Adoption of Industry 4.0 Evidence in an Emerging Economy: A Behavioral Reasoning Theory Perspective

Abstract: The manufacturing landscape is undergoing unprecedented change, focusing on incorporating digital technologies to maximize operational efficiency and profitability. Myriad potential benefits of adopting incumbent digital and advanced technologies are attracting the interest of entrepreneurs and practitioners across the world. Nonetheless, Industry 4.0 (I4.0) adoption needs rigorous efforts for effective implementation. In academic literature, the potential roadblocks of I4.0 have already been identified and analyzed. However, its adoption is not easy or straightforward; entrepreneurs are concerned about Industry 4.0 adoption. Stringent efforts from all stakeholders can make its adoption a success. The present research provides a holistic approach to analyzing behavioral patterns toward I4.0 adoption. Behavioral Reasoning Theory (BRT) is used to analyze behavioral intentions towards I4.0 adoption. The data of 215 respondents was collected from manufacturing industries. It is found that the construct *Reasons For* (RF) is positively related to attitude and intention, while *Reasons Against* (RA) did not show any significant relationship with intention. This research delivers insights to industrialists, entrepreneurs, management, and policymakers to analyze the behavioral patterns toward I4.0 adoption. The results indicate the full mediation of attitude between *reasons against* and *intention*. Also, full mediation of *reasons against* between *value* and *attitude* is examined.

Keywords*:* Industry 4.0; Values; Attitude; Behavioral intentions; Reasons for; Reasons against; Emerging Economy.

1. Introduction

Due to the exponential increase in competition in the last few decades, industries are making strenuous efforts to compete in the dynamic marketplace, resulting in advancements in industrial processes. In recent years, emerging technologies have led to better strategic planning and the usage of innovative business models (Longo et al., 2017). Manufacturing industries must focus on digital technologies and sustainability across various sectors, including production planning, control, and supply chain management (Srivastava et al., 2022). Companies need to be more agile and provide high-quality products to meet customer satisfaction at a reasonable cost. Therefore, industries must have state-of-the-art manufacturing

facilities and use innovative and creative business models (Alizadeh and Soltanisehat, 2020; Beltrami et al., 2021). The present manufacturing era is undergoing drastic organizational and process changes with the introduction of digital and advanced automation technologies (Hughes et al., 2022). Industrial revolutions have been with us since the middle of the eighteenth century to fulfill fluctuating customer requirements. The first industrial revolution (I1.0) was initiated through steam engines, with a subsequent increase in production volume. The second industrial revolution (I2.0) saw the introduction of electricity to drive machines and equipment (Yang and Gu, 2021). More recently, automation, electronics, information usage and communication technologies were introduced during I3.0.

After three successful industrial revolutions, Industry 4.0 (I4.0) came to prominence (around 2011). I4.0 enables business processes to be more agile, flexible, productive, and sustainable with enhanced quality and reduced cost (Yin et al., 2018; Matt and Rauch, 2020). I4.0 facilitates real-time tracking of business activities, enabling efficient operational control. Developing countries are working hard to reap the benefits of I4.0. Germany proposed a high-tech strategy 2020 plan. They had previously initiated ten "future projects" which were started from the year 2012. Japan has also laid the foundation for adopting I4.0. The Japanese government proposed the “Investments for the Future Strategy” in the year 2017, in which the adoption of New Industrial Revolution (NIR) aspects are being explored for society 5.0 (Kinoshita, 2019). India also initiated SAMARTH Udyog to transform conventional manufacturing systems into intelligent manufacturing.

I4.0 enables multi-faceted benefits, including sustainability (Nascimento et al., 2019) and opens doors for exponential business growth (Passchini et al., 2019). Lu (2017) presented a fact-finding study globally to explore and analyze the connection between I4.0 and the greener economy. Implications for participatory design and co-production theory were also identified. There was general ambiguity about the utilization of human resources in these advanced digital manufacturing systems; one view was that deployment of I4.0 will eliminate the workforce, but research studies conducted by Kadir and Broberg (2020) cleared up this misconception. The authors highlighted that operators with innovative, cognitive, and interdisciplinary skill sets would be required and stated that these jobs would be highly paid. Malik et al. (2022) analyzed the outcomes of adopting digital transformations on employment in I4.0. The authors found that these advanced technologies will result in greater transparency, reorganized

management, enhanced work-life balance, increased efficiency, optimized utilization of resources, and enhanced customer satisfaction.

Other perspectives have been explored with concerns raised around various issues e.g. the cost of adopting I4.0 technologies, availability of funds, data privacy and security issues, standard reference architecture, and availability of a skilled workforce (Mukhuty et al., 2022). Similarly, Horvath and Szabo (2019) discussed the need for more technical, financial, and human resources for I4.0 adoption. Small and medium enterprises (SMEs) have been highlighted; they often face challenges toward digital transformation (Masood and Sonntag, 2020). I4.0 is explored as a critical technology for achieving organizational excellence, with an exponential rise in efficiency and system performance (Mukhuty et al., 2022; Sharma et al., 2022). Also, I4.0 contributes towards achieving sustainable development goals (Srivastava et al., 2022). However, before adopting I4.0 technologies, an organization must analyze various constructs such as Values (V), Attitude (ATT), Reasons Against (RA), Reasons For (RF), and Intentions (INT) towards I4.0 implementation. In light of this, the proposed study intends to respond to the following research questions:

RQ1: What are the behavioral patterns of corporate professionals towards I4.0 adoption?

RQ2: Does company size play an improbable role in the association between behavioral aspects towards I4.0 adoption?

Accordingly, research objectives are framed as follows:

RO1: To examine behavioral reasoning perspectives (i.e. V, ATT, RA, RF, and INT) towards I4.0 adoption

RO2: To analyze the moderating role of company size in the association among RA/RF and ATT, V and ATT towards I4.0 adoption

To respond to these research questions as stated and to examine behavioral intentions, the present study proposes Behavioral Reasoning Theory (BRT) to explore values, attitudes, intentions and perspectives towards I4.0 adoption in the Indian context. The survey data was gathered from 215 respondents working in manufacturing industries. The rationale behind using BRT was to understand the behavioral intentions of the organization toward I4.0 adoption by analyzing attitudes, values and other associated behavioral variables. Therefore, it is a robust means of analyzing the theoretical framework (Sahu et al., 2020b). In addition, dependent variables (intention, attitude, reasons for/against) can be explained in a more comprehensive

way using BRT as compared to other conventional theories such as the Theory of Planned Behavior (TPB) or the Theory of Reasonable Action (TRA) (Claudy et al., 2015).

I4.0 technology has been flourishing for the last decade in various industrial sectors including mechanical industries (Veile et al., 2019), automobiles (Virmani et al., 2021), textile and clothing (Majumdar et al., 2021), food (Oltra-Mestre et al., 2021), healthcare (Aceto et al., 2020) and pharmaceuticals (Reinhardt et al., 2020). As analyzed by various researchers, I4.0 involves complex manufacturing operations, so its adoption is not a simple task. Ghobakhloo and Iranmanesh (2021) also highlighted the complexity of transforming to the digital phase, noting a potential problem in that it is resource-intensive. Schroeder et al. (2019) provided a solution-based approach in which the authors discussed the organization's analytical, leadership, digital management, and innovative capabilities to overcome I4.0 barriers. Previous studies have discussed I4.0 roadblocks, associated technologies (Zarzuela et al., 2020), maturity models and implementation strategies (Pacchini et al., 2019). However, to the best of our knowledge, no study is available to date dealing with organizations' behavioral intentions, perceptions, attitudes, and behavior toward I4.0 adoption. Once organizations are convinced of I4.0 benefits, then they are in a better position for I4.0 adoption. In the present research, behavior toward I4.0 adoption is analyzed using the BRT methodology. BRT is a novel methodology that investigates the relationships among values, intentions, reasons, and behavior (Sahu et al., 2020b)

The remainder of the research paper is as follows. The literature review and hypothesis development are explained in section 2. Research methodology, questionnaire design and development, and data collection are presented in section 3. Discussion, theoretical and applied inferences are discussed in the penultimate section, and finally, the last section presents the conclusion.

2. Literature Review

The literature review explains BRT and development of the hypotheses.

2.1 Behavioral Reasoning Theory (BRT)

Westaby proposed BRT in the year 2005. Behavioral theories are extensively used in various domains (Sahu et al., 2020b). BRT helps to comprehend policymaking and effective decision-

making of managers and leaders (Westaby et al., 2010). It is a method to analyze values, attitudes and intentions plus reasons for/against. It is crucial to understand human psychology towards particular concerns. BRT implies that values affect attitude, which in turn has a significant role in behavioral intentions. TPB and TRA are two fundamental theories used in similar ways to BRT. TPB states that intention is influenced by attitude, subjective norms and perceived control. However, behavioral reasoning theory also emphasizes reasons for a better understanding of the effective decision-making process. Reasons are critical determinants in exploring value, attitude, and intentional relationships. Reasons are classified into two categories: RF and RA (Tandon et al., 2020). Reasons for are the enablers that might explain the adoption of a particular behavior; on the other hand, reasons against are the challenges that might restrict an individual from adopting a particular behavior. Also, BRT postulates that reasons impact the relationship between values and attitude (Westaby, 2005). For instance, Tandon et al. (2020), while using BRT for food purchase, described reasons as nutritional content, natural content and ecological welfare. The authors described reasons against as usage barrier and risk barrier. Various researchers have used BRT in an array of different research domains like e-waste management (Dhir et al., 2021), food purchase (Tandon et al., 2020), m-banking (Gupta and Arora, 2017), organizational and behavioral aspects (Westaby et al., 2010), and lean practices implementation (Sahu et al., 2020a). These are shown in Table 1.

