Workforce Resilience in the Post-COVID-19 Era: Differences Based on Manufacturing–Service Orientation and Firm Size

Abstract

The devastating impact of COVID-19 on businesses has led to the redefinition of workforce resilience. This study hence explores workforce resilience factors that will be important in the post-COVID-19 era. It investigates whether these factors perform differently in the manufacturing vs. the service sector and in small and medium enterprises (SMEs) vs. large firms. Sixty-five firms were studied in Malaysia and analysed through Rasch modelling. The results indicate that three workforce resilience factors (positive thinking, sense of responsibility, and emotional control) are difficult to overcome in the manufacturing sector. Regarding the SMEs and large firm contexts, six workforce resilience factors (positive thinking, differentiation, degree of involvement, sense of responsibility, cognitive processes, and innovation) are complicated for SMEs. In comparison, two workforce resilience factors (work–life balance and decision-making) are difficult for large firms. Capitalising on these findings, managers in various organisations (manufacturing vs. service and SMEs vs. large firms) can adopt different strategies to leverage workforce resilience post-COVID. Moreover, government agencies can use these findings for policy-making when leading post-COVID-19 projects and initiatives.

Keywords: Workforce resilience, COVID-19, Manufacturing sector, Service sector, SMEs, Large firms, Malaysia

1. Introduction

COVID-19 pandemic volatility and uncertainty have led to the redefinition of the concept of resilience (Aldianto *et al.*, 2021). The disruption has redefined the workforce management concept, whereas the struggle to protect employment and improve productivity during the pandemic has exposed flaws in people management (Corrales-Estrada et al., 2021). The severity and long-term consequences of COVID-19 are expected to be prolonged and will continue to test individuals and organisations in many ways (Kuntz, 2021). As the most critical organisational resource, workforce resilience must be improved for an organisation suffering from an underperforming economy and a negative work–life balance (Lintz, 2020; Hillmann and Guenther, 2021). If observed from the positive side, COVID-19 has helped to create some opportunities in the area of digitalisation—particularly in terms of disruption through Industry 4.0 technologies such as big data, robotics, 3D printing, machine learning and artificial intelligence—which can improve workforce resilience (Hizam-hanafiah, Soomro and Abdullah, 2020; Soomro, Hizam-hanafiah and Abdullah, 2020).

Being more resilient may be seen as the panacea for organisations who wish to mitigate the effects of COVID-19, and redefining and redesigning a type of people management that suits the current environment is one of resiliency's critical components (Koh *et al.*, 2020; Lin and Liao, 2020). Workforce resilience is defined as a capability, capacity, characteristic, outcome, process, and sometimes a combination of these (Seville, 2018). It is the capacity of employees to recover quickly from difficulty, an adverse event, or a crisis (Brusset and Teller, 2017) and to enable the workforce to be agile in adapting and seizing

opportunities from adverse circumstances (Seville, 2018). Due to the new business landscape caused by COVID-19, the concept of workforce resilience has gained increased attention in management studies (Hillmann and Guenther, 2021). Even before COVID-19, organisations were being called upon to pay urgent attention to improving their workforce readiness (i.e., Parker and Ameen, 2018); hence, a pressing need is an in-depth explanation of how the workforce can survive and thrive after the turbulence of COVID-19. Furthermore, the resilience concept related to COVID-19 is dynamic depending on the organisational and industrial context (Vanany *et al.*, 2021). The theoretical understanding of post-COVID-19 workforce resilience should be investigated in multiple contexts following this argument. Therefore, this article compares two important firm typologies: manufacturing–service orientation and firm size.

