hence, this study considers exploring the barriers involved in the implementation of an industrial sharing economy. Some of the studies sought to address the barriers involved in the sharing economy implementation, such as May et al., (2017). However, similar kinds of studies are limited with well-known applications including transport, logistics, and space as mentioned earlier. The way of implementing the sharing economy differs in industrial sectors, where the machines, personnel, skill set, and other possibilities need to be explored with sharing economy applications. Further, this study mainly focuses on the developing case context of India where several markets are being added. This is in contrast to developed nations with the implementation of sharing economy in industries. Considering these facts and the present gap in the literature, this study addresses the research objectives mentioned below.

- *To explore the importance of implementing sharing economy in industrial sectors* – Currently no one is practicing sharing economy model in the industrial context, although it has enough potential for sustainable development, with emphasis on the economy, environment, and society. Hence, this research objective helps industrial practitioners to know the value of considering an industrial sharing economy agenda.
- *To identify the common barriers involved in the implementation of industrial sharing economy* – Although most big industrial institutions can demonstrate the success of sharing economy in other fields of applications, why has there been no sharing business model that pertains to industries? Hence, our objective is to identify what resistance is present and to promote the potential for a sharing economy in an industrial perspective.

- *To analyze the influence among common barriers and to identify the most influential barrier among collected common barriers* – There might be several barriers involved in the implementation of industrial sharing economy business model. Hence, we will identify the most influential barrier and, by eradicating that particular barrier, we will establish a notable impact on industrial sharing economy implementation. Less influential barriers will also be detailed.
- *To disseminate the results to provide valuable recommendations for better implementation of sharing economy in industrial sectors with Indian case context*.

In order to address the above mentioned objectives, two methodologies are adapted from the multi criteria decision making (MCDM) technique: the Best Worst Method (BWM) and Decision making trial and evaluation laboratory (DEMATEL). In two phases, the solution methodologies are involved in this study. BWM is used to shortlist the common collected barriers, and DEMATEL is used to analyze the interrelationship among shortlisted barriers. The barriers were collected from various primary and secondary sources, and they have been evaluated through the MCDM techniques based on the replies of Indian case decision makers. The significance of case study and methodologies adopted are detailed in the upcoming sections.

The remaining sections are presented as follows. Section 2 deals with the explanation of methods involved in the study (Best Worst Method and DEMATEL). A case illustration was discussed in Section 3; it contains various subsections, and each subsections is defined with the purpose of data collection, case analysis, and methods application. Section 4 discusses the obtained results, in which the results are acknowledged, compared, and validated with various sources. Based on the discussions of the results, several recommendations and managerial implications of the study are obtained and shown in Section 5. Finally, this study concludes in Section 6 with a summary of findings, known limitations, and recommended future scope for extended research.

## 2. Methods

To address the research objectives, this study utilized two step methodologies where the first step involves Best Worst Method and second step utilizes DEMATEL. This study aims to eradicate the barriers of industrial sharing economy implementation. In the virtual world it is difficult to propose practices for eradicating all barriers. Instead, an efficient approach is to propose eradicating practices for the most influential barriers. Among MCDM tools, DEMATEL is one of the effective methodologies which clearly identifies influences among factors (in this case: barriers). Based on the

diagraph, the influential factor can be easily identified among all common collected factors. Based on DEMATEL, decision makers can propose a set of customized practices, particularly with aim of eradicating the most influential barrier. This methodology has an input from both primary and secondary sources; however, the direct input gained from case decision maker replies is particularly vital. Detailed descriptions along with their significance and steps involved are given below.

### 2.1 Best Worst Method (BWM)

This study used BWM to shortlist the important barriers relevant to the case company based on the criteria weights. Several MCDM techniques are available throughout the literature to measure the weights of the criteria. Among those MCDM methods, one of the most applied methods to evaluate criteria weights is analytical hierarchy process (AHP). Recent studies proposed a new method – Best Worst Method – as an alternative to AHP for finding the criteria weights. The AHP has many limitations, which was further addressed by BWM, introduced by Rezaei (2015). Currently, BWM is gaining over AHP in popularity among researchers due to two key reasons: i) lengthy pairwise comparison process and ii) inconsistency between comparisons. However, in BWM, two vectors are used to identify the weights of the criteria instead of pairwise comparison, which increases the reliability of the results. In addition, easy analytical operations and more understandability gives more support to make decisions with BWM. With these advantages, several studies (Serrai et al., 2017; Gupta, 2018; Salimi and Rezaei, 2016; Salimi, 2017; Ahmad et al., 2017; Gupta and Barua, 2017; Rezaei et al., 2015, 2016) selected the BWM in various applications. Due to this significance, this study equipped this BWM methodology to identify the important barrier of industrial sharing economy through weights.

The weights and ranks are identified through following the BWM which are as follows (adapted from Rezaei, 2015).

#### *Step 1: Setting up decision criteria*

The first step is to set up the decision criteria. These are a set of criteria $\{c_1, c_2, \ldots..,c_n\}$ for 'n' number of attributes which will be evaluated in the study, although in some cases, alternatives are also considered.

#### *Step 2: Determine the best (most desirable) and worst (least desirable) criteria*

In this stage based on the decision makers replies, the best and worst criteria have been identified; however, no comparison or ranking has been done at this stage.

***Step 3: Identify preference among criteria – Best to others***

The best criterion will be determined among all other criteria using the scale 1 to 9; the resulting vector is from best to others, which is shown in Equation 1.

$A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})$,

where $a_{Bj}$ denotes the preference of the best criterion $B$ over criterion $j$. Hence, it is obvious that $a_{BB} = 1$.

***Step 4: Identify preference among criteria – Worst to others***

The worst criterion will be determined among all other criteria using the scale 1 to 9; the resulting vector is from worst to others, which is shown in Equation 2.

$A_W = (a_{1W}, a_{2W}, \ldots, a_{nW})^T$,

where $a_{jW}$ denotes the preference of the criterion $j$ over the worst criterion $W$. Hence, it is obvious that $a_{WW} = 1$.

***Step 5: Calculate the optimal weights***

This is the final step of the BWM, in which the weights of the considered attributes are calculated, in which the maximum absolute differences for all $j$ are minimized of the following set of $\{|w_B - a_{Bj}w_j|, |w_j - a_{jw}w_w|\}$, and the minimax model can be formulated as

$\min \max_j \{|w_B - a_{Bj}w_j|, |w_j - a_{jw}w_w|\}$

Subject to

$$\sum_j wj = 1 \ldots\ldots\ldots\ldots\ldots \quad (1)$$

$w_j \geq 0$. for all $j$.

The same model (1) discussed above can be solved by converting it into a linear programming problem as:

$\min \xi^L$

Subject to

$|w_B - a_{Bj}w_j| \leq \xi^L$, for all j

$|w_j - a_{jw}w_w| \leq \xi^L$, for all j

$$\sum_j wj = 1 \ldots\ldots\ldots\ldots \quad (2)$$

$w_j \geq 0$. for all j.

By solving the above two equations, we find the optimal weights ($w_1$ *, $w_2$*, $w_3$ *, … $w_n$*) of the considered evaluating criteria.

### 2.2 Decision making trial and evaluation laboratory (DEMATEL)

This study adapts the quantitative approach of analysis for deeper understanding; hence, the solution methodology is to be selected carefully. In this case, DEMATEL reveals the importance of each criteria and their influences among one another through the assistance of expert evaluation. DEMATEL is a famous method among researchers who deal with grey data, and this topic does include a lot of grey data or scarce information. The DEMATEL methodology was first pioneered by Gabus and Fontela in 1973 at Battelle Memorial Institute through Geneva Research Centre (Fontela and Gabus, 1974). It is mainly used to calculate the influence and importance through cause/effect relationships of considered criteria over another using the logical relationship matrix given by the decision makers. This cause/effect partition among the criteria assists the decision makers to prioritize elements based on their influencing nature. Over the years, due to various advantages of DEMATEL, several studies have been applied successfully in various fields of applications including supply chain, education, engineering, tourism, management, marine, and so on. There is a sequence of steps to be followed to evaluate the criteria through DEMATEL; the steps are as follows.