Table 1: Some applications of BRT

S. No.	Domain	Reference
1	E-waste management	Dhir et al. (2021)
2	Barriers of lean manufacturing	Sahu et al. (2020a)
3	Behavioral reasoning perspectives on organic diet purchase	Tandon et al. (2020)
4	Renewable Energy Sources	Claudy et al. (2013)
5	Social responsibility role in building up perspectives towards apparel	Park et al. (2017)
6	m-banking adoption perspectives	Gupta and Arora (2017)
7	Consumer confrontation to innovation	Claudy et al. (2015)
8	Leadership Decision Analysis	Westaby et al. (2010)
9	Linkages exploring behavior and intentions	Westaby (2005)
10	Conceptual design analysis	Welch and Dixon (1994)

BRT is commonly used to investigate empirical relations among V, ATT, RA, RF and INT. The fundamental BRT framework is illustrated in Figure 1.

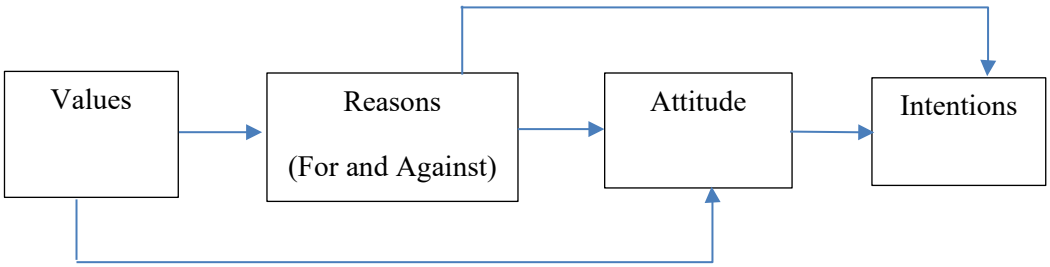

Figure 1: BRT Research Model (Claudy and Peterson, 2014)

After an extensive academic research, it was found that research studies in the domain of I4.0 beliefs, intentions and attitudes is limited. Empirical studies related to finding reasons for/against have yet to be explored. Therefore, we used the BRT approach in which reasons act as an intermediate attribute in the association between V, ATT and INT. Furthermore, the research model was extended by analyzing the role of company size in determining intentions.

2.2 Industry 4.0 Adoption

Accepting that I4.0 systems are complex, Virmani and Salve (2021) discussed that organizations need to upskill workforce expertise, motivate employees to enable organizational and process change and make sufficient funds available; these concerns can impede entrepreneurs and industrialists towards I4.0 adoption. Also, as a considerable investment is required to deploy highly advanced manufacturing technologies in the I4.0 working environment, industrialists must analyze the potential benefits, pros, and cons before adoption (Hamada, 2019).

Passchini et al. (2019) supported a method to assess readiness toward I4.0 adoption based on eight key identified technology enablers. The model was developed and tested in manufacturing industries located in Brazil. Another approach toward I4.0 adoption was discussed by Gupta et al. (2020); the institutional theory was used to analyze coercive pressure, mimetic and normative pressure. Yu and Schweisfurth (2020) analyzed critical factors that affect challenges and prospects toward I4.0 adoption. As advanced digital technologies are highly complex, Srivastava et al. (2022) used a Technology-Organizational-Environmental (TOE) framework to analyze I4.0 adoption.

2.3 Hypothesis Development

Various items under different constructs like values, attitude, reasons for/against, and intention are listed in Table 2.

Table 2: Items of various constructs identified through literature review

S. No.	Construct	Sub-Construct	Description of Items	References
1	Values (V)		I4.0 will help to enhance competitive advantage and establish new business models	Gupta et al. (2020); Calabrese et al. (2022)
2			I4.0 will help in increased agility and flexibility of the industry	Lu (2017); Merkel (2017); Belinski et al. (2020)
3			I4.0 will help to increase market share	Merkel (2017)
4			I4.0 will help in overall system efficiency	Massaro et al. (2021); Raji et al. (2021)
5	Reasons for (RF)	Production and Operational	I4.0 results in enhanced productivity and optimum utilization of resources	Massaro et al. (2021); Raji et al. (2021)
6			I4.0 results in reduced product variations and minimizes wastage	Massaro et al. (2021); Raji et al. (2021)
7			I4.0 helps in enhanced quality of products while improving working culture and safety of employees	Raji et al. (2021); Srivastava et al. (2022)
8			I4.0 helps in enhanced product customization	Raji et al. (2021); Srivastava et al. (2022)
9		Economic & Sustainability Benefits	I4.0 helps to increase returns on investment	Masood and Sonntag (2020); Mitra (2021)
10			I4.0 helps in cost reduction and increased profitability	Merkel (2017); Tortorella and Fettermann (2018)
11			I4.0 helps in producing green products	Horvath and Szabo (2019)
12	Reasons Against (RA)	Risk barriers	I4.0 may cause substantial economic loss if successful adoption does not happen	Raj et al. (2020); Ivanov and Dolgui (2021)
13			There may be an issue in the effective database managing structure	Dev et al. (2020); Matana et al. (2020)
14			I4.0 may result in the leakage of data and information	Kamble et al. (2019); Dev et al. (2020)
15		Procedural Barrier	Organizations do not have adequate research and development facilities	Lee et al. (2015); Massaro et al. (2021)
16			Standard reference architecture for adopting I4.0 may not be available	Kamble et al. (2018); Raj et al. (2020)
17			I4.0 may lack an effective knowledge management system	Manesh et al. (2020)
18			Seamless integration of equipment may be an issue	Jimeno-Morenilla et al. (2021)
19		Human Resource Barrier	Operators may lack interdisciplinary skill-sets	Majumdar et al. (2021); Virmani and Salve (2021)

20			Operators may be resistant to change	Dev et al. (2020); Kadir and Broberg (2020)
21			Operators may lack cognitive skill-sets	Ruppert et al. (2018); Ozkan-Ozen and Kazancognlu (2021)
22			Operators may not have adequate experience and qualifications	Majumdar et al. (2021); Virmani et al. (2021)
23			Operators may lack strong decision-making skill sets	Longo et al. (2017); Ozkan-Ozen and Kazancognlu (2021)
24		Usage Barrier	Employees are not comfortable with the usage of I4.0 technologies	Prause (2019); Upadhyay et al. (2021)
25			Industries face difficulties in adopting I4.0 due to a shortage of funds	Ortt et al. (2020); Raj et al. (2020)
26			Industries do not have sufficient Information and Technology facilities	Prause (2019); Majumdar et al. (2021)
27		Image Barrier	I4.0 involves complex operations, making it unfeasible to adopt	Majumdar et al. (2021); Virmani and Salve (2021)
28			Retrofitting equipment in conformity with I4.0 protocols is complex	Kamble et al. (2018); Virmani and Salve (2021)
29	Attitude toward I4.0 adoption (ATT)		Organizations understand the role of top management commitment in successful I4.0 adoption	Prause (2019); Majumdar et al. (2021)
30			Organizations understand the necessity of arranging training and educational programs for employees	Majumdar et al. (2021); Virmani and Salve (2021)
31			Organizations are confident that they can successfully adopt I4.0	Kaasinen et al. (2020); Majumdar et al. (2021)
32	Intention (INT)		Organizations are enthusiastic about bringing new and advanced I4.0 technologies into their systems	Prause (2019); Chiarini and Kumar (2021)
33			I4.0 adoption will bring brand image and status to an organization	Kruger and Steyn (2021); Virmani et al. (2021)
34			Organizations understand the strategic importance of I4.0 adoption	Bai et al. (2020); Ejsmont et al. (2020)

The hypotheses are explained as follows.

2.3.1 Value, Attitude and Intention

As per Schwartz (2010), values are beliefs that help achieve desired goals and motivate action. Researchers have found that multiple values guide attitude. Pollak et al. (2020) mentioned different values in the context of sustainability dimensions of I4.0 adoption i.e. social,

economic and environmental. Attitude (ATT) implies personal opinion for supporting/non-supporting any entity (Pratkanis et al., 2014) and can be strongly predicted by values (Ajzen, 1991; Fishbein and Ajzen, 1977). Souchet (2017) unlocked the worth perspectives of I4.0; the enhanced worth of products to customers was explained alongside performance and operational efficiency, which directly affects attitude. Helper et al. (2019) explained the value propositions of I4.0 in the context of conception and value capturing. I4.0 facilitates real-time tracking of product information, helping to investigate consumption patterns and product life cycles; this can be used in product customization and to improve serviceability.

