Motivations, Barriers & Readiness Factors for Quality 4.0 Implementation: An Exploratory Study

Purpose: Quality 4.0 is the new buzzword among quality professionals. There has been no empirical study of Quality 4.0 yet and hence the purpose of this paper is to investigate what are the motivations, barriers & readiness factors for Quality 4.0 Implementation.

Design/ Methodology/Approach: This study uses an online survey on senior quality professionals working in leading companies in Europe and America. 50 participants participated in this study.

Findings: This study finds the top five motivating, barriers and readiness factors for quality 4.0 implementation. These factors are ranked in terms of the order of importance as perceived by senior quality professionals

Research Implication: This is the first empirical study on Quality 4.0 which investigates the motivation, barriers and readiness factors of Quality 4.0. This study provides a theoretical base of Quality 4.0 body of knowledge in terms of its practical relevance & adoption in modern-day organizations.

Practical Implications: Organizations can use this study to understand what the motivation & barriers for implementing Quality 4.0. In addition, before implementation of Quality 4.0, the readiness factor for Quality 4.0 can be used by organizations to evaluate their preparedness before the actual implementation of the initiative.

Originality of Value: This is the first empirical study on Quality 4.0 which captures the viewpoints of senior quality professionals on the motivation, barriers and readiness factors of Quality 4.0.

Keywords: Quality 4.0, Industry 4.0, Quality Management, Quality Expert, CPS, IoT

1. Introduction

Modern organizations have undergone a sea change in engineering, manufacturing practices, processes, and technologies with the advent of Industry 4.0 (Sony, 2020a, 2020b; Sony and Naik, 2020). This phenomenon of fourth Industrial Revolution or Industry 4.0 is based on advanced manufacturing and engineering technologies, massive digitization, big data analytics, advanced robotics, adaptive automation, additive and precision manufacturing (e.g., 3D printing), modelling and simulation, artificial intelligence, and nano-engineering of materials

(Zonnenshain and Kenett, 2020). However, many companies are struggling with quality management as is evident from the numerous product recalls from the automobile industry and other industries. A challenge to consider is how far the traditional quality management practices and methods have absorbed changes in product development stages, cycle time compression and employee effort to match demand and customer expectations (Gunasekaran et al., 2019). Digitalisation creates new opportunities for organizations to incorporate technological advances to arrive at new optimums in operational excellence, performance and innovation (Sony et al., 2020). Quality 4.0 is closely aligning quality management with Industry 4.0 which will help organizations in enterprise efficiency, performance, and improved business models(Antony, Sony and Cudney, 2020). Technologies such as CPS, IoT and cloud computing are being used to meet requirements of quality of design, quality of conformance and quality of performance (Sony et al., 2020). The Quality 4.0 term was coined by Dan Jacob and it is about using technology to show that quality should be a company-wide strategy with the executives at the helm driving performance (Johnson, 2019). Quality 4.0 is a framework for implementing and achieving Quality in organizations and companies through advances in automation and ICT technologies. There are only a few companies which have partially implemented Quality 4.0 in parts, such as Iscar, Hamlet, RAFAEL and Kornit, however, there is a lack of evidence of successful implementation of Quality 4.0 (Zonnenshain and Kenett, 2020). Even though Quality 4.0 is about using technology in quality management activities of an organization (Johnson, 2019), the human element is also equally important to drive the performance of Quality 4.0 throughout the organization. It is, therefore, a joint optimisation of human and technical systems striving to meet the goals of Quality 4.0 implementation in an organization. But there is also no universally accepted framework for implementation of Quality 4.0 (Zonnenshain & Kenett, 2020). In the absence of framework, it would be pertinent to first understand the motivation and barriers for implementing Quality 4.0 empirically. In addition, there is yet to be an empirical study which captures senior quality professional's perception on what are the motivation & barriers for implementing Quality 4.0. Such a study is crucial because it will seek to fill the knowledge base on Quality 4.0 implementation. Therefore, the authors ask the following research question:

1. What are the top five motivations for implementing Quality 4.0?
2. What are the top five barriers for implementing Quality 4.0?

In addition, in the absence of studies on the successful implementation of Quality 4.0, measurement of the level of an organization's readiness and assessment of the prerequisites for

effectively implementing Quality 4.0 is important. Empirical studies in assessment of readiness factors of Quality 4.0 are needed, so that organizations can assess whether they are ready to implement Quality 4.0. Ranking of these readiness factors will help the organizations to further concentrate on those factors which will yield the most results. As there is no study conducted in this area, and the authors will assess

3. What are the factors for assessing organizational readiness for Quality 4.0 and how important are those?

To address the above research question, the present paper is structured as follows, Section 2 offers a review of the current literature on Quality 4.0 and readiness factors. Section 3 describes the research methods, including the instrument's development and its validation. The results and discussions are explicated in Section 4 and Section 5 is devoted to conclusions, limitations and future research opportunities.

2. Literature Review

The concept of quality during Industry 4.0 is undergoing a sea change and will include personalised service quality, mass customization and personalised production. Instead of product quality, more emphasis would be given to design, safety and service quality (Hyun Park et al., 2017). This has become a reality due to the advances in ICT technology. Quality 4.0 is thus a shift from product to services and on value creation to the markets and on the quality of business models, and more (Zonnenshain and Kenett, 2020). Quality, therefore, has become more data-driven with the availability of sensors and big data analytics. Even though philosophically QM was traditionally data-driven, quality engineers however in traditional quality management often make their decisions using only intuition and/or qualitative assessments (Zonnenshain and Kenett, 2020). However, with the availability of big data, quality management domain is expanded to be a data-driven method. In a recent study, it was found that big data analysis techniques is applicable to each phase of LSS in all the dimensions such as volume, variety, velocity, and veracity of big data (Gupta et al., 2020).Thus the implementation of Quality 4.0 will result in improved data-driven decision making in all the phases of Quality Management. Quality 4.0 being a relatively new concept, organizations find it difficult to assess whether they are ready for implementation of Quality 4.0 (Sony et al., 2020). The readiness factor will be a multi-dimensional phenomenon and literature is reviewed to unearth the dimensions of readiness factors.