***Step 1: Calculate the initial relationship matrix 'A'***

The first step of D is to calculate the initial relationship matrix 'A' based on the replies from the industrial and field experts using a scale that ranges from 0 to 4. In this scale, '0 is no influence,' '1 is very low influence,' '2 is low influence,' '3 is high influence,' and '4 is very high influence.'

$$\widetilde{\boldsymbol{A}} = \begin{bmatrix} 1 & a_{12} & a_{13} & \ldots. & a_{1(n-1)} & a_{1n} \\ a_{21} & 1 & a_{23} & \ldots. & a_{2(n-1)} & a_{2n} \\ \ldots. & \ldots. & \ldots. & \ldots. & \ldots. & \ldots. \\ \ldots. & \ldots. & \ldots. & \ldots. & \ldots. & \ldots. \\ a_{(n-1)1} & a_{(n-1)2} & a_{(n-2)3} & \ldots. & 1 & a_{(n-1)n} \\ a_{n1} & a_{n2} & a_{n3} & \ldots. & a_{n(n-1)} & 1 \end{bmatrix} \quad (3)$$

***Step 2: Calculate the normalized direct-relationship matrix 'X'***

The initial matrix (from step1) is normalized using equations 4 and 5.

$$K = \frac{1}{max_{1 \le i \le n}} \sum_{j=1}^{n} a_{ij} \quad (4)$$

$$X = K \times A \quad (5)$$

***Step 3: Calculate the total influence matrix 'T'***

Using equation 6, the total influence matrix is obtained.

$$\boldsymbol{T} = \boldsymbol{X} + \boldsymbol{X}^2 + ... + \boldsymbol{X}^h = \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X})^{-1}, \quad \text{when } \lim_{h \to \infty} \boldsymbol{X}^h = [0]_{n \times n}. \tag{6}$$

Explanation,

$$\boldsymbol{T} = \boldsymbol{X} + \boldsymbol{X}^2 + \cdots + \boldsymbol{X}^h$$

$$= \boldsymbol{X}\left(\boldsymbol{I} + \boldsymbol{X} + \boldsymbol{X}^2 + \cdots + \boldsymbol{X}^{h-1}\right)(\boldsymbol{I} - \boldsymbol{X})(\boldsymbol{I} - \boldsymbol{X})^{-1}$$

$$= \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X}^h)(\boldsymbol{I} - \boldsymbol{X})^{-1}$$

then,

$\boldsymbol{T} = \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X})^{-1}$, when $h \to \infty$.

'I' denotes the identity matrix.

***Step 4: Calculate the sum of rows and columns***

'r' and 's' denote the sum of rows and columns. It is obtained through equations 7 and 8.

$$\boldsymbol{r} = [r_i]_{n \times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n \times 1}, \quad \boldsymbol{s} = [s_j]_{n \times 1} = \left[\sum_{i=1}^{n} t_{ij}\right]'_{1 \times n} \tag{7}$$

$$\boldsymbol{T} = [t_{ij}], \quad i, j = 1, 2, ..., n, \tag{8}$$

***Step 5: Set up causal influence diagram***

. Based on the sum of rows '$r_i$' and sum of columns '$s_i$' the casual diagraph is developed.

## 3. Case study: An illustration

No literature is currently present that discusses the implementation and promotion of sharing economy in an industrial perspective. Instead, existing studies are more focused on transportation sector and leave the major sector (industries) unattended. Therefore, this study seeks to analyze the barriers of sharing economy implementation in industries, particularly SMEs. For this study, a specific research design has been adopted, in which iterative theory has been applied for selecting the common barriers of sharing economy implementation. Further, the research design includes data collection strategies, case selection, and interview protocol. Although the sharing economy has

received attention in recent days, it is not explored in industrial sectors; hence, it needs an in-depth case analysis to explore the concept up fully. With this concern, this study adopts the case methodology for better understanding the problem, and per the recommendations of Yin (2017), a data triangulation strategy was used in this case study approach.

### 3.1 Data collection

The first part of the research builds the theoretical basis for this study. The considered problem is to analyze barriers in the sharing economy, so with the help of primary and secondary data, the common barriers were collected. As per data triangulation, data were collected from three sources:

- ✓ From March 2018 to January 2019, in-depth interviews were conducted among 38 industrial managers from Indian context. Initially, 73 industrial mangers (collected from private industrial forums) for this interview were approached through mail and 38 managers responded positively. This interview starts with a basic explanation of the sharing economy in industrial perspective and then extends to follow-up questions. Finally, these discussions focus on the barriers hindering the implementation of sharing economy in their industries. In addition with the industrial managers, sometimes interviews were conducted with top management people to compare stakeholders' perspectives. From these interviews, few key barriers were collected and used in this research.
- ✓ Next, a systematic review of state-of-the-art practices in sharing economy was conducted in two key resources, SCOPUS and Web of Science. For this search, various strings were included: "sharing economy," "industries," "SMEs," and "sharing economy in India." In addition to this secondary data, some grey literatures (including media reports, white papers, proposals, and so on) and open access information from the industries were collected. At this stage, we compared the state-of-the-art practices and the practitioners' perspectives with regard to the implementation of sharing economy.
- ✓ Finally, a workshop was conducted among the 38 industrial managers, to which some research experts in the field were invited. Participants were presented with a list of the 32 barriers collected from the literature and interviews. They were instructed to cross mark the barrier/barriers that they felt were not a strong influence on the sharing economy in Indian industries. Finally, the results are shared with a common display to facilitate discussion. Among several rounds of discussions, some of the common barriers emerged as the most influential barriers of sharing economy implementation in Indian industries. Table 1 shows

the collected and categorized common barriers of industrial sharing economy. As mentioned earlier, there is no study focused on the industrial sharing economy, so no barrier can be previously identified from the literature. The process demonstrated that some of the common barriers to a conventional sharing economy (for instance, economic barriers and some stakeholder barriers) and to the industrial sharing economy are quite similar. In those cases, the barriers are adopted as it is. On the other hand, some conventional sharing economy barriers are transcribed to industrial sharing economy applications. The remaining barriers are identified with the assistance of experts.