Dev et al. (2020) revealed that operational excellence could be maximized through I4.0 and a circular economy can be achieved. However, I4.0 adoption is not easy, as explained by Hamada (2019). Organizations are hesitant towards I4.0 adoption and many do not fully understand its strategic importance. As per BRT, attitude is positively related to intention, causing a behavioral change. This is in agreement with TPB and TRA. Dhir et al. (2021) also stated that value (V) is related to attitude. Therefore, we theorize that

H1*: V has a positive (+) correlation with ATT to adopt I4.0*

2.3.2 Reasons For, Attitude and Intention

RF and RA are key constructs in BRT. Professionals use reasons to make crucial decisions, affecting their behavioral intentions (Claudy et al., 2015). According to BRT, attitude affects intention, which significantly correlates with behavior. Monteleone et al. (2019) used TPB to analyze attitudes and intentions for implanting agriculture 4.0. RF is found to be positively correlated with attitude in the context of I4.0 acceptance (Dhir et al., 2021). Based on relevant literature, reasons for adopting I4.0 have been categorized into production, operational, plus economic and sustainability paybacks (Raj et al., 2019). The values and benefits of I4.0 have been highlighted by various researchers like Hamada (2019) and Frank et al. (2019). These authors stated that I4.0 facilitates decision-makers in remote monitoring and control of equipment, predictive maintenance, optimized manufacturing solutions, better product development and design. Furthermore, Chauhan et al. (2021) discussed the significant benefits of I4.0 after its adoption.

De Sousa Jabbour et al. (2018) discussed how I4.0 adoption enhances competitiveness and helps attain sustainability benefits. Also, I4.0 adoption will pave the pathway toward circular economy adoption (Bag et al., 2020). Recent literature (Anosike et al., 2021) indicates that

digital transformations will significantly cut down production costs, improve product quality, reduce product variations and defects, and enhance the overall operational efficiency of a manufacturing firm. Also, Ejsmont et al. (2020) identified the crucial aspects of I4.0 adoption to be improved work culture, cooperation among stakeholders, strategic planning and decision-making, effective handling of data, interdisciplinary skill sets and communication, cyber-security as well as flexible organizational culture.

Raj et al. (2020) emphasized top management commitment and digital strategies as the most important contributing factors towards digital transformations. In addition, the authors discussed the need of training and development initiatives to enable the workforce to gain knowledge and expertise. According to a report generated by Deloitte in "The Fourth Industrial Revolution is Here - Are You Ready?", one thousand six hundred top management officials from 19 countries were surveyed. It was found that although business officials are optimistic about stewarding I4.0, they lack confidence in investment due to anticipated risk factors. Tyas and Naibaho (2019) discussed entrepreneur intentions and enthusiasm toward I4.0 adoption. The authors highlighted that creative and innovative entrepreneurship is essential for effective I4.0 adoption. Once a positive attitude is developed, it leads to intention towards adoption. I4.0 facilitates the coordinated use of highly advanced technologies to increase overall system efficiency (Helper et al., 2019).

Therefore, we have theorized that

H2*: ATT and INT have a positive (+) correlation in the context of I4.0 adoption*

H3*: RF and ATT have a positive (+) correlation in the context of I4.0 adoption*

H4*: RF and INT have a positive correlation (+) in the context of I4.0 adoption*

2.3.3 Reasons Against, Attitude and Intention

Claudy et al. (2013) reveal that *RA* have a pivotal role in developing attitude and intention to I4.0 adoption, which in turn affects behavior. The reasons against construct are categorized into risk, usage, procedural, human resource, and image barriers based on Innovation Resistance Theory (IRT); these impede organizations towards I4.0 adoption. The higher the intensity of these barriers, the higher the attitude intensity developed (Sahu et al., 2020a). The various constructs under reasons against are explained as follows.

Risk barrier: Risk barriers are associated with the risk linked with embracing I4.0 adoption. Industrialists fear data loss and privacy issues, economic losses, inefficient database

management and drastic organizational changes (Muller et al., 2018; Kaasinen et al., 2020; Sony, 2020). It is vitally important to have a well-organized and operative knowledge management structure so that stored knowledge can be instantly accessed, retrieved and applied (Manesh et al., 2020).

Procedural barrier: This includes lack of standard reference architecture and a suitable combination of equipment on a typical stage - significant contributing aspects of digital transformations (Kamble et al., 2018). I4.0-led factories must be equipped with intelligent sensors and advanced machinery which facilitates real-time visibility, self-optimizing capability and decision-making.

Human Resource barrier: Another crucial barrier is the human resource barrier; it is evident from previous research carried out by Romero et al. (2016), Longo et al. (2017), and Frank et al. (2019) that competent operators will be required to handle complex I4.0 manufacturing operations. These studies eliminated the hysteria that automation technologies will remove the need for humans; instead, the role of operators will be changed from active performers to passive observers (Virmani et al., 2021).

Usage Barrier: The usage barrier comprises sub-components related to the usage of I4.0 technologies. Since many industries cannot afford considerable investments to buy high-cost equipment, it may hinder them towards I4.0 adoption. Also, employees may not feel comfortable with advanced technologies (Kadir et al., 2019). Since companies are busy with their everyday busy schedules, they do not get time to consider transition from a traditional manufacturing system to I4.0.

Image Barrier: An image barrier involves the perception of adopting I4.0 technologies. Since I4.0 involves complex operations, employees and entrepreneurs presume these are extremely difficult to adopt. Because it is challenging to replace already existing set-ups, industries may face difficulty retrofitting machinery in compliance with I4.0 standards (Nascimento et al., 2019). Therefore, based on the literature reviewed above, we hypothesize that

H5: RA have a negative (-) correlation with ATT to adopt I4.0

H6: RA have a negative (-) correlation with INT to adopt I4.0

2.3.4 Value, Reason For and Reason Against

Values stimulate reasons instead of their generation in silos, ultimately impacting behavior (Westaby, 2005; Claudy et al., 2015). Values help individuals to inspect reasons and take action for selecting/rejecting any opinion (Sahu et al., 2020a). Furthermore, reasons are distinct from personal beliefs and have a crucial role in developing behavioral intentions (Norman et al., 2012). These perspectives imply that values and reasons are directly related i.e. the stronger the values, the higher the reasons, and vice versa (Sahu et al., 2020a). Pennington and Hastie (1993) also explained the relationship between values and reasons. Prior research on BRT also reveals positive relations between value and reasons for, as well as the negative relation between value and reasons against (Ryan and Cassidy, 2018). In an I4.0 environment, although physical ergonomics requirements will diminish, cognitive ergonomics will be needed to contribute to successful I4.0 adoption (Virmani and Salve, 2021). Bainbridge (1983) discussed the ironies of automation, removing the hysteria about job loss, and stated that a workforce would be required for any smooth running of equipment and processes. All these perspectives shows that value is positively correlated with reasons for and negatively correlated with reasons against. Therefore, the postulated hypotheses are

H7: V is positively (+) associated with RF in the context of I4.0 adoption

H8: V is negatively (-) associated with RA in the context of I4.0 adoption

2.3.5 Mediating Role of Reasons For/Reasons Against and Attitude

Prior scholarly literature (Sahu et al., 2020a; Russo et al., 2015; Westaby et al., 2010) indicates that reasons and attitude act as strong mediators. Also, it reveals that behavior and intentions can be better explained by the mediating roles of RF/RA and ATT (Sharma et al., 2021). On a similar note, Sivathanu (2018) stated that reasons have a significant role in predicting attitude and intention. A crucial need to analyze the area of attitude-intention was felt by Aschemann-Witzel and Aagaard (2014). Another study by Westaby (2005) indicated that reasons provide proper justification to examine the behavioral intention. Sahu et al. (2020a) also indicated that the value-reasons-attitude-intention path is of high significance and is more heuristic. Availability of IT infrastructure (Pessot et al., 2020), dedicated and skilled workforce (Longo et al., 2017), government support policies (Luthra et al., 2020), information management and optimum resource utilization (Luthra et al., 2020) were found to be crucial aspects of intelligent manufacturing systems.

Ricci et al. (2021) recognized the need for knowledge search and opportunity recognition for I4.0 adoption in SMEs. Yu and Schweisfurth (2020) explained that knowledge, awareness and potential benefits are the vital drivers of I4.0 adoption. Looking at these perspectives, we found it necessary to analyze the mediating role of reasons and attitude. Therefore, we hypothesize that

H9a: The relationship between V and ATT is mediated by RF/RA

H9b: The relationship between RF/RA and INT is mediated by ATT

2.3.6 Moderating Role of Company Size

Yu and Schweisfurth (2020) concluded that process innovation in SMEs is a key success factor towards I4.0 adoption. Furthermore, Agostini and Nosella (2019) stated that SMEs are more inclined towards I4.0 adoption due to strong top management commitment, social capital and absorptive capacity. A similar study conducted by Matt and Rauch (2020) discussed that SMEs often face difficulty in I4.0 adoption compared to large-sized industries. However, the authors mentioned that SMEs could more easily adopt I4.0 as IT infrastructure and associated frameworks can be built from scratch. Therefore, we hypothesize that

H10: Company size moderates the relationships between V and ATT, RF and ATT, RA and ATT.

The theoretical model of BRT is depicted in Figure 2.