2.1 Top Management Support

Top management support for quality management program is one of the key components for assessing organizational readiness (Flynn et al., 1995). It is referred to as the degree to which the top management understands the importance of Quality 4.0 and the extent to which they are willing to support its implementation within the organization. The implementation of Quality 4.0 may result in major changes to organizational structure and business processes and thus, top management support will beneficial. In addition, top management support for Quality 4.0 will help in implementing change management initiatives within the organization (Antony, Sony and Cudney, 2020). It will also inculcate a sense of adoption among employees within the organization (Sony et al., 2020). Thus, top management support will be one of the dimensions for the readiness of organization for implementation of Quality 4.0.

2.2 Quality 4.0 Vision and Strategy

Digital data is used by organizations to create a competitive advantage by creating products and services at a competitive price (Porter and Heppelmann, 2014). Digital data is used in Quality 4.0 to manage the quality of the products and services (Hyun Park et al., 2017). Therefore, Quality 4.0 should be aligned to the vision and strategy of the organization, so that it becomes clear in terms of what organizations should do now in terms of Quality 4.0 so that organizations can realise its vision in the future (Zonnenshain and Kenett, 2020). In a strategic sense, what should be the sum of Quality 4.0 actions an organization should undertake to reach its long term goals(Sony et al., 2020). Thus, to assess the organizational readiness for Quality 4.0, the degree of alignment of Quality 4.0 with the vision and strategy of the organization should be undertaken(Antony, Sony and Cudney, 2020). In addition, how vision and strategy are disseminated within employees will help the organization to adapt to Quality 4.0 initiatives.

2.3 Leadership

Quality 4.0 requires a process of innovation and learning because the core concept of Quality 4.0 is about aligning the practice of quality management with the emerging capabilities of Industry 4.0 (Sony et al., 2020) which will help the organizations drive towards operational excellence. Thus, Quality 4.0 requires a leadership style that considers innovation and learning. Leadership is the skill to inspire, motivate and channelize activities to achieve organizational goals (Waddell et al., 2007). Leadership would be one of the Quality 4.0 readiness factors which will be a critical success factor(Antony, Sony and Cudney, 2020).

2.4 Training & Reward

Unlike traditional quality management, Quality 4.0 uses many technologies for its effective implementation (Schönreiter, 2016). To cite some instances smart glasses will be used in non-conformity management, quality control and change management. Smart gloves will be used in quality control, dispatching and manipulation. RFID (radio frequency identification) technology barcodes, QR codes, drones, autonomous vehicles, 3D printing, simulation by virtual reality and collaborative robots, amongst other things, will be used in manufacturing and quality control (Závadská and Závadský, 2018). Therefore, existing quality employees must be trained for them to be effective in their new roles using advanced technologies. In addition, a reward system enforces the adoption of new quality management practices (Allen and Kilmann, 2001). Therefore, training and reward would be one of the dimensions of Quality 4.0 readiness.

2.5 Knowledge & Awareness of Quality 4.0

The modern factory is thus becoming more complex and intelligent due to big data analytics, machine learning and cloud computing with the advent of Industry 4.0 (Saldivar et al., 2015). Besides, technology enablers such as IoT, CPS, and Industrial internet makes the modern-day workplace a complex phenomenon (Cheng et al., 2016; Wang et al., 2016). In this highly automated and integrated computing environment, the role of quality professionals will be challenging. It is because all the jobs containing repetitive and simple activities of quality management will be done by the intelligent and self- regulating CPS. Those higher-order quality professional jobs which are left for humans will require higher process integration, cross-functional perspectives, reduction in hierarchical levels, less demand for central management capacities. In a nutshell, it can be summarized as existing jobs will become complex requiring a large repertoire of skill sets (Bonekamp and Sure, 2015; Frey and Osborne, 2017). Therefore, quality professionals' jobs will consist of complex problem solving, emotional competence, core knowledge(Antony, Sony, Sunder M, et al., 2020) and application of Quality 4.0 tools and so on. Therefore, the knowledge and awareness of quality professionals about Quality 4.0 will be one of the dimensions of Quality 4.0 readiness.

2.6 Organizational Culture towards Quality 4.0

Organizational culture is defined as a set of norms, beliefs and values shared by members of the organization (Gimenez-Espin et al., 2013). Organizational culture drives employees by influencing their behaviours, performance outcomes and organization's external environment for attaining organizational goals (De Long and Fahey, 2000). Quality 4.0 promotes data

interchange, analytics and quality management which will create a culture of transparency, connectivity, collaboration and insights using machine learning algorithms, therefore there is a need for an open, receptive culture to embrace change (Sony et al., 2020). There is also a need for data-driven culture and new Quality 4.0 technologies should be a growth opportunity for employees. There is a need to promote an organizational culture which embraces organizational change in a strategic manner by human resources change intervention management strategies. Hence a change centric organizational culture will be one of the dimensions of readiness factor for implementing Quality 4.0.