**Table 1: Collection and categorization of common barriers**

| S. No | Barrier Category | Sub barriers | Definition | Source |
|---|---|---|---|---|
| 1 | **Economic barriers (A)** | Capital cost | As usual, like other new strategies, initiating sharing economy causes some capital cost for setting up new business model, recruiting new peoples, conducting pilot studies and so on. However, the major advantage of sharing economy is that you can get the expected financial results soon after implementation whereas other strategies are limited. | Forgacs and Dimanche, 2016; Onete et al., 2018 and Experts' opinions |
| 2 | | Lack of incentive on practicing sharing economy | This is one of the time and cost consuming process at its initial stage, although its returns are good for long term. However, the business organizations need some support from external funding as incentives to tackle the initial financial disturbances while initiating industrial sharing economy. | |
| 3 | **Stakeholder barriers (B)** | Lack of rules and regulations | In Indian case context, rules and regulations are not very strict compared to developed nations like US or EU. This hinders the case industry to participate in sharing economy activities. For instance, if the other partner of sharing economy chain expels the agreed terms of sharing contract (the shared resources are not agreeable in terms of quality, quantity, time, and so on), then it takes legal help to resolve the conflict and it takes time, which significantly affects the whole business performance as worst as possible. | Munkøe, 2017; Kassan and Orsi, 2012; Ma and Lan, 2018; Kartz, 2015; Ganapati et al., 2018; Berkowitz and |

| | | | | |
|---|---|---|---|---|
| 4 | | Lack of multi stakeholders collaboration | Lack of interest among multi stakeholders is a common barrier of any new emerging strategy and sharing economy is not exempt from this. Due to the lack of awareness, education and assumed complexity of sharing economy in industries hinder the stakeholders to avoid getting into the sharing economy. | Souchaud, 2019 |
| 5 | | Lack of pressures from stakeholders (lack of necessity) | Due to the lack of awareness and other reasons, there is no pressure from the stakeholders on implementing sharing economy in industries. It shows the urgency and importance of sharing economy has not been updated in industrial perspective due to less existing literature works. | |
| 6 | **Social barriers (C)** | Lack of trust | If both industries are tied in a cooperative agreement, they would share resources including common logistics, sharing warehousing, sharing finished products in time of high demand, and so on. However, in these cases due to lack of trust among the sharing partners they are hesitant to share their resources. Even though they may agree to sharing, still the efficiency of the shared resources is not reliable at all times from the perspective of sharing partners. | Cheng et al., 2019; Phua, 2019; Hawlitschek et al., 2018 |
| 7 | | Lack of willingness to change | Despite the tremendous advantages of practicing an industrial sharing economy, many organizations lack willingness to change to this new system. It is due to their conventional thinking and mostly they think the new strategies are more risky and less comfortable for them. | |
| 8 | | Network issues (between actors | In the case industry, the network involved within the actors among sharing economy is really complex because of the lack of | |

| | | | | |
|---|---|---|---|---|
| | | involved in sharing economy) | transparency among the coordination of actors. It is mainly due to the lack of proper communication channels; specific communication platforms need to be designed for sharing economy transactions. | |
| 9 | | Level of awareness | There is no certain level of awareness of sharing economy in the considered case industry; instead, they assumed that sharing economy implementation in industries is very complex. Hence, there is a need to educate the simplicity of the concepts and their implementation practices. | Experts' opinions |
| 10 | | Differences in values | In implementing an industrial sharing economy, every actor has different goals and opinions unlike service sectors. Hence, it becomes tough to design a system which satisfies all the value chain actors of an industrial sharing economy. | |
| 11 | | Reckless dynamics of interactions | Industries most often have fewer opportunities of better communication than service sectors. Hence, this might be considered as one of the communication barriers for implementing industrial sharing economy. | Onete et al., 2018 |
| 12 | **Technical barriers (D)** | Lack of technology (IoT, Block chain, ICT) to implement sharing economy in industries and | If two industries are really planning to connect in a sharing economy grid, they need to identify a solid technology to stay connected. For instance there is on online platform to measure (IoT tools) and track (block chain) the performance of their mutual sharing. | Borcuch, 2016; Onete et al., 2018 |

| | | | | |
|---|---|---|---|---|
| | | manufacturing companies | | |
| 13 | | Lack of expertise | The sharing economy is just an initial level business level; hence, there is need for experts who can assist and tackle the inherent problems that may arise during resources sharing. | Experts' opinions |
| 14 | | High probability of risks | If the case industry is connected in the loop of sharing economy with another industry in their own industrial park, a high probability of risk still exists. For instance, as agreed in the time of high demand, the other industry has to share their resources as agreed but if that industry fails to provide necessary resources at the right time, disruption in whole supply chain will occur. | |
| 15 | | Lack of sharing economy business model with industrial perspective | Unlike Airbnb and Uber, there is no standard sharing platform for industrial sharing economy, which significantly hinders the industries to take part of sharing activities. | |
| 16 | | Lack of interactive platforms which can assist the industries to share their resources | There are no interactive platforms for the industrial partners to engage, communicate, and orient on sharing their resources with reliability. | Onete et al., 2018 |

| | | | | |
|---|---|---|---|---|
| 17 | | Lack of forecasting on potential resources flow | As far as concerned, sharing of resources is not sequential; the availability of the resources for sharing might vary at times. For instance, two industries are good in their sharing agreement, but still at the time of necessity of resources, one industry depends on other. If that sharing industry also has plans for a task on that particular resource (a resource expected to be shared with other industries), then a conflict occurs among sharing partners. In simple words, the resources meant to be shared have uncertain availability. | Experts' opinions |
| 18 | | Lack of access and transparency to data | This might be one of the root causes of the lack of trust and reputation. On both parties, sharing can be done through mutual contract; however, the tough part is tracking the resources' flow, accessing the data and a potential lack of transparency. This hinders the industry to share their resources with limited data of trust and support and with fewer details of sharing/shared resources. | |
| 19 | | Complex, demanding, sensitive | Unlike service sectors, implementing sharing economy is a complex process. Due to several value chain actors, high costs and huge resources are involved. | Onete et al., 2018 |
| 20 | | Lack of sharing partner evaluation (certification) platforms | Like the supplier selection, this is a broad topic of selecting the proper sharing partner. In the future, a pool of industries may expect to share and receive resources. However, it is necessary to access their previous records and their values and trust on the business chain. Hence, there is a need for strict sharing partner evaluation methods, which are currently unavailable for the companies. | Experts' opinions |

### 3.2 Case analysis

Sharing economy in industries might be a new contribution to the literature, but several industries are trying to integrate the strategy to achieve benefits in all three dimensions (economy, environment, and society). Among 38 companies who participated in the study, we need to choose one to serve as the case company and to apply our findings in greater depth. We want to explore in depth the case study methodology and to learn that industrial manager's perspective on the sharing economy. Initially, the research team analyzed all the companies' backgrounds, including their financial positions, their supply chain operations, top level management, commitment to sustainable development strategies, and so on. Once we acquired proper knowledge about the companies, we started an iterative process. Six industries are selected at the first level of case analysis, with the filter criteria that the company should be a small or medium scale enterprise (SME) or big supplier to multinational companies (MNCs). For any strategy, implementation is easier for MNCs or big players, whereas SMEs often struggle. In addition, more assistance is needed for SMEs due to their more limited resources, capital, and knowledge. To understand the in-depth barriers of sharing economy in industries, analyzing medium scale enterprises are best choice, which serves both academic and practitioners' benefits. After first level of screening, among six SME level industries, two were selected based on their willingness index and earlier sustainable development activities. This screening helped the research team to get a clear idea on the barriers of sharing economy in their industries, because if a less willing industry was selected, there might be a chance of bias in their response; the greatest portion of the study depends on the decision maker's response. In many cases, due to mandatory sustainable development activities, industry decision makers are often too formal or too hesitant to give responses, and that reluctance would strongly affect the study's results. The final level of screening was done based on the availability of industrial managers and accessibility; further, more advanced insights can only be collected from more access to industries. Between the final two industries, one industry is more accessible than the other, and it provides ample room for the research team to explore more fully the different stakeholders' perspectives and to analyze the differences in opinions of the actors who will be involved in sharing economy.