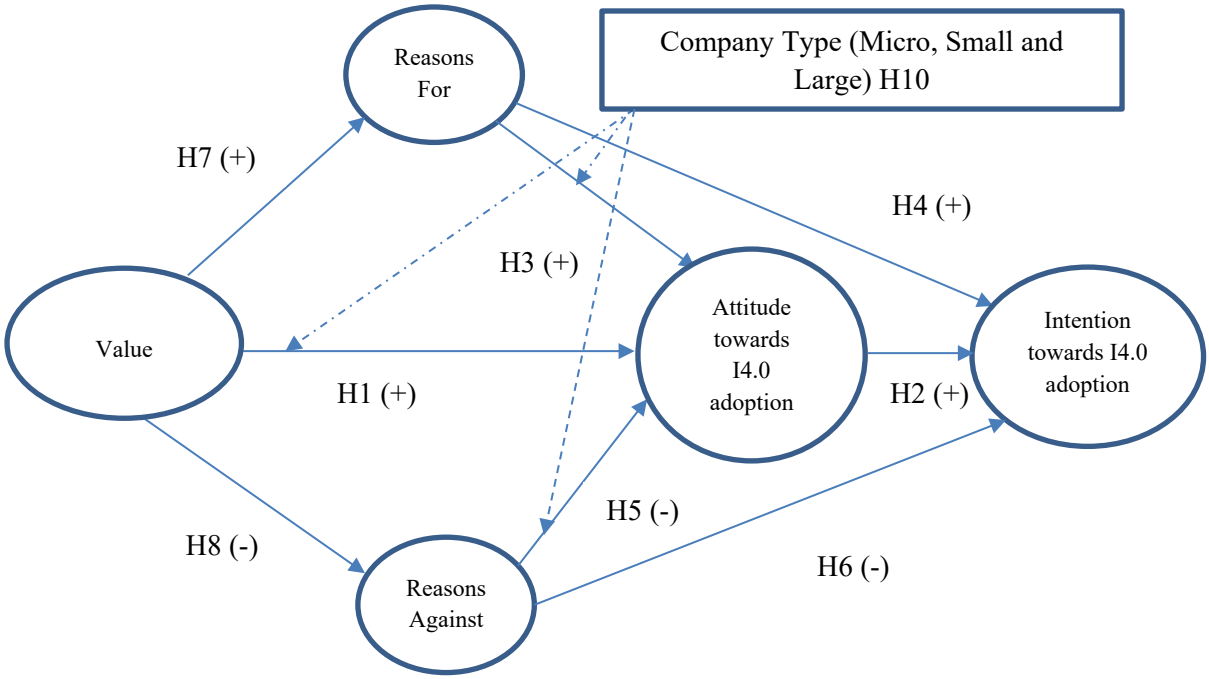

Figure 2: Theoretical Model of BRT

3. Research Methodology

The research methodology is explained as follows:

3.1 Survey Response and Data Collection

The complete details regarding the demographic profiles and organizational characteristics of respondents are shown in Table 3.

Table 3: Respondents Profile

Variable	Sub-variable	Number	%
Profile of Respondents			
Gender	Male	153	71.16
	Female	62	28.83
Age (in years)	41-45	62	28.83
	46-50	80	37.20
	51-55	48	22.32
	> 55	25	11.62
Education Level	Bachelor	133	61.86
	Master	63	29.30
	Doctorate	19	8.83
Organization's characteristics			
Number of employees	01-100	64	29.76
	101-200	43	20.00
	201-300	52	24.18
	> 300	56	26.04
Years of Establishment (years)	< 10	27	12.55
	11-20	53	24.65
	21-30	87	40.46
	> 30	48	22.32
Industry Type	Automobile	94	43.72
	Leather	57	26.51
	Metallurgical	36	16.74
	Aviation	28	13.02

The questionnaire comprises two segments; the first segment aims to collect the demographic profile data, and the second contains questions related to the study's objectives. So, the second section consisted of questions about various constructs i.e. V, RA, RF, ATT, and INT. The purpose of the questionnaire was to collect responses using statements corresponding to constructs toward adopting I4.0. A convenience sampling technique was used to gather responses, where industry experts were asked to provide the references of other people working in the area closest to the I4.0 adoption. Utmost care was given to choosing high-ranked executives and officials with sound knowledge and expertise in the required domain. Electronic mail was sent to respondents with an explanatory cover letter stating the aim of the

research study. Since many respondents were busy with their routine schedules, telephone calls were also made to collect some responses. It took around three months to collect the data. Most of the participants responded without any reminders, while for some, reminders were sent.

A questionnaire was sent to 400 people with 225 questionnaires received. Ten questionnaires were incomplete and hence discarded; they were not considered for any further investigation. Therefore, 215 questionnaires were finally evaluated. A response rate of 53.75 % was sufficient to proceed. Responses were assessed on a five-point Likert scale. Indian manufacturing industries contribute significantly to enhancing the country's Gross Domestic Product (GDP); they account for 16-17% of the manufacturing GDP (Goenka, 2021). Therefore, experts from manufacturing industries were chosen and contacted through e-mails with cover letters indicating the research's objectives and purpose. The percentage of different industry domains who participated are automobile (43.72%), leather (26.51%), metallurgical (16.74%) and aviation (13.02%). All respondents were well qualified and had sound knowledge of the area under investigation. Qualifications of the participants included bachelor's degree (61.86%), master's degree (29.3%), and doctorate (8.83%).

3.2 Data Analysis

The data gathered was examined in two phases. In the first phase, Confirmatory Factor Analysis (CFA) examined the identified constructs. Also, instrument consistency, convergent and divergent validity were evaluated. The values of Average Variance Extracted (AVE) and Composite Reliability (CR) were shown to be satisfactory. In the subsequent phase, Structural Equation Modelling (SEM) was performed to examine the hypotheses developed using the BRT research model. To analyze mediation and moderation effects, process macro v3.6 was used.

3.3 Non-Response Bias

Since our research includes survey data, this may be susceptible to any form of bias. Any ambiguity was removed using Armstrong and Overton's (1977) non-response bias. The respondents were segregated into early and late responders. By carrying out a *t*-test, the results computed showed no substantial differences between the late and early responders. Also, based on organization dimensions, there is no noteworthy variance among early responders and late-responders. So in total, we can safely say that the calculated results are reliable.

3.4 Common Method Bias

Common Method Bias is an extensively used method in many sectors; it is also known as Common Method Variance (CMV). We used Harmon's Single Factor Test. Despite taking all precautionary measures for collecting responses, the % variance was computed to be 23%; this is far less than the upper acceptable value of 50%. In addition, another popular method, the Common Latent Factor (CLF) method, was used where the common factor was encumbered with all identified items. This gave a much better understanding. In this case, the values were computed to be within the acceptable range (Craighead et al., 2011).

4. Results and Discussion of Findings

India, including other emerging economies, is on the path to I4.0 adoption. Industrial managers need to identify their weaknesses and strengths to make the journey to I4.0 adoption successful. As per a report by Singh (2017) for readiness assessment for 2016-17, India ranked 91st out of 139 countries in I4.0 adoption. In this research, we have analyzed I4.0 adoption patterns using BRT. Various constructs analyzed were values, attitudes, reasons for/against and intention. The convergent validity is shown in Table 4.

Table 4: Convergent validity

S. No.	Construct	Items	Notation	Loading	AVE	CR
1	Value		V1	0.724	0.680	0.893
2			V2	0.886		
3			V3	0.958		
4			V4	0.706		
5	Reasons for	Production and Operational	POM1	0.789	0.547	0.822
6			POM2	0.942		
7			POM3	0.596		
8			POM4	0.567		
9		Economic & Sustainability Benefits	ES1	0.800	0.502	0.75
10			ES2	0.626		
11			ES3	0.690		
12	Reasons Against	Risk Barrier	RB1	0.926	0.863	0.949
13			RB2	0.887		
14			RB3	0.973		
15		Procedural Barrier	PB1	0.837	0.550	0.828
16			PB2	0.799		
17			PB3	0.688		

18			PB4	0.623		
19		Human Resource Barrier	HR1	0.823	0.500	0.832
20			HR2	0.636		
21			HR3	0.696		
22			HR4	0.730		
23			HR5	0.635		
24		Usage Barrier	UB1	0.767	0.635	0.839
25			UB2	0.799		
26			UB3	0.825		
27		Image Barrier	IB1	0.855	0.796	0.886
28			IB2	0.928		
29	Attitude towards I4.0 adoption		AT1	0.684	0.553	0.787
30			AT2	0.786		
31			AT3	0.757		
32	Intention		INT1	0.749	0.547	0.778
33			INT2	0.876		
34			INT3	0.560		

Discriminant validity is shown in Table 5.

Table 5: Discriminant validity

Construct	AVE	CR	V	RA	RF	ATT	INT
V	0.680	0.893	**0.824**				
RA	0.541	0.949	0.113	**0.735**			
RF	0.511	0.875	-0.060	-0.038	**0.715**		
ATT	0.553	0.787	0.018	0.327	0.191	**0.744**	
INT	0.547	0.778	-0.044	0.058	0.206	0.200	**0.739**

Note: V, RA, RF, ATT, INT implies Values, Reasons Against, Reasons For, Attitude and Intention respectively.

Testing outcomes of the hypotheses are shown in Table 6.