2.7 Customer Centredness

Customer-centric organization have been discussed for the last fifty years however, many firms are struggling to fully align themselves with customer-centric paradigms (Shah et al., 2006).The success of quality management practice depends on how the organization produces product and services to meet customer needs. An organization which is customer centric will align its quality programs to meet the customer needs to satisfy the customers (Herrmann et al., 2000; Kuei and Madu, 2003). A customer-centric organization analyse the customer needs and produce products and services to meet its needs. It does it by collecting the customer feedbacks and improving the existing products and services or designing new products and services (Wechsler and Schweitzer, 2019; Osakwe, 2020). In modern organizations, customers drive customer satisfaction not only through excellent products, but also through customer-centric processes (Kreuzer et al., 2020). Therefore, a customer-centric organization will be one of the readiness factors for implementing Quality 4.0.

2.8 Supplier Centredness

Supplier management is one of the key components of quality management (Theodorakioglou et al., 2006). A Supplier management system in an organization allows it to monitor, inspect, audit, and analyse suppliers at regular intervals so that good quality materials can be attained for the organizations (Park et al., 2001). The suppliers are also sometimes part of the design process so that they are aware and can supply the raw materials at the desired quality levels (Petersen et al., 2005). An appropriate supplier relationship management can lead to better quality products at economical rates (Cannon and Homburg, 2001; Rajagopal and Rajagopal, 2009). Thus, an effective supplier management system will be one of the dimensions for assessing readiness for Quality 4.0.

The table 1 depicts the possible readiness factors for Quality 4.0 implementation.

Table 1: Quality 4.0 readiness factors		
Sr No	**Readiness Factor for Quality 4.0**	**Sources**
1	Top Management Support	(Flynn et al., 1995; Antony, Sony and Cudney, 2020; Sony et al., 2020)
2	Quality 4.0 Vision and Strategy	(Porter and Heppelmann, 2014; Hyun Park et al., 2017; Antony, Sony and Cudney, 2020; Sony et al., 2020; Zonnenshain and Kenett, 2020)
3	Leadership	(Porter and Heppelmann, 2014; Hyun Park et al., 2017; Antony, Sony and Cudney, 2020; Sony et al., 2020; Zonnenshain and Kenett, 2020)
4	Training & Reward	(Allen and Kilmann, 2001; Schönreiter, 2016; Závadská and Závadský, 2018; Antony, Sony and Cudney, 2020; Sony et al., 2020)
5	Knowledge & Awareness of Quality 4.0	(Bonekamp and Sure, 2015; Saldivar et al., 2015; Cheng et al., 2016; Wang et al., 2016; Frey and Osborne, 2017; Antony, Sony and Cudney, 2020; Antony, Sony, Sunder M, et al., 2020)
6	Organizational Culture towards Quality 4.0	(De Long and Fahey, 2000; Gimenez-Espin et al., 2013; Antony, Sony and Cudney, 2020; Sony et al., 2020)
7	Customer Centredness	(Herrmann et al., 2000; Kuei and Madu, 2003; Shah et al., 2006; Wechsler and Schweitzer, 2019; Kreuzer et al., 2020; Osakwe, 2020)
8	Supplier Centredness	(Cannon and Homburg, 2001; Park et al., 2001; Petersen et al., 2005; Theodorakioglou et al., 2006; Rajagopal and Rajagopal, 2009; Antony, Sony and Cudney, 2020)

3. Research Methodology

The authors utilised an online survey for data collection targeted at senior quality professionals working in large manufacturing and service sectors. Online survey was designed to obtain a large amount of information on Quality 4.0 from the respondents in the shortest possible time.. The survey instrument developed for this study was divided into two sections. The first one was to ascertain general information about the respondents such as understanding their qualifications, training and experiences etc, the second section was devoted to open-ended questions about the motivations and barriers. Open ended questions were used so as to elicit wide variety of responses from the respondents(Reja et al., 2003). The second section was devoted to readiness factors of Industry 4.0. The readiness factors which were tabulated in table one was given to respondents. The 5 point Likert scale was used. "Strongly Disagree" to " Strongly Agree" so as to capture the responses on respondent on the readiness factor. Moreover, as senior quality professionals are busy and an unnecessary long questionnaire may not be attractive to them, the short nature of the questionnaire scaffolds respondents in answering the survey in a short period of time. A pilot study was conducted during the scale development process. The online survey protocol was first piloted (Boynton and Greenhalgh, 2004). with 10 experts. Five were academics who have extensively published at least five quality management articles. Other five were senior quality management practitioners with a minimum ten years of experience in the field and who have implemented Quality 4.0.   The purpose of piloting the survey questionnaire was to validate the instrument and ensure that the questions aligned with the research questions set by the researchers (Couper and Miller, 2008). The comments and feedback from the pilot study were used to revise the survey questions in terms of readability and relevance to the research. Most of the comments were positive and hence the survey questionnaire was deemed suitable for research. The revised online survey link was sent out to 200 experts who are working in their respective organisations in roles such as senior quality professionals at Director and Vice President levels. The contacts were obtained through LinkedIn and each of the respondents was contacted through email. This research methodology was adopted in previous studies (Antony et al., 2019; Antony, Sony and Gutierrez, 2020). The authors used two criteria in the selection of such subject matter expert; i) all respondents should have a minimum of five years' experience in their role as quality professionals, ii) should be working in an organisation as a Quality Director or similar senior position. Setting such criteria will enable the authors to glean knowledge from a high calibre

of experts within the survey participants, who are responsible quality professionals in their respective organisations.

A total of 50 responses were collated over 12 weeks yielding a response rate of 25%. Easterby-Smith et al., (2012) argue that a 20% survey response rate is widely considered to be sufficient. The sample characteristics are given in Table 2.