This case industry is located in the Southern region of India; it is a small scale enterprise that is striving hard to improve their level of organization to the next level. To boost the nation's small-scale enterprises, the Tamil Nadu government initiated the SIDCO (Small Industries Development Corporation) project in 1958 in Guindy; later, it was extended to 118 industrial estates around the state. The government's SIDCO project provides basic infrastructure for industries to lease, own, or

rent up to 56 acres. In addition, along with the infrastructure support, the government provides the raw materials including iron, steel, wax, and papers with less cost through the government-based raw materials company. Currently, the case industry's manufacturing hub is in one of the SIDCO industrial estates. With the Tamil Nadu government's support, the case industry started their career a decade back and grew along with other companies in this industrial region. The industrial managers let the research team know that they are eager to introduce sharing economy in their operations and management. Currently, the case industry manufactures various automotive parts including brackets, control arms and panels, cross members, engine mountings, pallets and shells. They are a major supplier of auto parts to big domestic players including Tafe, Wheels India Limited, Bridgestone, Ashok Leyland, and TVS Rubber. Their domestic clients are the suppliers of many original equipment automotive manufacturing companies including Ford, Mahindra, Nissan, Renault, Toyota, and so on. Recent globalization and industrialization makes the Indian context as a fruitful hub for production and consumption, especially for big names in the automotive markets that receive more products from Indian automotive suppliers.

Due to the pressures among global stakeholders, new strategies have been developed and implemented (including sustainable development goals, circular economy, and so on) among organizations. In this process, the implementation of sustainable development strategies has extended with supply chains. Over recent years, many guidelines were introduced by the big organizations to make their supply chain sustainable through implementing sustainable and circular strategies in all levels of suppliers. The case industry here is a sub supplier of the big organization, and the big organizations have forced their sub suppliers to adopt sustainable strategies through their suppliers (domestic suppliers – tier 1). In addition, our case industry is trying to move to the next level in the supply chain as a direct supplier to global organizations. Due to these reasons, they are ready to explore various sustainable and circular strategies; in fact, they are fascinated with the circular strategy known as the "sharing economy." Currently, there are more than 200 industries in the particular industrial estate; hence, they are interested to share their resources and operations with other companies to provide better service with less consumption of resources through the newly popular "sharing economy."

With this volunteer background from the case industry, the research team started to work on the research process. Initially, the research team visited the industry and led a discussion workshop with all staff members regarding the sharing economy theme. In this workshop, various perspectives and an understanding of sharing economy among the case industry workers were evaluated. After this

evaluation, the research team arranged a seminar to educate employees on the basis of the sharing economy and their benefits in sustainability. After this seminar, enough time was given to the case industry workers including top-level management, shop floor workers, and management team to evaluate the common barriers of the sharing economy in industrial perspective. Further, the data collection and processing are discussed in the upcoming sections.

### 3.3 Methods application:

To analyze the common barriers involved in the implementation of industrial sharing economy, this study adapts two methodologies: BWM and DEMATEL. For both methods, the data were collected from the case industry workers (including all levels) through questionnaires. Two different set of questionnaires were prepared to corresponding methods. Detailed application of the adapted methods are as follows.

#### 3.3.1 Best Worst Method (BWM)

Due to the significance of BWM, which has been already detailed in the above sections, this study adapted this MCDM method to evaluate the common barriers. In the initial stage of data collection, there were 20 barriers identified for the research; however, our objective was to consider the barriers most relevant to the considered case industry. In this concern, BWM method (based on the steps mentioned earlier) was used to identify the relevant barriers by categorizing the best and worst barriers of sharing economy. Table 2 shows the relevant criteria to be considered for this study based on their global weights. Among 20 barriers, only 15 barriers were considered for next level of influential analysis among barriers. Table 3 shows the final set of common barriers along with their definitions in terms of industrial perspective.

**Table 2: Category and sub barriers Best Worst weights**

| Weights | Category | Sub-Barriers | Sub-barriers weight | Global weights | Rank |
|---|---|---|---|---|---|
| 0,061798 | A | Capital cost | 0,6000 | 0,0371 | 9 |
| 0,061798 | A | Lack of incentive on practicing sharing economy | 0,4000 | 0,0247 | 15 |
| 0,168539 | B | Lack of rules and regulations | 0,1250 | 0,0211 | 16 |
| 0,168539 | B | Lack of multi stakeholders collaboration | 0,6500 | 0,1096 | 2 |
| 0,168539 | B | Lack of pressures from stakeholders (lack of necessity) | 0,2250 | 0,0379 | 8 |
| 0,196629 | C | Lack of trust | 0,5191 | 0,1021 | 4 |
| 0,196629 | C | Lack of willingness to change | 0,0535 | 0,0105 | 20 |
| 0,196629 | C | Network issues (between actors involved in sharing economy) | 0,1391 | 0,0274 | 12 |
| 0,196629 | C | Level of awareness | 0,1391 | 0,0274 | 12 |
| 0,196629 | C | Differences in values | 0,0795 | 0,0156 | 18 |
| 0,196629 | C | Reckless dynamics of interactions | 0,0696 | 0,0137 | 19 |
| 0,573034 | D | Lack of technology (IoT, Block chain, ICT) to implement sharing economy in industries and manufacturing companies | 0,1214 | 0,0695 | 5 |
| 0,573034 | D | Lack of expertise | 0,0728 | 0,0417 | 7 |
| 0,573034 | D | High probability of risks | 0,0910 | 0,0522 | 6 |
| 0,573034 | D | Lack of sharing economy business model with | 0,0607 | 0,0348 | 10 |

| | | | | | |
|---|---|---|---|---|---|
| | | industrial perspective | | | |
| 0,573034 | D | Lack of interactive platforms which can assist the industries to share their resources | 0,3396 | 0,1946 | 1 |
| 0,573034 | D | Lack of forecasting on potential resources flow | 0,0455 | 0,0261 | 14 |
| 0,573034 | D | Lack of access and transparency to data | 0,1820 | 0,1043 | 3 |
| 0,573034 | D | Complex, demanding, sensitive | 0,0350 | 0,0201 | 17 |
| 0,573034 | D | Lack of sharing partner evaluation (certification) platforms | 0,0520 | 0,0298 | 11 |

**Table 3: Final set of barriers for analysis**

| S. No | Barriers |
|---|---|
| 1 | Lack of trust (**B1**) |
| 2 | Lack of technology (IoT, Block chain, ICT) to implement sharing economy in industries and manufacturing companies (**B2**) |
| 3 | Lack of expertise (**B3**) |
| 4 | High probability of risks (**B4**) |
| 5 | Network issues (between actors involved in sharing economy) (**B5**) |
| 6 | Level of awareness (**B6**) |
| 7 | Lack of rules and regulations (**B7**) |
| 8 | Lack of sharing economy business model with industrial perspective (**B8**) |
| 9 | Capital cost (**B9**) |
| 10 | Lack of multi stakeholders' collaboration (**B10**) |
| 11 | Lack of interactive platforms which can assist the industries to share their resources (**B11**) |
| 12 | Lack of forecasting on potential resources flow (**B12**) |
| 13 | Lack of pressures from stakeholders (lack of necessity) (**B13**) |
| 14 | Lack of access and transparency to data (**B14**) |
| 15 | Lack of sharing partner evaluation (certification) platforms (**B15**) |

### 3.3.2 Decision making and trial evaluation laboratory (DEMATEL)

After the final set of barriers are identified from BWM, then the barriers are analyzed with DEMATEL. Based on the steps of DEMATEL explained in the previous section, the barriers are analyzed as follows:

***a) Calculate the initial relationship matrix 'A'***

From the replies of case industry personnel, the initial relationship matrix among common barriers were calculated from equation (3), which is shown in Table 4.

***b) Calculate the normalized direct-relationship matrix 'X'***

Table 5 shows the normalized direct relation matrix (X) which is obtained using equations (4) and (5). The normalized direct relation matrix is often referred as 'X'.

***c) Calculate the total influence matrix 'T'***

Table 6 shows the total influence matrix (T) which is obtained from the normalized direct relation matrix (X) using equation (6).