Table 6: Hypothesis testing results

Hypothesis	Path	Beta	p-value	Supported (Yes/No)
H1	Value → Attitude	-0.019	ns	No
H2	Attitude → Intention	0.174	**	Yes
H3	Reasons For → Attitude	0.343	**	Yes
H4	Reasons For → Intention	0.320	**	Yes
H5	Reasons Against → Attitude	0.218	ns	No
H6	Reasons Against → Intention	-0.005	ns	No
H7	Value → Reasons For	-0.033	ns	No
H8	Value → Reasons Against	-0.210	**	Yes

** implies $p < 0.01$, ns implies non-significant

Hypothesis H1, where the value is positively related to attitude, is not supported. The result is consistent with Dhir et al. (2021), who analyzed e-waste patterns. The possible reasons for this may involve the critical challenges faced by organizations during I4.0 adoption. Similar research results were reported by Frank et al. (2019). Entrepreneurs are curious about I4.0 adoption but need to learn about the process of the actual adoption. Therefore, analyzing an organization's readiness must be a priority before starting I4.0 adoption. Strategic planning can lead to increased chances of success in adopting I4.0. Hypothesis H2, where attitude is positively correlated with intention ($\beta = 0.174$, $p < 0.01$), is supported. Hypothesis H3, reasons for is positively related to attitude, is also seen to be supported ($\beta = 0.343$, $p < 0.01$). The probable cause for this may be the attainment of operational excellence, cost reduction and competitive advantage by I4.0 adoption (Ooi et al., 2018). I4.0 technological advancements were found to enhance sustainability and flexibility. Also, it stimulates creative and innovative business models, improves the product life cycle and creates better end-to-end progressions (Hughes et al., 2022). The other crucial aspect is top management commitment; this plays an equally important role in I4.0 adoption through sufficient investment and efficient handling of involved risks (Prause, 2019). Entrepreneurs are therefore curious to utilize this opportunity to have novel and innovative business models, revealing their interest and enthusiasm and formulating efficient business strategies to increase market share and enhance brand image (Kruger and Steyn, 2020). The SEM results are shown in Figure 3.

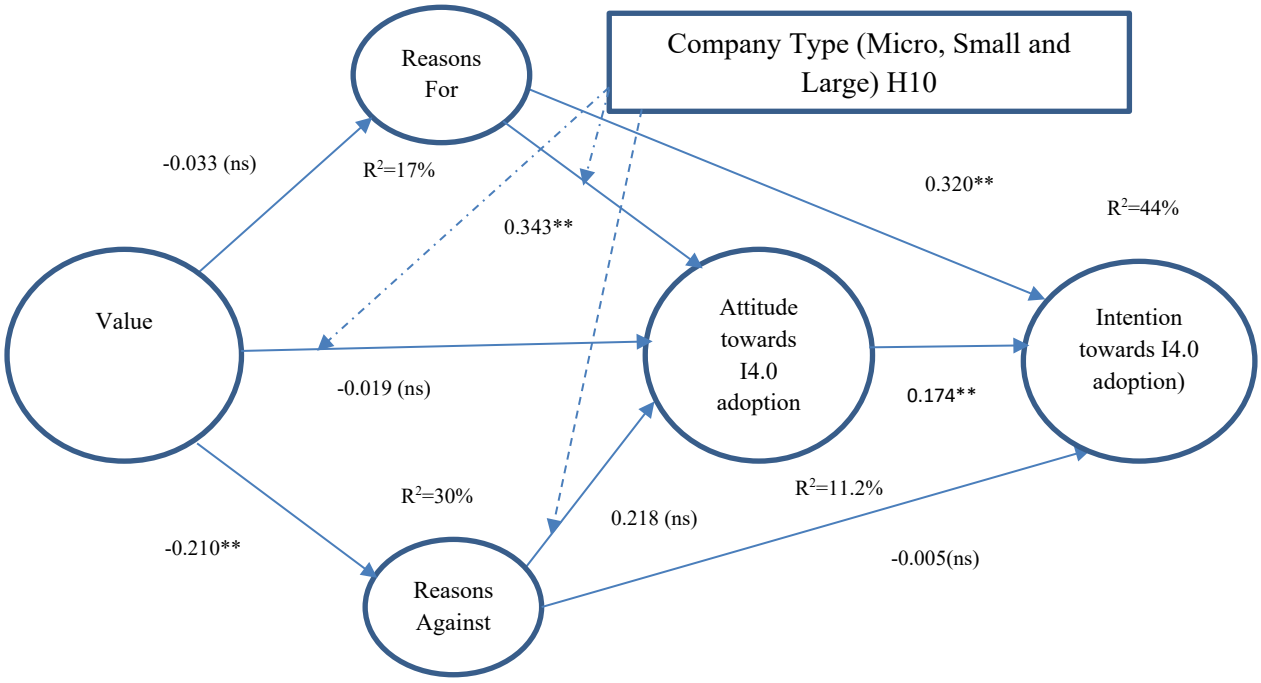

Figure 3: Propssed model results

Hypothesis H4, reasons for is positively correlated with intention, is supported ($\beta = 0.320$, $p < 0.01$). This finding is consistent with Dalenogare et al. (2018). These authors analyzed reasons from three key metrics - products, side-effects, and operational benefits - towards I4.0 adoption in Brazilian industries. Hypothesis H5, reasons against is negatively associated with attitude, is not supported. I4.0 problems can be tackled by workforce development, enhancing IT/digital skillsets, interdisciplinary, creative, innovative thinking, research and development activities (Ozkan-Ozen and Kazancoglu, 2021; Jaeger and Upadhyay, 2021). Also, Hypothesis H6, reasons against is negatively associated with intention, is not supported. A similar finding was reported by Tandon et al. (2020), who analyzed behavioral intentions for food purchases. This implies that intentions and attitude towards I4.0 may have some indirect effect. Looking towards I4.0 benefits, industrialists are passionate about achieving high operational performance and organizational excellence. Hypothesis H7, value is positively related with reasons for, is not supported. Hypothesis H8, value is negatively correlated to reasons against ($\beta = -0.210$, $p < 0.01$), is supported. The probable reasons may be challenges confronting the path of I4.0 adoption. It implies that industrialists who are tempted to excel in their sectors must be aware of the latest technologies and trends. Clear comprehension of I4.0 benefits affects the reasons for/reasons against I4.0 adoption. Hypothesis H9a examines the mediating role of attitude in determining the association between reasons for/reasons against and intention toward I4.0 adoption. Our results show full mediation of attitude between reasons against and intention as shown in Table 7 and Table 8.

Table 7: Indirect Effects (Mediation Analysis)

	Effect	**se**	**LLCI**	**ULCI**
V → RF → ATT	-0.0146	0.0146	-0.0508	0.0062
V → RA → ATT	0.0530	0.0253	0.0089	0.1063
RF → ATT → INT	0.0624	0.0427	-0.0010	0.1624
RA → ATT → INT	0.0535	0.0251	0.0129	0.1098

Table 8: Results of Mediation Analysis

V → RF → ATT						
	Beta	**se**	***t***	***p***	**LLCI**	**ULCI**
Direct Effect	0.0696	0.072	0.9636	0.3363	-0.0728	0.2121
V → RA → ATT						
	Beta	**se**	***t***	***p***	**LLCI**	**ULCI**
Direct Effect	0.0021	0.0711	0.0290	0.9769	-0.1380	0.1421
RF → ATT → INT						
	Beta	**se**	***t***	***p***	**LLCI**	**ULCI**

Direct Effect	0.2585	0.1409	0.8346	0.0680	-0.0192	0.5362
RA → ATT → INT						
	Beta	**se**	***t***	***p***	**LLCI**	**ULCI**
Direct Effect	0.0335	0.0653	0.5133	0.6083	-0.0951	0.162

Hyp No mediation is observed of attitude between reasons for and intention. Our results follow Sahu et al. (2020a) and Claudy et al. (2013). Additionally, hypothesis 9b analyzes the mediating association of *reasons for/against* in analyzing the association between value and attitude. The results show that *reasons for* do not mediate the relationship between value and attitude. Also, while estimating the mediation effect of *reasons against* between value and attitude, a full mediation effect was seen; these results were found to be consistent with Sahu et al. (2020a). These authors analyzed behavioral patterns toward lean practices implementation.

othesis H10 analyzes the moderating role of company size in estimating the relation between value and attitude, *reasons for* and attitude, and *reasons against* and attitude. The results shown in Table 9 indicate that company size does not moderate the relationship among value, RF, RA, and attitude. The possible cause may be the eagerness for I4.0 towards its adoption. Henceforth, behavioral patterns of organizations are assumed to be predominant, irrespective of company size.

Table 9: Moderation Analysis

Relation	**Beta**	***t***	***p***	**LLCI**	**ULCI**	**Moderation**
V → ATT	0.1087	1.2437	0.2150	-0.0636	0.2809	No
RF → ATT	0.0166	0.0930	0.9260	-0.3349	0.3681	No
RA → ATT	0.0587	0.7784	0.4372	-0.0899	0.2073	No

4.1 Theoretical Implications

Manufacturing industries significantly contribute to the nation's economy and employment opportunities for all generations. In a highly competitive and dynamic market, I4.0 adoption helps enterprises to enhance overall operational efficiency and profitability. Since research studies analyzing the behavioral intentions toward I4.0 adoption are limited, the present research has thoroughly explored the dimensions of behavioral intentions. The empirical results highlighted the behavioral aspects and provided a I4.0 adoption framework. This research aimed to examine the intention of businesses to adopt I4.0 using various constructs like reasons for/against, attitude and values. The findings provide deep insights into the performance of industrial managers by analyzing their behavioral intentions toward I4.0 adoption. Also, the

role of company size as a moderator to influencing behavioral dimensions has been examined. Results and analysis found that company size does not moderate the relationship between value, RA, RF and attitude. These findings agree with Vrchota et al. (2019), who stated that organizations are highly engaged and interested in adopting I4.0. The proposed research model can help managers to understand contributing behavioral enablers and inhibitors (reasons for and reasons against) for I4.0 adoption. The study includes a novel aspect by analyzing behavioral factors and extending theoretical findings in behavioral patterns toward I4.0 adoption.