Table 2: Sample Characteristics

Row Labels	Manufacturing		Manufacturing Total	Service		Service Total	Grand Total
	Quality Director	Quality Manager		Quality Director	Quality Manager		
Female	**6**	**2**	**8**	**2**	**1**	**3**	**11**
26 to 35 years		2	2				2
Brazil		1	1				1
UK		1	1				1
36 to 45 years	2		2		1	1	3
Germany	1		1				1
UK					1	1	1
US	1		1				1
46 to 55 years				2		2	2
US				2		2	2
56 to 65 years	4		4				4
Finland	2		2				2
UK	1		1				1
US	1		1				1
Male	**25**	**6**	**31**	**5**	**3**	**8**	**39**
26 to 35 years	4		4	1		1	5
Brazil	2		2				2
Italy				1		1	1
Romania	2		2				2
36 to 45 years	8	3	11		1	1	12
Brazil					1	1	1
Costa Rica	1		1				1
Germany	2		2				2
Portugal	1		1				1
Romania	3		3				3
Switzerland	1		1				1
UK		2	2				2
US		1	1				1
46 to 55 years	11	2	13	3		3	16
Brazil	1		1	2		2	3
Germany	1		1				1
Italy	1	1	2				2
Netherlands	1		1	1		1	2
Sweden	2		2				2
UK	4		4				4
US	1	1	2				2
56 to 65 years	2	1	3	1	2	3	6
France	1		1				1
Germany		1	1				1
Italy					1	1	1
UK	1		1		1	1	2
US				1		1	1
Grand Total	**31**	**8**	**39**	**7**	**4**	**11**	**50**

All the questionnaires were sent out to survey participants on the same day. The authors have also utilised peer-reviewed articles for designing the questionnaire and sent automatic reminders to some respondents for reducing non-response bias. Moreover, the authors have reassured all the participants well in advance that the data collected will be kept completely confidential. Reliability analysis (alpha) was conducted for the questionnaire was conducted for the readiness factors. The Cronbach Alpha was calculated, and it was found to greater than 0.7 for all the quality 4.0 readiness factors. The rule of thumb for reliability analysis, according to Nunnally (1994) is that a reliability level of 0.70 will suffice in exploratory settings. The Cronbach alpha values above 0.7 indicate that internal consistency of scale(Hair et al., 2014).

Furthermore, none of the item to total correlation of the scale fell below 0.3, indicating positive consistency of the scale. Besides, it also depicts the importance of each factor of the scale.

4.0 Results & Discussion

To find out what are the motivations, barriers, for implementing Quality 4.0, the respondents were asked open-ended questions on the same theme. Open-ended questions elicits a wide variety of responses and such questions allow the respondent to express an opinion without being influenced by the researcher (Reja et al., 2003). The open-ended questions were analysed using MS Excel. This software was used because it is a well-known and easily available software, besides, spread sheet software provide powerful tools which will enable to systematise, analyse, visualise, share and manage information to make more informed decision or conclusions (Niglas, 2007) which are essential to analyse open ended questions. In phase 1 of the analyses the individual responses were coded as it is. This were the first order coding. Subsequently, it was attached a theme name for the second order coding(Corbin and Strauss, 2008). All the related themes were clubbed easily using the sort feature of MS Excel. The authors independently analysed the first order codes and Interrater reliability was calculated in simple percentages. It was found to be 90 %. Wherever, there were differences it was settled through discussion. The themes were frequency analysed using various excel functions. The answers were coded into second order themes was counted and frequency analysis was conducted. The data is depicted in figure 1.
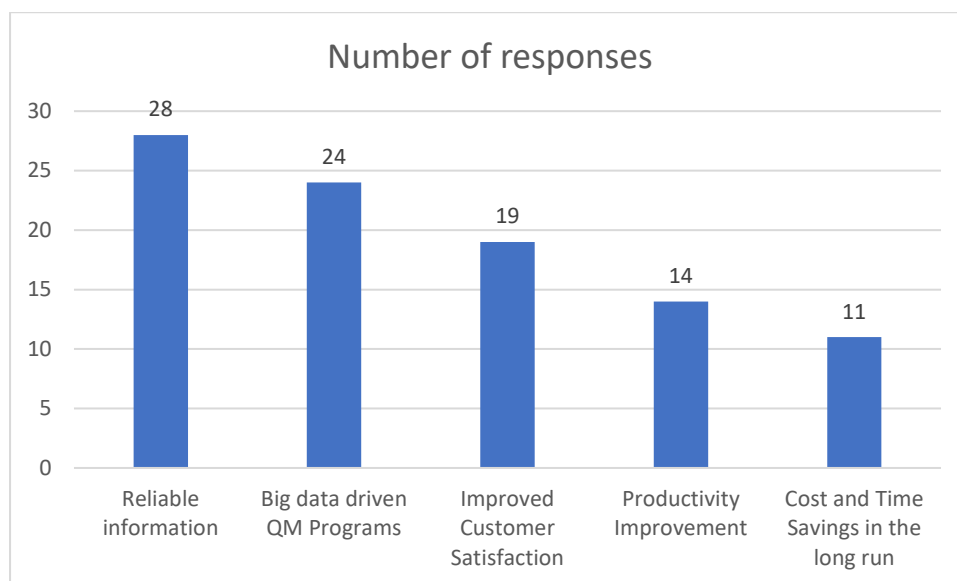