***d) Calculate the sum of rows and columns***

Table 7 shows the sum of rows and sum of columns which were calculated based on equation (7) and (8). In which, '$r_i$' is denoted as sum of rows and is denoted as '$s_i$' denoted as sum of columns for criteria

***e) Set up causal influence diagram***

The causal influence diagram shows the influence of barriers of industrial sharing economy among one another. Based on the two axes formed by $r_i+s_i$ and other is $r_i-s_i$ which acts as x and y axis, respectively, the barriers can be identified with their position. The most influential barrier captured is found at the top of the diagraph and the least influential barrier is depicted at the bottom of the diagraph. The causal influence diagram for both dimensions and criteria is shown in Fig. 1.

**Table 4: Initial influence matrix**

| | B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 | B9 | B10 | B11 | B12 | B13 | B14 | B15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **B1** | 0 | 2 | 2 | 2 | 3 | 3 | 4 | 2 | 4 | 1 | 1 | 4 | 2 | 2 | 2 |
| **B2** | 1 | 0 | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 1 | 1 | 4 | 1 | 1 | 2 |
| **B3** | 1 | 1 | 0 | 1 | 3 | 3 | 3 | 2 | 4 | 1 | 1 | 4 | 1 | 1 | 2 |
| **B4** | 1 | 1 | 2 | 0 | 3 | 3 | 3 | 2 | 4 | 1 | 1 | 4 | 1 | 1 | 2 |
| **B5** | 1 | 1 | 2 | 1 | 0 | 1 | 3 | 1 | 4 | 1 | 1 | 4 | 1 | 1 | 1 |
| **B6** | 1 | 1 | 2 | 1 | 3 | 0 | 3 | 1 | 4 | 1 | 1 | 4 | 1 | 1 | 1 |
| **B7** | 1 | 1 | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **B8** | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 0 | 4 | 1 | 1 | 4 | 1 | 1 | 2 |
| **B9** | 1 | 1 | 2 | 1 | 1 | 1 | 3 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| **B10** | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 0 | 1 | 4 | 2 | 2 | 2 |
| **B11** | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 1 | 0 | 4 | 2 | 2 | 2 |
| **B12** | 1 | 1 | 2 | 1 | 1 | 1 | 3 | 1 | 4 | 1 | 1 | 0 | 1 | 1 | 1 |
| **B13** | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 1 | 1 | 4 | 0 | 2 | 2 |
| **B14** | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 1 | 1 | 4 | 1 | 0 | 2 |
| **B15** | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 | 4 | 1 | 1 | 4 | 1 | 1 | 0 |

**Table 5: Normalized direct relationship matrix**

| | B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 | B9 | B10 | B11 | B12 | B13 | B14 | B15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **B1** | 0.0000 | 0.0377 | 0.0377 | 0.0377 | 0.0566 | 0.0566 | 0.0755 | 0.0377 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0377 | 0.0377 | 0.0377 |
| **B2** | 0.0189 | 0.0000 | 0.0377 | 0.0377 | 0.0566 | 0.0566 | 0.0566 | 0.0377 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0377 |
| **B3** | 0.0189 | 0.0189 | 0.0000 | 0.0189 | 0.0566 | 0.0566 | 0.0566 | 0.0377 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0377 |
| **B4** | 0.0189 | 0.0189 | 0.0377 | 0.0000 | 0.0566 | 0.0566 | 0.0566 | 0.0377 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0377 |
| **B5** | 0.0189 | 0.0189 | 0.0377 | 0.0189 | 0.0000 | 0.0189 | 0.0566 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0189 |
| **B6** | 0.0189 | 0.0189 | 0.0377 | 0.0189 | 0.0566 | 0.0000 | 0.0566 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0189 |
| **B7** | 0.0189 | 0.0189 | 0.0377 | 0.0189 | 0.0189 | 0.0189 | 0.0000 | 0.0189 | 0.0189 | 0.0189 | 0.0189 | 0.0189 | 0.0189 | 0.0189 | 0.0189 |
| **B8** | 0.0189 | 0.0189 | 0.0377 | 0.0189 | 0.0566 | 0.0566 | 0.0566 | 0.0000 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0377 |
| **B9** | 0.0189 | 0.0189 | 0.0377 | 0.0189 | 0.0189 | 0.0189 | 0.0566 | 0.0189 | 0.0000 | 0.0189 | 0.0189 | 0.0189 | 0.0189 | 0.0189 | 0.0189 |
| **B10** | 0.0189 | 0.0377 | 0.0377 | 0.0377 | 0.0566 | 0.0566 | 0.0566 | 0.0377 | 0.0755 | 0.0000 | 0.0189 | 0.0755 | 0.0377 | 0.0377 | 0.0377 |
| **B11** | 0.0189 | 0.0377 | 0.0377 | 0.0377 | 0.0566 | 0.0566 | 0.0566 | 0.0377 | 0.0755 | 0.0189 | 0.0000 | 0.0755 | 0.0377 | 0.0377 | 0.0377 |
| **B12** | 0.0189 | 0.0189 | 0.0377 | 0.0189 | 0.0189 | 0.0189 | 0.0566 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0000 | 0.0189 | 0.0189 | 0.0189 |
| **B13** | 0.0189 | 0.0377 | 0.0377 | 0.0377 | 0.0566 | 0.0566 | 0.0566 | 0.0377 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0000 | 0.0377 | 0.0377 |
| **B14** | 0.0189 | 0.0377 | 0.0377 | 0.0377 | 0.0566 | 0.0566 | 0.0566 | 0.0377 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0189 | 0.0000 | 0.0377 |
| **B15** | 0.0189 | 0.0189 | 0.0377 | 0.0189 | 0.0566 | 0.0566 | 0.0566 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0755 | 0.0189 | 0.0189 | 0.0000 |