Reasons against do not have a substantial influence on intention. The probable cause may have emerged from industrial managers' positive approach to adopting I4.0; dedication shown by leaders motivates and encourages the whole organization. Strategic planning and decision-making tools must be adopted towards I4.0 adoption; these are needed to overcome I4.0 roadblocks as indicated in RA constructs (risk, procedural, human resource, usage and image barrier). Compared to other theories like TPB and TRA, BRT provides a more holistic approach to analyzing behavioral intentions. Additionally, this study can be a foundation for researchers to explore behavioral aspects of I4.0 adoption.

4.2 Practical Implications

The results provide a deep understanding to all stakeholders, including policymakers, practitioners and industrial managers, curious about I4.0 adoption. RF must be clearly understood so that organizations realize the benefits of I4.0 (Kamble et al., 2018). In our findings, the intensity of construct *reasons for* (R^2 = 17%) is lower than *reasons against* (R^2 = 30%); this gives a crystal-clear explanation to organizations about the influence of various constructs contributing towards I4.0 adoption. Thus, attitude and intention can be evaluated accordingly. Sahu et al. (2020a) also reported that attitude positively correlates with behavioral intentions to adopt lean practices. Furthermore, using BRT framework analysis, organizations will be in a better position to assess reasons for and reasons against constructs toward I4.0 adoption. For instance, usage, procedural, human resource and image roadblocks must be handled strategically so that I4.0 can be adopted effectively and efficiently.

Training and educational programs based on I4.0 need to be periodically held so that the workforce can become accustomed to advanced technologies. As initial cost is a significant roadblock in I4.0 adoption, lean automation technologies must be designed and developed. It

has been shown that small-scale and medium-scale industries are often unaware of I4.0 core technologies and benefits, so awareness programs/conferences must be organized. Also, many entrepreneurs were found to be conscious of replacing existing set-ups with highly advanced equipment. Around 70 % of Indian micro, small and medium enterprises (MSMEs) are hesitant towards I4.0 adoption because of a lack of comprehensive knowledge and proper guidance, high initial costs, and lack of a skilled workforce (Singh, 2019).

Research and development departments must be strengthened; these provide the best alternatives for retrofitting equipment to comply with I4.0 requirements and standards. This action will require less investment by comparison. Moreover, the government must formulate conducive policies and regulatory frameworks to help industries in the best possible ways. The government needs to address legal and security concerns and improve telecommunication infrastructure facilities.

5. Conclusion and Scope for Future Work

In the present scenario, I4.0 is one of the most important topics of discussion among researchers, industrialists, managers and policymakers. This is substantiated by the numerous publications in the context of I4.0 in recent times. Available academic literature has indicated various roadblocks, maturity models and key technologies of I4.0 adoption, but understanding behavioral intentions is fairly novel and adds significant knowledge to existing literature. This research presents a BRT framework to analyze the attitude-intention relationship using values and reasons in the I4.0 environment. The results obtained add to the body of knowledge by providing findings of behavioral patterns toward I4.0 adoption. BRT is used to test various constructs such as attitude, value, intentions, reasons for, and reasons against. The research model was tested using 215 responses from Indian manufacturing industries. Additionally, the mediating roles of RF, RA and ATT were analyzed. The moderating roles of company size were also examined.

The research findings have presented a psychological way of thinking about adopting I4.0 technologies. The results have proposed several significant implications for industrial managers who wish to adopt I4.0. The *reasons for* construct includes potential advantages, which were divided into two sub-constructs i.e. production and operational, economic and sustainability. The positive aspects of I4.0 include increased market share and profitability,

reduced operation cost, fewer defects, product variation, increased operational efficiency, machine-to-machine communication, remote monitoring, real-time equipment control etc. Despite the advantages stated, industrialists and entrepreneurs are concerned about adopting I4.0 because of the substantial initial cost and anticipated risk. *Reasons against* constructs were categorized into risk, procedural, human resource, usage, and image barrier. The results reveal a firm intention of organizations to adopt I4.0 practices. As discussed, I4.0 technologies are fairly expensive, and the domain of lean automation technologies needs to be explored so that even small-scale industries can embrace I4.0 adoption. I4.0 roadblocks include a lack of standard reference adoption architecture, absence of comprehensive understanding of I4.0 protocols, lack of digital skillsets, and security and privacy issues. Thus, the government must increase the availability of knowledge centers for organizations; these can facilitate industries in understanding I4.0 core technologies, explain possible benefits, overcome associated barriers, help with erection and commissioning, mentor staff and provide a holistic approach to I4.0 adoption.

These findings will encourage researchers and other practitioners to explore the behavioral dimensions further. As our results are computed only for industries in India, the results cannot be generalized and may vary according to geographical location. Also, as cross-sectional data was collected and analyzed, it may be subject to bias due to social desirability. Our research analysis estimates results based on only a few manufacturing-type industries in India. The results can be verified across the world and in other industrial domains such as chemicals, leather, food, beverages, textiles etc.

References

Aceto, G., Persico, V., & Pescapé, A. (2020). Industry 4.0 and health: Internet of things, big data, and cloud computing for healthcare 4.0. *Journal of Industrial Information Integration*, *18*, 100129.

Agostini, L., & Nosella, A. (2019). The adoption of Industry 4.0 technologies in SMEs: results of an international study. *Management Decision*, *58*(4), 625-643.

Agrawal, R., Wankhede, V. A., Kumar, A., Upadhyay, A., & Garza-Reyes, J. A. (2021). Nexus of circular economy and sustainable business performance in the era of digitalization. *International Journal of Productivity and Performance Management*, *71*(3), 748-774.

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, 50 (2), 179–211.

Alizadeh, R., & Soltanisehat, L. (2020). Stay competitive in 2035: A scenario-based method to foresight in the design and manufacturing industry. *Foresight*, *22*(3), 309-30.

Anosike, A., Alafropatis, K., Garza-Reyes, J. A., Kumar, A., Luthra, S., & Rocha-Lona, L. (2021). Lean manufacturing and internet of things–A synergetic or antagonist relationship?. *Computers in Industry*, *129*, 103464.

Armstrong, J. S., & Overton, T. S. (1977). Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, *14*(3), 396-402.

Aschemann-Witzel, J., & Niebuhr Aagaard, E. M. (2014). Elaborating on the attitude–behavior gap regarding organic products: Young Danish consumers and in-store food choice. *International Journal of Consumer Studies*, *38*(5), 550-558.

Bag, S., Yadav, G., Wood, L. C., Dhamija, P., & Joshi, S. (2020). Industry 4.0 and the circular economy: Resource melioration in logistics. *Resources Policy*, *68*, 101776.

Bai, C., Dallasega, P., Orzes, G., & Sarkis, J. (2020). Industry 4.0 technologies assessment: A sustainability perspective. *International Journal of Production Economics*, *229*, 107776.

Bainbridge, L. (1983). Ironies of automation. In *Analysis, design and evaluation of man–machine systems* (pp. 129-135). Pergamon.

Belinski, R., Peixe, A. M., Frederico, G. F., & Garza-Reyes, J. A. (2020). Organizational learning and Industry 4.0: Findings from a systematic literature review and research agenda. *Benchmarking: An International Journal*. *27*(8), 2435-2457.

Beltrami, M., Orzes, G., Sarkis, J., & Sartor, M. (2021). Industry 4.0 and sustainability: Towards conceptualization and theory. *Journal of Cleaner Production, 312*, 127733.

Benitez, G. B., Ayala, N. F., & Frank, A. G. (2020). Industry 4.0 innovation ecosystems: An evolutionary perspective on value cocreation. *International Journal of Production Economics*, *228*, 107735.

Calabrese, A., Dora, M., Levialdi Ghiron, N., & Tiburzi, L. (2022). Industry's 4.0 transformation process: How to start, where to aim, what to be aware of. *Production Planning & Control, 33*(5), 492-512.

Chauhan, C., Singh, A., & Luthra, S. (2021). Barriers to industry 4.0 adoption and its performance implications: An empirical investigation of emerging economy. *Journal of Cleaner Production*, *285*, 124809.

Chiarini, A., & Kumar, M. (2021). Lean Six Sigma and Industry 4.0 integration for operational excellence: Evidence from Italian manufacturing companies. *Production Planning & Control*, *32*(13), 1084-1101.

Claudy, M. C., & Peterson, M. (2014). Understanding the underutilization of urban bicycle commuting: A behavioral reasoning perspective. *Journal of Public Policy & Marketing*, *33*(2), 173-187.

Claudy, M. C., Garcia, R., & O'Driscoll, A. (2015). Consumer resistance to innovation—A behavioral reasoning perspective. *Journal of the Academy of Marketing Science*, *43*(4), 528-544.

Claudy, M. C., Peterson, M., & O'driscoll, A. (2013). Understanding the attitude-behavior gap for renewable energy systems using Behavioural reasoning theory. *Journal of Macromarketing*, *33*(4), 273-287.

Craighead, C. W., Ketchen, D. J., Dunn, K. S., & Hult, G. T. M. (2011). Addressing common method variance: guidelines for survey research on information technology, operations, and supply chain management. *IEEE Transactions on Engineering Management*, *58*(3), 578-588.

Dalenogare, L. S., Benitez, G. B., Ayala, N. F., & Frank, A. G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics*, *204*, 383-394.

de Sousa Jabbour, A. B. L., Jabbour, C. J. C., Foropon, C., & Godinho Filho, M. (2018). When titans meet–Can industry 4.0 revolutionize the environmentally-sustainable manufacturing wave? The role of critical success factors. *Technological Forecasting and Social Change*, *132*, 18-25.