Figure 1: Top five motivation factors for adoption of Quality 4.0

Reliable and accurate data is the backbone of all quality management programs (Saraph et al., 1989) and therefore in this study, the respondents have voted reliable data from sensors which will be converted to reliable and accurate data for quality management as the primary reason for the adoption of Quality 4.0. Big data driven integration in quality management will lead to multi-way flow of information from various departments, supply chains and from the customers (Hyun Park et al., 2017). Big data, therefore, is a huge untapped wealth of data which can be used in Quality 4.0 (Gupta et al., 2020) for the strategic positioning of the organization. Hence, this study finds that big data driven quality management initiatives are the second motivating reason for the adoption of Quality 4.0. Customer satisfaction is improved when the products and services conform to the needs of the customers (Jahanshahi et al., 2011). Quality 4.0 utilises big data to analyse the customer needs to produce quality products and services (Sony et al., 2020). Hence, this study finds improved customer satisfaction as the third motivating reason for the implementation of Quality 4.0. Industry 4.0 is a joint optimisation of technical and social (human) systems using advances in ICTs and therefore, it will improve the overall productivity of the organization (Sony and Naik, 2020). Quality 4.0 is also a joint optimisation of the social and technical system to manage products and services. To cite an example in traditional quality management systems sampling inspection was carried out because the cost and human effort required for total inspection were high. However, in Quality 4.0 with the help of information technology low-cost total inspection is possible. Therefore, such joint optimisation will lead to productivity improvement and therefore respondents voted it as a fourth motivating factor. The initial cost of Quality 4.0 in terms of fixed costs will be high in terms of investments in technology, automation, training etc. (Sony et al., 2020) However, it will reduce the internal and external failure costs in the long run leading to the concept that quality is free. In traditional quality management data collection, data verification, analysis documentation etc is a time-consuming process, however, through intelligent algorithms it can be computerized and lead to time savings in the long run. Therefore, in the long run cost and time-savings are possible with the implementation of Quality 4.0 and hence respondents voted it as a fifth motivating factor.

To gain a complete understanding of Quality 4.0, in addition to motivations the respondents were asked what were the reasons for non-adoption or barriers of Quality 4.0 in organizations? The top five reasons for non-adoption is explicated in Figure 2.
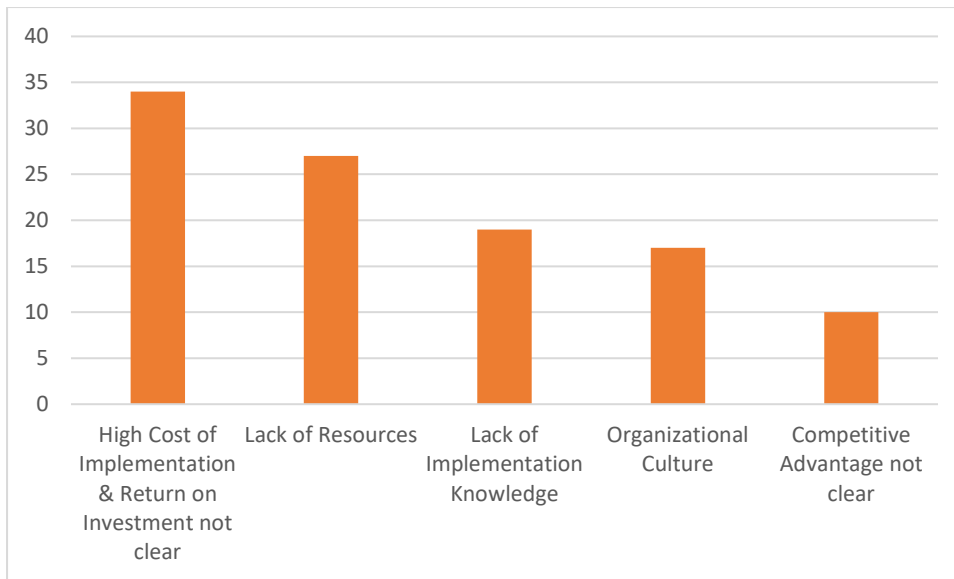
Figure 2: Top Five barriers of Quality 4.0 in Organizations

The initial cost of implementation of Quality 4.0 is high. To estimate the return on investment from Quality 4.0 in the long run, there would be a significant reduction in internal and external failure costs. Besides, there would be an increase in the market share of products and services due to increased customer satisfaction. Therefore, ROI on Quality 4.0 should include both financial metrics and other non-financial metrics such as increased customer satisfaction, customer loyalty, customer retention, increased organization agility etc to gain a clear understanding of Quality 4.0 implementation. Since Quality 4.0 is a new concept respondents are unclear about how to estimate the return on investment for Quality 4.0 initiatives and hence respondents have voted high cost of investment and return on investment not clear as the first barrier factor.

The second barrier factor was lack of resources. Quality 4.0 implementation calls for resources in terms of physical resources such as CPS, IoT, RFID, Sensors, smart manufacturing etc (Shin et al., 2018), intellectual resources such as technical know-how, databases, intelligent algorithms etc (Sony et al., 2020) and human resources such as skilled quality manager, Quality Engineers, Quality Directors etc (Schönreiter, 2016; Johnson, 2019) and financial resources such as cash, credits for operation & maintenance of quality management programs(Chiarini, 2020; Sony et al., 2020).

The third barrier factor is lack of implementation knowledge of Quality 4.0. There is no universally accepted framework for implementation of Quality 4.0 (Zonnenshain and Kenett,

2020). The knowledge base of Quality 4.0 in terms of implementation framework should be standardised so that organization finds it easier to implement for organizations.

The fourth barrier factor of Quality 4.0 is a conducive organizational culture. Organizational or corporate culture is the "pattern of values, norms, beliefs, attitudes and assumptions that may not have been articulated but how people in organizations behave and things get done. It can be expressed through the medium of a prevailing management style in the organization" (Armstrong and Stephens, 2005). The innovative culture stands out as the type of culture that is more suitable for the implementation of Industry 4.0 (Ziaei Nafchi and Mohelská, 2020). In such a culture an organization creates an environment which encourages employees to take risky behaviour, accepts new challenges and supports creative work to meet the quality goals. Not all organizations have such a conducive organizational culture and therefore, this is a non-adoption factor for the implementation of Quality 4.0.