**Table 6: The total influence matrix Tc for criteria**

| | B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 | B9 | B10 | B11 | B12 | B13 | B14 | B15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **B1** | 0.0221 | 0.0633 | 0.0797 | 0.0645 | 0.1024 | 0.0987 | 0.1357 | 0.0671 | 0.1467 | 0.0406 | 0.0406 | 0.1390 | 0.0610 | 0.0621 | 0.0684 |
| **B2** | 0.0379 | 0.0230 | 0.0744 | 0.0605 | 0.0961 | 0.0927 | 0.1103 | 0.0630 | 0.1378 | 0.0379 | 0.0379 | 0.1306 | 0.0400 | 0.0408 | 0.0641 |
| **B3** | 0.0365 | 0.0400 | 0.0354 | 0.0408 | 0.0927 | 0.0894 | 0.1064 | 0.0607 | 0.1329 | 0.0365 | 0.0365 | 0.1259 | 0.0386 | 0.0393 | 0.0618 |
| **B4** | 0.0372 | 0.0408 | 0.0731 | 0.0230 | 0.0944 | 0.0910 | 0.1083 | 0.0618 | 0.1353 | 0.0372 | 0.0372 | 0.1282 | 0.0393 | 0.0400 | 0.0630 |
| **B5** | 0.0334 | 0.0365 | 0.0655 | 0.0372 | 0.0310 | 0.0478 | 0.0971 | 0.0391 | 0.1213 | 0.0334 | 0.0334 | 0.1149 | 0.0352 | 0.0359 | 0.0398 |
| **B6** | 0.0346 | 0.0379 | 0.0679 | 0.0386 | 0.0877 | 0.0310 | 0.1007 | 0.0406 | 0.1258 | 0.0346 | 0.0346 | 0.1192 | 0.0365 | 0.0372 | 0.0413 |
| **B7** | 0.0289 | 0.0316 | 0.0567 | 0.0322 | 0.0429 | 0.0414 | 0.0305 | 0.0338 | 0.0552 | 0.0289 | 0.0289 | 0.0523 | 0.0305 | 0.0310 | 0.0345 |
| **B8** | 0.0365 | 0.0400 | 0.0718 | 0.0408 | 0.0927 | 0.0894 | 0.1064 | 0.0243 | 0.1329 | 0.0365 | 0.0365 | 0.1259 | 0.0386 | 0.0393 | 0.0618 |
| **B9** | 0.0299 | 0.0328 | 0.0588 | 0.0334 | 0.0445 | 0.0429 | 0.0872 | 0.0351 | 0.0387 | 0.0299 | 0.0299 | 0.0542 | 0.0316 | 0.0322 | 0.0358 |
| **B10** | 0.0401 | 0.0627 | 0.0787 | 0.0639 | 0.1016 | 0.0979 | 0.1166 | 0.0665 | 0.1456 | 0.0215 | 0.0401 | 0.1380 | 0.0605 | 0.0616 | 0.0677 |
| **B11** | 0.0401 | 0.0627 | 0.0787 | 0.0639 | 0.1016 | 0.0979 | 0.1166 | 0.0665 | 0.1456 | 0.0401 | 0.0215 | 0.1380 | 0.0605 | 0.0616 | 0.0677 |
| **B12** | 0.0316 | 0.0346 | 0.0621 | 0.0352 | 0.0469 | 0.0453 | 0.0920 | 0.0371 | 0.1149 | 0.0316 | 0.0316 | 0.0387 | 0.0334 | 0.0340 | 0.0377 |
| **B13** | 0.0393 | 0.0616 | 0.0772 | 0.0627 | 0.0997 | 0.0962 | 0.1145 | 0.0653 | 0.1430 | 0.0393 | 0.0393 | 0.1355 | 0.0230 | 0.0605 | 0.0665 |
| **B14** | 0.0386 | 0.0605 | 0.0758 | 0.0616 | 0.0979 | 0.0944 | 0.1124 | 0.0641 | 0.1404 | 0.0386 | 0.0386 | 0.1330 | 0.0408 | 0.0230 | 0.0653 |
| **B15** | 0.0359 | 0.0393 | 0.0705 | 0.0400 | 0.0910 | 0.0877 | 0.1044 | 0.0421 | 0.1305 | 0.0359 | 0.0359 | 0.1236 | 0.0379 | 0.0386 | 0.0243 |

## 4. Results and Discussions

This section presents the obtained results and further extends the discussion which can be valuable to an understanding of the industrial sharing economy in Indian context. Initially, the results are introduced and then are verified for reliability. The results coincide with existing literature, feedback from decision makers and experts and, finally, with observations made on all the above collections.

**Table 7: Sum of influences given and received**

| Barriers | Notation | $r_i$ | $s_j$ | $r_i+s_i$ | $r_i-s_i$ |
|---|---|---|---|---|---|
| Lack of trust | **B1** | 1.191794 | 0.522587 | 1.714381 | 0.669208 |
| Lack of technology (IoT, Block chain, ICT) to implement sharing economy in industries and manufacturing companies | **B2** | 1.047076 | 0.667251 | 1.714327 | 0.379825 |
| Lack of expertise | **B3** | 0.973314 | 1.02617 | 1.999484 | -0.05286 |
| High probability of risks | **B4** | 1.009856 | 0.698126 | 1.707982 | 0.31173 |
| Network issues (between actors involved in sharing economy) | **B5** | 0.801518 | 1.223107 | 2.024625 | -0.42159 |
| Level of awareness | **B6** | 0.868241 | 1.14371 | 2.011951 | -0.27547 |
| Lack of rules and regulations | **B7** | 0.559129 | 1.538957 | 2.098087 | -0.97983 |
| Lack of sharing economy business model with industrial perspective | **B8** | 0.973314 | 0.767094 | 1.740408 | 0.206219 |
| Capital cost | **B9** | 0.616875 | 1.846699 | 2.463574 | -1.22982 |
| Lack of multi stakeholders' collaboration | **B10** | 1.162921 | 0.522587 | 1.685508 | 0.640335 |
| Lack of interactive platforms which can assist the industries to share their resources | **B11** | 1.162921 | 0.522587 | 1.685508 | 0.640335 |
| Lack of forecasting on potential resources flow | **B12** | 0.706701 | 1.696873 | 2.403574 | -0.99017 |
| Lack of pressures from stakeholders (lack of necessity) | **B13** | 1.123596 | 0.607175 | 1.73077 | 0.516421 |
| Lack of access and transparency to data | **B14** | 1.084985 | 0.636937 | 1.721922 | 0.448048 |
| Lack of sharing partner evaluation (certification) platforms | **B15** | 0.937435 | 0.799818 | 1.737253 | 0.137617 |

Table 8 shows the influence given and received by each criterion over one another. Based on the values of sum of rows and sum of columns, the diagraph with all criteria was plotted, which is shown in Fig 1.