Dev, N. K., Shankar, R., & Qaiser, F. H. (2020). Industry 4.0 and circular economy: Operational excellence for sustainable reverse supply chain performance. *Resources, Conservation and Recycling*, *153*, 104583.

Dhir, A., Koshta, N., Goyal, R. K., Sakashita, M., & Almotairi, M. (2021). Behavioural reasoning theory (BRT) perspectives on E-waste recycling and management. *Journal of Cleaner Production*, *280*, 124269.

Ejsmont, K., Gladysz, B., Corti, D., Castaño, F., Mohammed, W. M., & Martinez Lastra, J. L. (2020). Towards 'Lean Industry 4.0′–Current trends and future perspectives. *Cogent Business & Management*, *7*(1), 1781995.

Fishbein, M., & Ajzen, I. (1977). Belief, attitude, intention, and behavior: An introduction to theory and research. *Philosophy and Rhetoric*, *10*(2), 130-132.

Frank, A. G., Dalenogare, L. S., & Ayala, N. F. (2019). Industry 4.0 technologies: Implementation patterns in manufacturing companies. *International Journal of Production Economics*, *210*, 15-26.

Ghobakhloo, M., & Iranmanesh, M. (2021). Digital transformation success under Industry 4.0: A strategic guideline for manufacturing SMEs. *Journal of Manufacturing Technology Management*, *32*(8), 1533-56.

Goenka, P. (2021**).** Auto industry has a major role to play in India's economic growth. https://indianexpress.com/article/opinion/columns/indian-it-industry-auto-sector-coronavirus-economy-7275457/, accessed on July 12, 2021.

Gupta, A., & Arora, N. (2017). Consumer adoption of m-banking: a behavioral reasoning theory perspective. *International Journal of Bank Marketing*, 35(4), 733-47.

Gupta, S., Modgil, S., Gunasekaran, A., & Bag, S. (2020, July). Dynamic capabilities and institutional theories for Industry 4.0 and digital supply chain. In *Supply Chain Forum: An International Journal*, 21(3), 139-57.

Hamada, T. (2019). Determinants of decision-makers' attitudes toward Industry 4.0 adaptation. *Social Sciences*, *8*(5), doi:10.3390/socsci8050140.

Helper, S., Martins, R., & Seamans, R. (2019). Who profits from industry 4.0? theory and evidence from the automotive industry. *Theory and Evidence from the Automotive Industry* (January 31, 2019). NYU Stern School of Business.

Horváth, D. & Szabó, R. Z. (2019). Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities?. *Technological Forecasting and Social Change*, *146*, 119-132.

Hughes, L., Dwivedi, Y. K., Rana, N. P., Williams, M. D., & Raghavan, V. (2022). Perspectives on the future of manufacturing within the Industry 4.0 era. *Production Planning & Control*, *33*(2-3), 138-158.

Ivanov, D., & Dolgui, A. (2021). A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. *Production Planning & Control*, *32*(9), 775-788.

Jaeger, B., & Upadhyay, A. (2020). Understanding barriers to circular economy: Cases from the manufacturing industry. *Journal of Enterprise Information Management*, *33*(4), 729-45.

Jimeno-Morenilla, A., Azariadis, P., Molina-Carmona, R., Kyratzi, S., & Moulianitis, V. (2021). Technology enablers for the implementation of Industry 4.0 to traditional manufacturing sectors: A review. *Computers in Industry*, *125*, 103390.

Kaasinen, E., Schmalfuß, F., Özturk, C., Aromaa, S., Boubekeur, M., Heilala, J., ... & Walter, T. (2020). Empowering and engaging industrial workers with Operator 4.0 solutions. *Computers & Industrial Engineering*, *139*, 105678.

Kadir, B. A., & Broberg, O. (2020). Human well-being and system performance in the transition to industry 4.0. *International Journal of Industrial Ergonomics*, *76*, 102936.

Kadir, B. A., Broberg, O., & da Conceicao, C. S. (2019). Current research and future perspectives on human factors and ergonomics in Industry 4.0. *Computers & Industrial Engineering*, *137*, 106004.

Kamble, S. S., Gunasekaran, A., & Sharma, R. (2018). Analysis of the driving and dependence power of barriers to adopt industry 4.0 in Indian manufacturing industry. *Computers in Industry*, *101*, 107-119.

Kamble, S. S., Gunasekaran, A., Parekh, H., & Joshi, S. (2019). Modeling the internet of things adoption barriers in food retail supply chains. *Journal of Retailing and Consumer Services*, *48*, 154-168.

Kinoshita, M. (2019). JAPAN ON THE NEW INDUSTRIAL REVOLUTION (NIR): Direction and its global implication, 1-16.

Kruger, S., & Steyn, A. A. (2021). A conceptual model of entrepreneurial competencies needed to utilize technologies of Industry 4.0. *The International Journal of Entrepreneurship and Innovation*, *22*(1), 56-67.

Lee, J., Bagheri, B., & Kao, H. A. (2015). A cyber-physical systems architecture for industry 4.0-based manufacturing systems. *Manufacturing Letters*, *3*, 18-23.

Longo, F., Nicoletti, L., & Padovano, A. (2017). Smart operators in industry 4.0: A human-centered approach to enhance operators' capabilities and competencies within the new smart factory context. *Computers & Industrial Engineering*, *113*, 144-159.

Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration*, *6*, 1-10.

Luthra, S., Kumar, A., Zavadskas, E. K., Mangla, S. K., & Garza-Reyes, J. A. (2020). Industry 4.0 as an enabler of sustainability diffusion in supply chain: an analysis of influential strength of drivers in an emerging economy. *International Journal of Production Research*, *58*(5), 1505-1521.

Majumdar, A., Garg, H., & Jain, R. (2021). Managing the barriers of Industry 4.0 adoption and implementation in textile and clothing industry: Interpretive structural model and triple helix framework. *Computers in Industry*, *125*, 103372.

Malik, N., Tripathi, S. N., Kar, A. K., & Gupta, S. (2022). Impact of artificial intelligence on employees working in industry 4.0 led organizations. *International Journal of Manpower*, *43*(2), 334-354.

Manesh, M. F., Pellegrini, M. M., Marzi, G., & Dabic, M. (2020). Knowledge management in the fourth industrial revolution: Mapping the literature and scoping future avenues. *IEEE Transactions on Engineering Management*, *68*(1), 289-300.

Masood, T., & Sonntag, P. (2020). Industry 4.0: Adoption challenges and benefits for SMEs. *Computers in Industry*, *121*, 103261.

Masood, T., & Sonntag, P. (2020). Industry 4.0: Adoption challenges and benefits for SMEs. *Computers in Industry*, *121*, 103261.

Massaro, M., Secinaro, S., Dal Mas, F., Brescia, V., & Calandra, D. (2021). Industry 4.0 and circular economy: An exploratory analysis of academic and practitioners' perspectives. *Business Strategy and the Environment*, *30*(2), 1213-1231.

Matana, G., Simon, A., Godinho Filho, M., & Helleno, A. (2020). Method to assess the adherence of internal logistics equipment to the concept of CPS for industry 4.0. *International Journal of Production Economics*, *228*, 107845.

Matt, D. T., & Rauch, E. (2020). SME 4.0: the role of small-and medium-sized enterprises in the digital transformation. In *Industry 4.0 for SMEs* (pp. 3-36). Palgrave Macmillan, Cham.

Merkel, A. (2017). Germany Industrie 4.0", Digital Transformation Monitor, 1-8.

Mitra, A. (2021). On the capabilities of Cellular Automata-based MapReduce model in Industry 4.0. *Journal of Industrial Information Integration*, *21*, 100195.

Monteleone, S., De Moraes, E. A., & Maia, R. F. (2019, June). Analysis of the variables that affect the intention to adopt Precision Agriculture for smart water management in Agriculture 4.0 context. In 2019 Global IoT Summit (GIoTS) (pp. 1-6). IEEE.

Mukhuty, S., Upadhyay, A., & Rothwell, H. (2022). Strategic sustainable development of Industry 4.0 through the lens of social responsibility: The role of human resource practices. *Business Strategy and the Environment*, *31*(5), 2068-81.

Müller, J. M., Buliga, O., & Voigt, K. I. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change*, *132*, 2-17.

Nascimento, D. L. M., Alencastro, V., Quelhas, O. L. G., Caiado, R. G. G., Garza-Reyes, J. A., Rocha-Lona, L., & Tortorella, G. (2019). Exploring Industry 4.0 technologies to enable

circular economy practices in a manufacturing context: A business model proposal. *Journal of Manufacturing Technology Management, 30*(3), 607-627.

Norman, P., Conner, M. T., & Stride, C. B. (2012). Reasons for binge drinking among undergraduate students: An application of behavioral reasoning theory. *British Journal of Health Psychology*, *17*(4), 682-698.

Oltra-Mestre, M. J., Hargaden, V., Coughlan, P., & Segura-García del Río, B. (2021). Innovation in the Agri-Food sector: Exploiting opportunities for Industry 4.0. *Creativity and Innovation Management*, *30*(1), 198-210.

Ooi, K. B., Lee, V. H., Tan, G. W. H., Hew, T. S., & Hew, J. J. (2018). Cloud computing in manufacturing: The next industrial revolution in Malaysia?. *Expert Systems with Applications*, *93*, 376-394.

Ortt, R., Stolwijk, C., & Punter, M. (2020). Implementing Industry 4.0: Assessing the current state. *Journal of Manufacturing Technology Management*, *31*(5), 825-836.