The fifth barrier factor is that the competitive advantage is not clear. In the era of the fourth industrial revolution, the challenges that organizations are facing today is finding the proper way to shape competitive advantages (Adamik and Nowicki, 2018). This is important as it paves the way for long-term survival in the market. The nature of the relationship between Quality 4.0 implementation and competitive advantage is not studied. Therefore, there is no clarity for organizations as to how competitive advantage is formed due to the implementation of Quality 4.0.

To explore the readiness factors, a thorough literature review was carried out (Sony et al., 2020). Also, the respondents were also asked about readiness factors which did not appear in the review to make the factor list exhaustive. The respondents were requested to grade the factors based on the five-point Likert scale (1 -Strongly Disagree 2- Slightly Disagree 3- Neutral 4- Slightly agree 5- Strongly agree). These factors were subsequently ranked on mean scores and are explicated in table 3.

Table 3: Readiness Factors for Quality 4.0		
Readiness Factors	**Mean**	**Std dev**
Top Management Support	4.27	1.90
Organisational Culture towards Quality 4.0	4.18	1.96
Leadership	4.09	1.81
Quality 4.0 Vision and Strategy	3.82	1.89
Knowledge and Awareness on Quality 4.0	3.71	1.77
Customer centeredness	3.66	2.02
Supplier centric	3.42	1.89
Training and rewards	2.99	1.98

The respondents felt top management support is the first readiness factor for the implementation of Quality 4.0. Quality 4.0 implementation will require resources and also change initiatives to be implemented throughout the organization, therefore top management support for Quality 4.0 will be key for its success (Sony et al., 2020). Thus, an organization whose top management is aware and supports a Quality 4.0 initiative will be ready to implement Quality 4.0.

The second readiness factor for the implementation of Quality 4.0 is having an organizational culture towards Quality 4.0. The organization should embrace a new organizational culture of transparency, connectivity, collaboration and insights using big data & machine learning algorithms (Sony and Naik, 2019a, 2019b; Sony, 2020a) to make QM decisions The members within the organization should embrace the new Technology & big data driven culture. Hence, an organization whose culture is open for accepting change will be ready to implement Quality 4.0.

The third readiness factor for the implementation of Quality 4.0 is leadership. Leadership is the skill to inspire, motivate and channel activities to achieve organizational goals (Waddell et al., 2007). A leadership style which promotes innovation, learning and acceptance for the new practices of quality management with the emerging capabilities of Industry 4.0 (Sony et al., 2020), will benefit the organization to transition and accept Quality 4.0. Consequently, an organization which possesses leaders who are innovative, risk-taking, advocates digital transformation, promotes learning & growth will be ready to implement Quality 4.0.

The fourth readiness factor for implementation is Quality 4.0 vision and strategy. The digital data is used by organizations to create a competitive advantage by creating quality products and services at competitive price (Porter and Heppelmann, 2014). Quality 4.0 will, therefore, help the organization to attain its vision and strategy. Therefore, Quality 4.0 vision and strategy should be aligned to organization vision & strategy and the organization which does this will be ready to implement Quality 4.0.

The fifth readiness factor for the implementation of Quality 4.0 is knowledge & awareness on Quality 4.0. The modern-day employees after implementation of the digital transformation of organizational repetitive jobs will be automated and what remains for humans will require a large repertoire of skill set (Bonekamp and Sure, 2015; Frey and Osborne, 2017). Quality professionals implementing Quality 4.0 will require both complex interdisciplinary technical skills along with soft skills. Therefore, respondents felt that the knowledge and awareness of quality professionals about Quality 4.0 will be one of the dimensions of Quality 4.0 readiness.

The sixth readiness factor for the implementation of Quality 4.0 is a customer-centric organization. The success of quality management practice depends on how the organization produces product and services to meet customer needs. An organization which is customer-centric will align its quality programs to meet the customer needs to satisfy the customers (Herrmann et al., 2000; Kuei and Madu, 2003). A customer-centric organization analyses the customer needs and produce products and services to meet its needs (Wechsler and Schweitzer, 2019; Osakwe, 2020). Quality 4.0 with its multi-flow big data sharing capabilities using IT technology in all of the five stage product design (Hyun Park et al., 2017), will help in meeting the requirement of customer-centric organizations. An organization whose philosophy is customer-centric will be ready to implement Quality 4.0 in the organization.

The seventh readiness factor for implementation of Quality 4.0 is supplier management. A good supplier management system in an organization allows it to monitor, inspect, audit, and analyse suppliers at regular intervals so that good quality materials can be obtained for the organizations (Park et al., 2001). Thus, an organization with an effective supplier management system will be ready to implement Quality 4.0.

The eighth readiness factor for the implementation of Quality 4.0 is training and reward. Quality 4.0 uses many technologies for its effective implementation (Zonnenshain and Kenett, 2020). Therefore, existing quality employees must be trained for them to be effective in the new roles using advanced technology. In addition, the reward system enforces the adoption of

new quality management practices (Allen and Kilmann, 2001). Therefore, organization, where the training and reward systems are better, will be ready to implement Quality 4.0 readiness.

5.0 Conclusion

Quality 4.0 is a new buzzword among organizations and only a few organizations have implemented it successfully. There is no academic study which has captured senior quality professional's perspectives on Quality 4.0. This study finds the top five motivation factors, & barriers for implementation of Quality 4.0. As well, this study also investigates and finds out the readiness factors and how important they are for Quality 4.0.