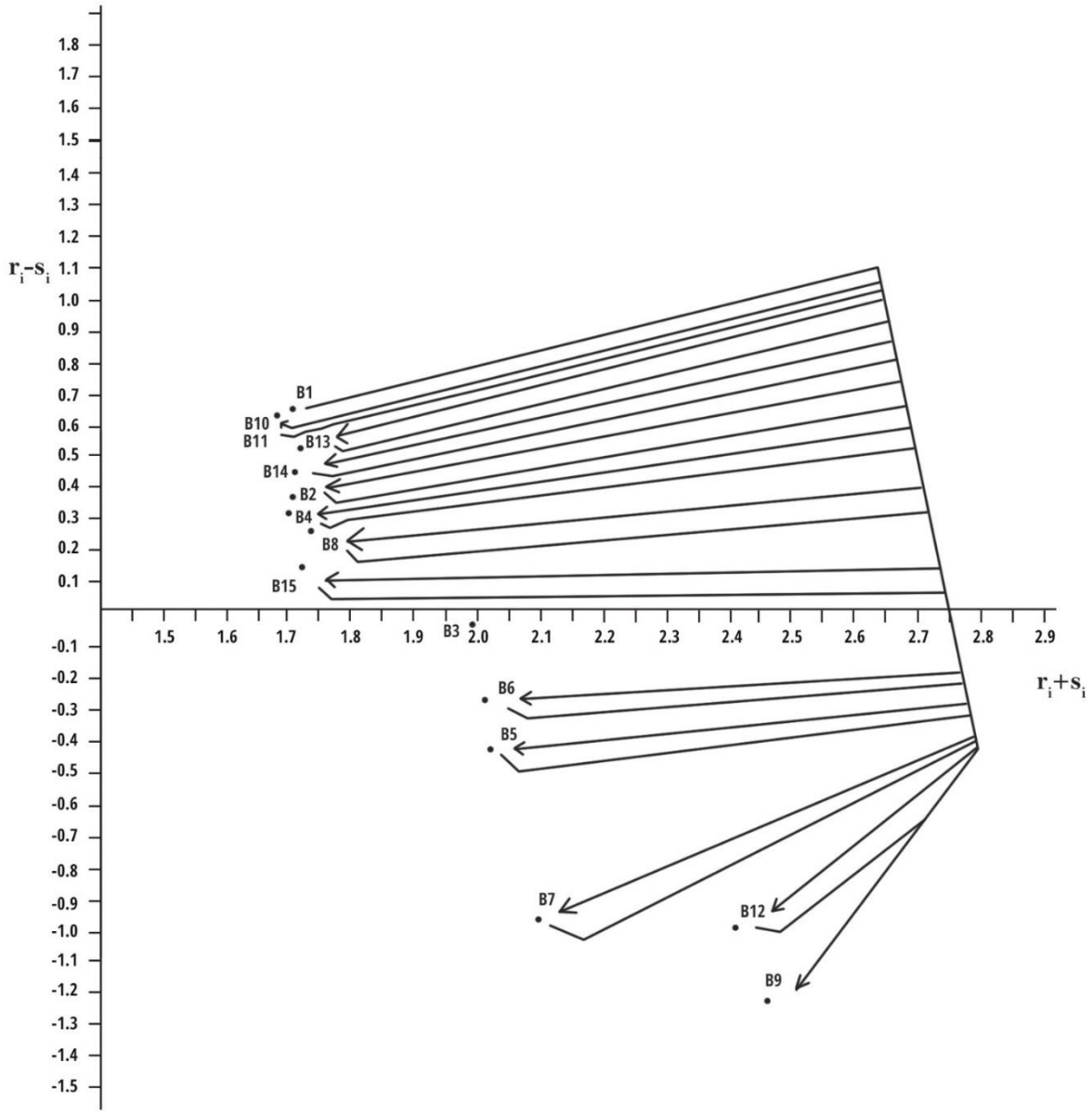


**Figure 1: Cause and effect influential diagraph**

This study considers 15 criteria for DEMATEL analysis. Among those 15 criteria, five criteria were presented in the effect group and the remaining ten criteria were presented in the cause group. In general, influencing criteria are categorized in the cause group and influenced criteria in the effect

group. From the figure, it is evident that ‘Lack of trust’ (**B1**) is the most influential (highest) barrier whereas ‘Capital cost’ (**B9**) is the least influential (lowest) barrier in the industrial sharing economy. The cause group consists of barriers as follows: B10>B11>B13>B14>B2>B4>B8>B15, whereas the effect group consists of barriers as B3>B6>B5>B7>B12>B9. Next to the most influential barrier, ‘Lack of multi stakeholder collaboration’ (**B10**) holds the second position. Once the results obtained, the research team started the exploration of results with three different approaches. First, the obtained results are compared with existing studies; secondly the results are discussed with the decision makers; and finally, the research team observed and summarized the combined sources of literature and case decision makers’ comments on the results.

As far as the literature concerned, the obtained results highly coincide with existing literature, although no previous exact literature is an exact match. Still, the basic concept looks similar in both industrial and other sharing economy. For instance, May et al. (2017) unlocked the sharing economy through identifying its barriers from a general perspective; they highlighted trust as a key factor in the implementation of sharing economy. In this study, one respondent stated: “For me, the sharing economy all boils down to trust. And in a world with low trust it becomes harder.” Another respondent stated: “Personally? I would never in my life go in an Uber taxi. Never in my life! I trust in 2 or 3 taxi companies. It’s like, put myself in a car with someone else – are you completely crazy!? It can be any crazy person at all!” These statements clearly resemble the obtained results; however, the basic layer of common sharing economy is interlinked with industrial sharing economy in terms of trust and reputation. All the above examples are given by the respondents involved in a single use and low wages; however, from the industrial perspective it is not a one-time job and it involves huge money along with work. Hence, the barrier may be greater in an industrial sharing economy than at a customer-level sharing economy.

After this correlation with the literature, the results are shown to the case decision makers. Initially they agree with the most influential barrier, because they are highly sensitive in sharing company details and resources with another company where trust plays a major factor. But in a striking departure, the industrial mangers were shocked at the result of least influential barrier: capital cost as the least influential barrier. According to the case industrial managers, capital cost plays a major hindrance in any newly proposed strategy, but in this case it is very much the opposite. With this contradictory statement, the research team began a detailed discussion with case industrial managers. That discussion determined that, unlike other strategies, capital cost is not the primary barrier because it provides an economic benefit very quickly if it is properly implemented when

compared to other sustainable strategies. Hence, industries don't really have an issue on the monetary side, but due to the complex structure and unclear business model, industries are afraid to implement sharing economy. This lack of trust on the sharing economy model extends with lack of stakeholder collaboration, which links to the lack of necessity of sharing economy in industries. However, most of the results were totally accepted by the industrial managers and they are ready to transform their practices.

The considered case company is situated in an industrial park surrounded by similar industries. Even with this situation, the case decision makers doubt the level of trust involved in sharing economy implementation among the industries. With this case, if two industries are located distant from one another, the trust factor is still questionable so regardless of the distance between the industries, a lack of trust plays a major role. It is mainly due to the actors involved in the operations because they are basically competitors. Understandably, industries are usually very careful with their cooperation agreements. In addition, there are no clear rules of engagement and it becomes tougher due to few strong regulations. If there is heavy demand for a certain resource that is needed to be shared, any one of the industry members who does not follow the lead time will likely encounter a difficult situation. Another major threat in the implementation of sharing economy is lack of transparency. For instance, if one member of the industry shared a resource from another industry and the recipient industry over utilized or engaged in any malpractice regarding that resource, the industry who shares would be frightened to continue sharing their resources.

After the barrier of trust, our research team observed that lack of technologies plays a major role in the implementation of sharing economy. Because stakeholders are not interested in sharing economy implementation due to the lack of transparency discussed earlier. But in recent years several technologies have been introduced to the field to improve transparency among operations. No particular technology can be selected to resolve this major barrier of the industrial sharing economy. Mostly, the case industry considers there is a need for an active sharing business model considering both supply and demand perspectives along with risk resilience. With these obtained insights of the results and industry expectations, specific recommendations are given in the upcoming sections.

## 5. Recommendations and framework development

From the insights gained from the discussions it can be determined that trust and reputation form the building blocks of the sharing economy in industries. However, other barriers are influenced by these trust and reputation factors. If these factors are addressed then there is a significant possibility

of implementing sharing economy in industries, but it is essential that the fundamental barrier of lack of trust must be mitigated. By considering this fact, three elements are recommended to eradicate the lack of trust, reputation, and transparency in the industrial sharing economy. Those elements include a platform for the sharing economy, an intermediator or trust provider, and Industry 4.0 and digitalization technologies.

### *i) Business model/Platform for sharing economy*

Successful examples of sharing economy, such as Uber and Airbnb, are possible only with a successful business model/platform. The platform/business model is designed to be user friendly; anyone can join easily as host or recipient without much hassle. The model also provides a wide range of options for the recipient to choose, which increases the comfort and customization of the service with less cost. This kind of sharing platform needs to be designed with industrial necessities. If an industry needs to meet the demand through certain resources, there should be a platform to search for the resources and this platform/business model should offer a range of choices with less cost involved. This kind of new business model assists the stakeholders to consider and shift to a sharing economy without any initial hesitation. If the platform is handy to access, as found in a mobile app, then more industrial partners could join and be ready to share their resources.

### *ii) Intermediator or trust provider*

The next issue is lack of trust on the created business model or platform. Even with successful examples in the sharing economy, several trust-related issues occur. For example, in 2011 an apartment rented through Airbnb was fully damaged and all the materials were stolen. In the early days of the company, Airbnb did not address liabilities, but due to pressures from various sources, they began to insist on security deposits to favor their hosts (The Economist, 2013). In a similar way, regulatory problems in successful business models may emerge. Many homes rented through Airbnb attract tourists whose objective is to party or to celebrate and, upon occasion, their actions or their noise end up affecting the neighborhood. Without adherence to some regulations, legal issues may arise. Another example of where responsibility should be placed occurs with Uber's successful business model. Uber drivers are not commercially-licensed drivers, so they may experience more accidents or lack some important knowledge. In addition, if an accident occurs it may not be obvious whether the Uber driver or the other driver was at fault. Responsibility may be difficult to determine. The above mentioned instances are still involved in the well-developed sharing economy model where peer to peer services are exchanged. These problems can become even more vulnerable from

an industrial perspective: what happens if an expensive rented machine becomes damaged? What happens if it affects the shop floor plan? What safety measures are required to be inherent with exchanged resources? In order to address these and related questions that pertain to responsibility, there should be a third party who takes care of all the insurance, safety, and other regulatory-based measures to increase trust among the actors involved in the industrial sharing economy.