Ozkan-Ozen, Y. D., & Kazancoglu, Y. (2021). Analyzing workforce development challenges in the industry 4.0. *International Journal of Manpower*, *43*(2), 310-333.

Pacchini, A. P. T., Lucato, W. C., Facchini, F., & Mummolo, G. (2019). The degree of readiness for the implementation of Industry 4.0. *Computers in Industry*, *113*, 103125.

Park, M., Cho, H., Johnson, K. K., & Yurchisin, J. (2017). Use of behavioral reasoning theory to examine the role of social responsibility in attitudes toward apparel donation. *International Journal of Consumer Studies*, *41*(3), 333-339.

Pennington, N., and Hastie, R. (1993). Reasoning in explanation-based decision making. *Cognition*, *49* (1–2), 123-163.

Pessot, E., Zangiacomi, A., Battistella, C., Rocchi, V., Sala, A., & Sacco, M. (2020). What matters in implementing the factory of the future: Insights from a survey in European manufacturing regions. *Journal of Manufacturing Technology Management*, *32*(3), 795-819.

Pollak, A., Hilarowicz, A., Walczak, M., & Gąsiorek, D. (2020). A Framework of Action for Implementation of Industry 4.0. an Empirically Based Research. *Sustainability*, *12*(14), 5789.

Pratkanis, A. R., Breckler, S. J., & Greenwald, A. G. (Eds.). (2014). *Attitude structure and function*. Psychology Press.

Prause, M. (2019). Challenges of industry 4.0 technology adoption for SMEs: The case of Japan. *Sustainability*, *11*(20), 5807.

Raj, A., Dwivedi, G., Sharma, A., de Sousa Jabbour, A. B. L., & Rajak, S. (2020). Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective. *International Journal of Production Economics*, *224*, 107546.

Raji, I. O., Shevtshenko, E., Rossi, T., & Strozzi, F. (2021). Industry 4.0 technologies as enablers of lean and agile supply chain strategies: An exploratory investigation. *The International Journal of Logistics Management*, *32*(4), 1150-1189.

Reinhardt, I. C., Oliveira, J. C., & Ring, D. T. (2020). Current perspectives on the development of Industry 4.0 in the pharmaceutical sector. *Journal of Industrial Information Integration*, *18*, 100131.

Ricci, R., Battaglia, D., & Neirotti, P. (2021). External knowledge search, opportunity recognition and Industry 4.0 Adoption in SMEs. *International Journal of Production Economics,* 108234.

Romero, D., Bernus, P., Noran, O., Stahre, J., & Fast-Berglund, Å. (2016, September). The operator 4.0: Human cyber-physical systems & adaptive automation towards human-automation symbiosis work systems. In *IFIP international conference on advances in production management systems* (pp. 677-686). Springer, Cham.

Ruppert, T., Jaskó, S., Holczinger, T., & Abonyi, J. (2018). Enabling technologies for operator 4.0: A survey. *Applied Sciences*, *8*(9), 1-19.

Russo, M., Buonocore, F., & Ferrara, M. (2015). Motivational mechanisms influencing error reporting among nurses. *Journal of Managerial Psychology*, *30*(2), 118-132.

Ryan, J., & Casidy, R. (2018). The role of brand reputation in organic food consumption: A behavioral reasoning perspective. *Journal of Retailing and Consumer Services*, *41*, 239-247.

Sahu, A. K., Padhy, R. K., & Dhir, A. (2020a). Determinants and barriers of implementing lean manufacturing practices in MSMEs: a behavioral reasoning theory perspective. *Production Planning & Control*, 1-16.

Sahu, A. K., Padhy, R. K., & Dhir, A. (2020b). Envisioning the future of behavioral decision-making: A systematic literature review of behavioral reasoning theory. *Australasian Marketing Journal (AMJ)*, *28*(4), 145-159.

Schroeder, A., Ziaee Bigdeli, A., Galera Zarco, C., & Baines, T. (2019). Capturing the benefits of industry 4.0: a business network perspective. *Production Planning & Control*, *30*(16), 1305-1321.

Schwartz, S. H. (2010). Basic values: How they motivate and inhibit prosocial behavior. *American Psychological Association,* https://doi.org/10.1037/12061-012

Sharma, M., Kumar, A., Luthra, S., Joshi, S., & Upadhyay, A. (2022). The impact of environmental dynamism on low-carbon practices and digital supply chain networks to enhance sustainable performance: An empirical analysis. *Business Strategy and the Environment,31*(4), 1776-88.

Sharma, R., Dhir, A., Talwar, S., & Kaur, P. (2021). Over-ordering and food waste: The use of food delivery apps during a pandemic. *International Journal of Hospitality Management*, *96*, 102977.

Singh, M.M. (2017). India's readiness for Industry 4.0: A focus on automotive sector. *Confederation of Indian Industry*, 1-46.

Singh, P.P. (2019). Indian MSMEs struggle for technology adoption continues, poor digital understanding economic growth. https://www.financialexpress.com/industry/sme/msme-tech-small-business-technology-msme-cloud-adoption-digital-technology-india-sme-forum-intel-india/1770091/. Accessed on July 20, 2021.

Sivathanu, B. (2018). Adoption of Internet of Things (IOT) Based Wearables for Healthcare of Older Adults – a Behavioural Reasoning Theory (BRT) Approach. *Journal of Enabling Technologies*, *12*(4), 169–85.

Sony, M. (2020). Pros and cons of implementing Industry 4.0 for the organizations: a review and synthesis of evidence. *Production & Manufacturing Research*, *8*(1), 244-272.

Souchet, S. (2017). Unlocking the value of I4.0", KPMG Insights. https://home.kpmg/xx/en/home/insights/2017/11/unlocking-the-value-of-i-4-0.html, accessed on July 12, 2021.

Srivastava, D. K., Kumar, V., Ekren, B. Y., Upadhyay, A., Tyagi, M., & Kumari, A. (2022). Adopting Industry 4.0 by leveraging organizational factors. *Technological Forecasting and Social Change*, *176*, 121439.

Srivastava, D. K., Kumar, V., Ekren, B. Y., Upadhyay, A., Tyagi, M., & Kumari, A. (2022). Adopting Industry 4.0 by leveraging organisational factors. *Technological Forecasting and Social Change*, *176*, 121439.

Tandon, A., Dhir, A., Kaur, P., Kushwah, S., & Salo, J. (2020). Behavioural reasoning perspectives on organic food purchase. *Appetite*, *154*, 104786.

Topleva, S. (2018). Industry 4.0: Transforming economy through value added. *Asian Journal of Economic Modelling*, *6*(1), 37-46.

Tortorella, G. L., & Fettermann, D. (2018). Implementation of Industry 4.0 and lean production in Brazilian manufacturing companies. *International Journal of Production Research*, *56*(8), 2975-2987.

Tyas, E. H., & Naibaho, L. (2019, November). The urgency of entrepreneurship learning in the industrial age of 4.0. In *Journal of Physics: Conference Series*,*1387*(1), 012032.

Upadhyay, A., Ayodele, J. O., Kumar, A., & Garza-Reyes, J. A. (2021). A review of challenges and opportunities of blockchain adoption for operational excellence in the UK automotive industry. *Journal of Global Operations and Strategic Sourcing*, *14*(1), 701-760.

Veile, J. W., Kiel, D., Müller, J. M., & Voigt, K. I. (2019). Lessons learned from Industry 4.0 implementation in the German manufacturing industry. *Journal of Manufacturing Technology Management*, *31*(5), 977-997.

Virmani, N., & Salve, U. R. (2021). Significance of Human Factors and Ergonomics (HFE): Mediating its role between Industry 4.0 implementation and operational excellence. *IEEE Transactions on Engineering Management,* 10.1109/TEM.2021.3091398.

Virmani, N., Salve, U. R., Kumar, A., & Luthra, S. (2021). Analyzing roadblocks of Industry 4.0 adoption using graph theory and matrix approach. *IEEE Transactions on Engineering Management*, 10.1109/TEM.2020.3048554.

Vrchota, J., Volek, T., & Novotná, M. (2019). Factors introducing industry 4.0 to SMES. *Social Sciences*, *8*(5), 130.

Welch, R. V., & Dixon, J. R. (1994). Guiding conceptual design through behavioral reasoning. *Research in Engineering Design*, *6*(3), 169-188.

Westaby, J. D. (2005). Behavioural reasoning theory: Identifying new linkages underlying intentions and behavior. *Organizational Behavior and Human Decision Processes*, *98*(2), 97-120.

Westaby, J. D., Probst, T. M., & Lee, B. C. (2010). Leadership decision-making: A behavioral reasoning theory analysis. *The Leadership Quarterly*, *21*(3), 481-495.

Yang, F., & Gu, S. (2021). Industry 4.0, a revolution that requires technology and national strategies. *Complex & Intelligent Systems*, *7*(3), 1311-1325.

Yin, Y., Stecke, K. E., & Li, D. (2018). The evolution of production systems from Industry 2.0 through Industry 4.0. *International Journal of Production Research*, *56*(1-2), 848-861.

Yu, F., & Schweisfurth, T. (2020). Industry 4.0 technology implementation in SMEs–A survey in the Danish-German border region. *International Journal of Innovation Studies*, *4*(3), 76-84.

Zarzuelo, P. I., Soeane, M. J. F., & Bermúdez, B. L. (2020). Industry 4.0 in the port and maritime industry: A literature review. *Journal of Industrial Information Integration*, *20*, 100173.