The main limitation of this study is the small sample size. However, it should be noted that Quality 4.0 is a new concept and relatively few companies have implemented it (Zonnenshain and Kenett, 2020) and hence a sample size of 50 senior professionals gives an adequate view of the relatively new phenomenon.

Future studies should include samples from developing countries so that wider viewpoints of motivations, and barriers of Quality 4.0 can be captured. There is also a need for a global study to be carried out to compare the motivation & barrier factors in various countries and continents. In addition, readiness factors can be compared across sectors. Also, there is an urgent need for a study to explore the relationship between Quality 4.0 and business performance and business growth.

References

Adamik, A. and Nowicki, M. (2018), "Preparedness of companies for digital transformation and creating a competitive advantage in the age of Industry 4.0", *Proceedings of the International Conference on Business Excellence*, Vol. 12, pp. 10–24.

Allen, R.S. and Kilmann, R.H. (2001), "The role of the reward system for a total quality management based strategy", *Journal of Organizational Change Management*.

Antony, J., Sony, M. and Cudney, E. (2020), "Quality 4.0: Motivations and Challenges from apilot survey in European", *Future Factory*, pp. 1–7.

Antony, J., Sony, M., Dempsey, M., Brennan, A., Farrington, T. and Cudney, E.A. (2019),

"An evaluation into the limitations and emerging trends of Six Sigma: an empirical study", *The TQM Journal*, Vol. 31 No. 2, pp. 205–221.

Antony, J., Sony, M. and Gutierrez, L. (2020), "An Empirical Study Into the Limitations and Emerging Trends of Six Sigma: Findings From a Global Survey", *IEEE Transactions on Engineering Management*, available at:https://doi.org/10.1109/TEM.2020.2995168.

Antony, J., Sony, M., Sunder M, V. and Douglas, A. (2020), "A Global Study on Quality Professionals", *Future Factory*, pp. 1–5.

Armstrong, M. and Stephens, T. (2005), *A Handbook of Management and Leadership: A Guide to Managing for Results*.

Bonekamp, L. and Sure, M. (2015), "Consequences of Industry 4.0 on human labour and work organisation", *Journal of Business and Media Psychology*, Vol. 6 No. 1, pp. 33–40.

Boynton, P.M. and Greenhalgh, T. (2004), "Selecting, designing, and developing your questionnaire", *Bmj*, Vol. 328 No. 7451, pp. 1312–1315.

Cannon, J.P. and Homburg, C. (2001), "Buyer–supplier relationships and customer firm costs", *Journal of Marketing*, Vol. 65 No. 1, pp. 29–43.

Cheng, G.-J., Liu, L.-T., Qiang, X.-J. and Liu, Y. (2016), "Industry 4.0 development and application of intelligent manufacturing", *Information System and Artificial Intelligence (ISAI), 2016 International Conference On*, pp. 407–410.

Chiarini, A. (2020), "Industry 4.0, quality management and TQM world. A systematic literature review and a proposed agenda for further research", *The TQM Journal*.

Corbin, J. and Strauss, A. (2008), *Basics of Qualitative Research (3rd Ed.): Techniques and Procedures for Developing Grounded Theory*, available at:https://doi.org/10.4135/9781452230153.

Couper, M.P. and Miller, P. V. (2008), "Web survey methods: Introduction", *Public Opinion Quarterly*, Vol. 72 No. 5, pp. 831–835.

Easterby-Smith, M., Thorpe, R. and Jackson, P.R. (2012), *Management Research*.

Flynn, B.B., Schroeder, R.G. and Sakakibara, S. (1995), "The impact of quality management practices on performance and competitive advantage", *Decision Sciences*, Vol. 26 No. 5,

pp. 659–691.

Frey, C.B. and Osborne, M.A. (2017), "The future of employment: how susceptible are jobs to computerisation?", *Technological Forecasting and Social Change*, Vol. 114, pp. 254–280.

Gimenez-Espin, J.A., Jiménez-Jiménez, D. and Martinez-Costa, M. (2013), "Organizational culture for total quality management", *Total Quality Management & Business Excellence*, Vol. 24 No. 5–6, pp. 678–692.

Gunasekaran, A., Subramanian, N. and Ngai, W.T.E. (2019), "Quality management in the 21st century enterprises: Research pathway towards Industry 4.0", available at:https://doi.org/https://doi.org/10.1016/j.ijpe.2018.09.005.

Gupta, S., Modgil, S. and Gunasekaran, A. (2020), "Big data in lean six sigma: a review and further research directions", *International Journal of Production Research*, Vol. 58 No. 3, pp. 947–969.

Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E. (2014), "Multivariate data analysis: Pearson new international edition", *Essex: Pearson Education Limited*.

Herrmann, A., Huber, F. and Braunstein, C. (2000), "Market-driven product and service design: Bridging the gap between customer needs, quality management, and customer satisfaction", *International Journal of Production Economics*, Vol. 66 No. 1, pp. 77–96.

Hyun Park, S., Seon Shin, W., Hyun Park, Y. and Lee, Y. (2017), "Building a new culture for quality management in the era of the Fourth Industrial Revolution", *Total Quality Management & Business Excellence*, Vol. 28 No. 9–10, pp. 934–945.

Jahanshahi, A.A., Gashti, M.A.H., Mirdamadi, S.A., Nawaser, K. and Khaksar, S.M.S. (2011), "Study the effects of customer service and product quality on customer satisfaction and loyalty", *International Journal of Humanities and Social Science*, Vol. 1 No. 7, pp. 253–260.