***iii) Industry 4.0 and digitalization***

Finally, the third important recommendation is to utilize Industry 4.0 and digitalization technologies. In recent years, a platform called 'homeexchange.com' become famous for modern home consumption practices. This platform helps two parties to switch their homes on their vacation in two different places; this provides great opportunity of exploring new places with no/low cost. However, the idea is not new; home swapping has existed as far back as the 1950s. What is novel is the ability to reach a much broader audience due to the availability of technology. Likewise, resource sharing is quite old in manufacturing sectors, but the introduction of Industry 4.0 and digitalization can boost a new level of sharing consumption in industrial perspectives. Generally, integrating Industry 4.0 techniques and digitalization can offer a wide range of beneficial activities including easy mobilization of resources, tracking the resources, increasing transparency in operations (digitalization), creating easy access (cloud manufacturing), and so on.

***Industrial sharing economy mitigating strategies framework:***

Collectively, by applying three factors mentioned earlier, the industry can eradicate the major barriers of industrial sharing economy including lack of trust, lack of transparency, lack of business model or technical platform, and so on. However, each of the above-mentioned factors is only achieved through

certain practices, which needs to be explored further. The general framework developed based on the above discussions and recommendations is given below (shown in Figure 2).

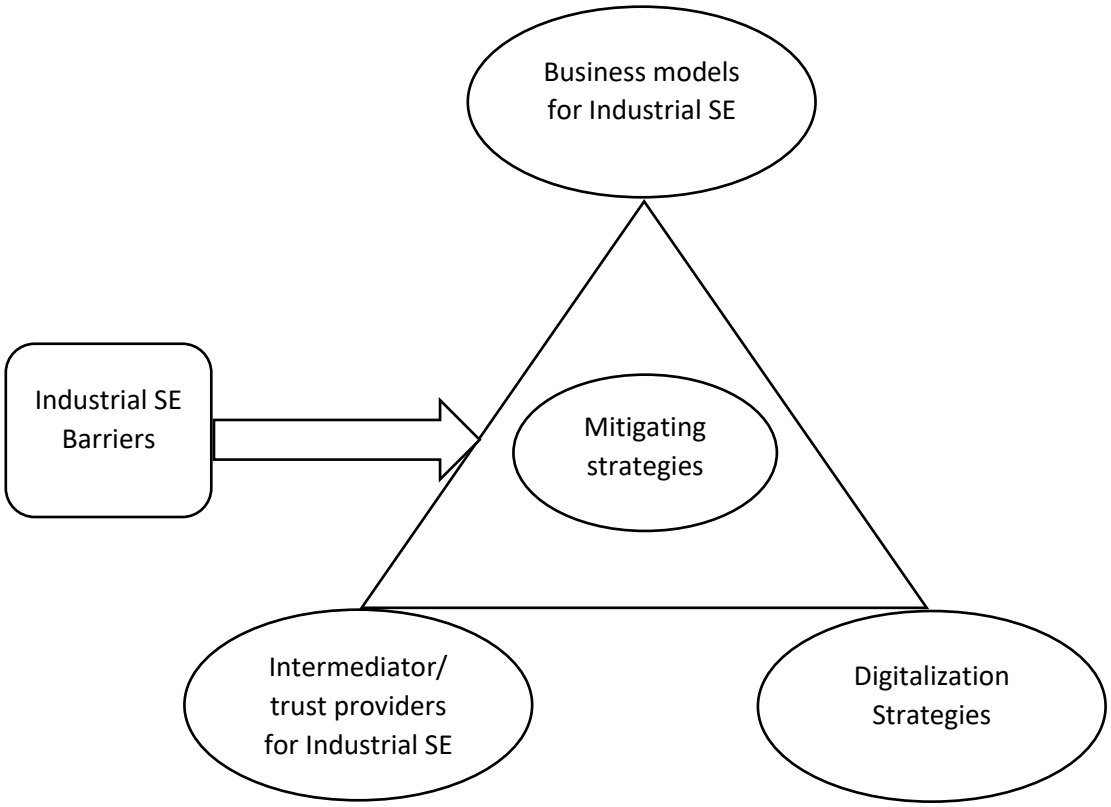


**Figure 2: Industrial sharing economy barrier mitigating framework**

Initiating this proposed framework can improve the chances of increasing the implementation of sharing economy from an industrial perspective, which further leads to achieving several sustainable development goals. By sharing resources (including personnel, materials, and machines) within the industries, this industrial sharing economy helps to achieve a number of SDGs, including Goal 8: decent work and economic growth, Goal 9: industry, innovation, and infrastructure, Goal 11: sustainable cities and communities, Goal 12: responsible consumption and production, Goal 13: climate action, and Goal 17: partnerships. These mentioned goals are enough to claim that the implementation of industrial sharing economy has a huge impact on sustainable development by addressing all three pillars (economy, environment, and society).

## 6. Conclusion

Success stories of sharing economy encourage companies to rethink their business model, which results in more academic papers published every year. Despite the rapid publications on sharing economy concepts and applications, two things are clear: i) misconceptions on the fundamental

concept are often overlapped with other similar concepts, including servitization, and ii) no clear research exists with the application of sharing economy in other fields of applications excluding space, logistics, and transportation. Contrary to this, owing to the technological development, tremendous opportunities exist with the inclusion of sharing economy in existing conventional business models especially in industrial manufacturing companies. More specifically, I4.0 opens up a promising possibility of incorporating sharing economy by sharing personnel, machines, and other resources to balance the customer expectation along with forecasted demand and supply. This study could be a pioneering work on the sharing economy with an industrial perspective where other existing studies are limited with successful applications. In addition, this study considers the complex case context of India to explore the industrial sharing economy with a case study methodology. The barriers are collected from the assistance of literatures and opinions of experts, and the findings are analyzed through two MCDM methods, BWM and DEMATEL. The common collected barriers of industrial sharing economy were shortlisted based on the case company with BWM and the shortlisted common barriers are analyzed with DEMATEL. This analysis provides us with the most influential criterion among other common criteria, and that barrier further assists industrial managers to specifically focus on that influential criterion. Here, 20 common barriers were considered initially and 15 were shortlisted through BWM. From the 15 shortlisted barriers, 'Lack of trust' (**B1**) and 'Capital cost' (**B9**) are found as most influential and least influential barrier of industrial sharing economy, respectively. There are a number of managerial implications that can be derived from this study, and these findings will assist industrial managers to understand the importance of practicing an industrial sharing economy business model. In addition, this study helps them to identify the resistance factors (barriers) for implementing the industrial sharing economy, and further to narrow down by identifying the most influential barrier among common barriers. This investigation on influential barriers leads industrial managers to come up with certain eradicating or mitigating practices for the influential barrier without considering other less influential barriers. Further, some of the key recommendations are given in order to address the identified influential barrier. Several contributions were offered by the study, both scientifically and with the practitioner's perspective, which is still not exempt from limitations. The major limitation of the study is the results are case specific. India has different geographical contexts and this case may not resemble the whole nation, but it does provide a pioneering overview of industrial sharing economy in an Indian context. In the future, this study can be considered as pilot work, and further the same can be extended with different geographical locations and applications-based cross sectoral analysis with statistical validations.

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