Johnson, S. (2019), "Quality 4.0: A trend within a trend", *Quality*, Vol. 58 No. 2, pp. 21–23.

Kreuzer, T., Röglinger, M. and Rupprecht, L. (2020), "Customer-centric prioritization of process improvement projects", *Decision Support Systems*, p. 113286.

Kuei, C. and Madu, C.N. (2003), "Customer-centric six sigma quality and reliability

management", *International Journal of Quality & Reliability Management*.

De Long, D.W. and Fahey, L. (2000), "Diagnosing cultural barriers to knowledge management", *Academy of Management Perspectives*, Vol. 14 No. 4, pp. 113–127.

Niglas, K. (2007), "Media Review: Microsoft Office Excel Spreadsheet Software.", *Journal of Mixed Methods Research*, Vol. 1 No. 3, pp. 297–299.

Nunnally, J.C. (1994), *Psychometric Theory 3E*.

Osakwe, C.N. (2020), "Customer centricity: an empirical analysis in the micro-sized firm", *Journal of Strategic Marketing*, Vol. 28 No. 5, pp. 455–468.

Park, S., Hartley, J.L. and Wilson, D. (2001), "Quality management practices and their relationship to buyer's supplier ratings: a study in the Korean automotive industry", *Journal of Operations Management*, Vol. 19 No. 6, pp. 695–712.

Petersen, K.J., Handfield, R.B. and Ragatz, G.L. (2005), "Supplier integration into new product development: coordinating product, process and supply chain design", *Journal of Operations Management*, Vol. 23 No. 3–4, pp. 371–388.

Porter, M.E. and Heppelmann, J.E. (2014), "How smart, connected products are transforming competition", *Harvard Business Review*, Vol. 92 No. 11, pp. 64–88.

Rajagopal and Rajagopal, A. (2009), "Buyer–supplier relationship and operational dynamics", *Journal of the Operational Research Society*, Vol. 60 No. 3, pp. 313–320.

Reja, U., Manfreda, K.L., Hlebec, V. and Vehovar, V. (2003), "Open-ended vs. close-ended questions in web questionnaires", *Developments in Applied Statistics*, Vol. 19 No. 1, pp. 159–177.

Saldivar, A.A.F., Li, Y., Chen, W., Zhan, Z., Zhang, J. and Chen, L.Y. (2015), "Industry 4.0 with cyber-physical integration: A design and manufacture perspective", *Automation and Computing (Icac), 2015 21st International Conference On*, pp. 1–6.

Saraph, J. V, Benson, P.G. and Schroeder, R.G. (1989), "An instrument for measuring the critical factors of quality management", *Decision Sciences*, Vol. 20 No. 4, pp. 810–829.

Schönreiter, I. (2016), "Significance of quality 4.0 in post merger process harmonization", *International Conference on Enterprise Resource Planning Systems*, pp. 123–134.

Shah, D., Rust, R.T., Parasuraman, A., Staelin, R. and Day, G.S. (2006), "The path to

customer centricity", *Journal of Service Research*, Vol. 9 No. 2, pp. 113–124.

Shin, W.S., Dahlgaard, J.J., Dahlgaard-Park, S.M. and Kim, M.G. (2018), "A Quality Scorecard for the era of Industry 4.0", *Total Quality Management & Business Excellence*, Vol. 29 No. 9–10, pp. 959–976.

Sony, M. (2020a), "Pros and cons of implementing Industry 4.0 for the organizations: a review and synthesis of evidence", *Production & Manufacturing Research*, Vol. 8 No. 1, pp. 244–272.

Sony, M. (2020b), "Design of cyber physical system architecture for industry 4.0 through lean six sigma: conceptual foundations and research issues", *Production & Manufacturing Research*, Vol. 8 No. 1, pp. 158–181.

Sony, M., Antony, J. and Douglas, J.A. (2020), "Essential ingredients for the implementation of Quality 4.0", *The TQM Journal*, available at:https://doi.org/https://doi.org/10.1108/TQM-12-2019-0275.

Sony, M. and Naik, S. (2019a), "Ten Lessons for managers while implementing Industry 4.0", *IEEE Engineering Management Review*, Vol. 47 No. 2, pp. 45–52.

Sony, M. and Naik, S. (2019b), "Critical factors for the successful implementation of Industry 4.0: a review and future research direction", *Production Planning & Control*, pp. 1–17.

Sony, M. and Naik, S. (2020), "Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model", *Technology in Society*, p. 101248.

Theodorakioglou, Y., Gotzamani, K. and Tsiolvas, G. (2006), "Supplier management and its relationship to buyers' quality management", *Supply Chain Management: An International Journal*.

Waddell, D., Devine, J., Jones, G.R. and George, J.M. (2007), *Contemporary Management*.

Wang, S., Wan, J., Zhang, D., Li, D. and Zhang, C. (2016), "Towards smart factory for industry 4.0: a self-organized multi-agent system with big data based feedback and coordination", *Computer Networks*, Vol. 101, pp. 158–168.

Wechsler, J. and Schweitzer, J. (2019), "Creating customer-centric organizations: the value of design artefacts", *The Design Journal*, Vol. 22 No. 4, pp. 505–527.

Závadská, Z. and Závadský, J. (2018), "Quality managers and their future technological expectations related to Industry 4.0", *Total Quality Management & Business Excellence*, pp. 1–25.

Ziaei Nafchi, M. and Mohelská, H. (2020), "Organizational Culture as an Indication of Readiness to Implement Industry 4.0", *Information*, Vol. 11 No. 3, p. 174.

Zonnenshain, A. and Kenett, R.S. (2020), "Quality 4.0—the challenging future of quality engineering", *Quality Engineering*, pp. 1–13.