Manufacturing and service businesses and products and services have significant differences. In manufacturing, technical skills dominate, whereas in service businesses, interpersonal skills take a considerable lead. In both cases, the organisations can be labour intensive and require workforce resilience. In short, manufacturing businesses are more equipment oriented, whereas service businesses are more people oriented (Ivanov, Dolgui, and Sokolov, 2018). COVID-19 has led to severe challenges in some manufacturing businesses' supply chains, whereas remote services have made work easier for most service-based businesses (Papagiannidis, Harris, and Morton, 2020; Vanany et al., 2021). In terms of final products and services, the production and delivery of goods are usually handled separately, whereas in the service business, the production, delivery, and consumption of services often occur at the same time (Duchek, 2020; Salleh and Zulkifli, 2020). Physical distancing is the primary method of mitigating of the spread of COVID-19, and it has affected business in different ways. For example, in manufacturing firms, goods can be purchased to store in inventory to satisfy customers' needs, but services are offered upon customer demand in service firms. These differences have created unique challenges for workforce management, and understanding the contrasts can help develop better workforce resilience for organisations moving towards the post-COVID-19 era (Lagowska, Sobral, and Furtado, 2020).

Firm size is also an essential determinant of organisational resilience (Polyviou, Croxton and Knemeyer, 2020; Vanany *et al.*, 2021). A similar impact is expected on workforce resilience. In general, small and medium-sized enterprises (SMEs) expect immediate results, but large companies work better under long-term sustainable circumstances (Cho, Lee, and Cho, 2017). SMEs have fast and unstructured supply chain and work processes, but large firms have slow and well-defined processes. COVID-19 has been brutal for SMEs because they have minimal cash flow, and extended lockdown situations have hampered their sales and business activities. In some cases, these circumstances have led to bankruptcies and layoffs (Carroll and Conboy, 2020). In SMEs, decision-making lies with few people, but decision-making occurs across the board with several departments in large firms. Moreover, small businesses initially thrive on owners' equity, but large firms need robust funding from multiple sources. Similar to revenue, the SME customer base is small, but large firms enjoy a broader customer base (Arntz, Gregory, and Zierahn, 2017). In the COVID-19 pandemic, SMEs' lack of technological infrastructure has disadvantaged them. In contrast, large firms have, in most cases, leveraged digital technologies such as blended learning and remote deliveries. Doing so will further improve their collaborations in workforce resilience with the advent of the metaverse concept (Shin and Park, 2021). Overall, SMEs have been severely affected, and workforce resilience is even more concerning in emerging economies due to minimal resources and a lack of regulations (Ncube et al., 2021).

The majority of the previous literature on workforce resilience has concentrated on leadership (Bargavi, James Daniel Paul and Samuel, 2016; Förster and Duchek, 2017); organisational crises (Teo, Lee, and Lim, 2017; Koh *et al.*, 2020); digital disruptions (Caza and Milton, 2012; Britt *et al.*, 2016; Birkie, Trucco and Fernandez Campos, 2017); and, to some extent, the COVID-19 pandemic (Aldianto *et al.*, 2021; Corrales-Estrada *et al.*, 2021; Queiroz, Fosso Wamba and Branski, 2021). However, the forward-looking literature is scarce on workforce resilience in the post-COVID-19 era discussing topologies such as the manufacturing–service orientation and firm size in a single study. The main goal of this paper is to perform a comparative analysis of (1) manufacturing and service firms and (2) SMEs and large firms in terms of their differential performances on workforce readiness in the post-COVID-19 era. The insights from the dichotomies surrounding these two firm topologies provide an interesting theoretical extension. Moreover, the valuable insights may serve as a useful guide for firms to improve the capacity of employees to deal with volatile and uncertain situations. In addition, the current research offers a deeper understanding of dynamic workforce resilience in different settings. In this study, Rasch measurement theory (RMT) was used to study 65 firms across Malaysia. In brief, the following research questions guided this research study:

RQ1: Which workforce resilience factors perform differently between the manufacturing and service sectors? Which of these factors are the most challenging to overcome in the post-COVID-19 era for each group?

RQ2: Which workforce resilience factors perform differently between SMEs and large firms? Which of these factors are the most challenging to overcome in the post-COVID-19 era for each group?

This paper is structured as follows. First, based on the literature, a theoretical landscape is presented in Section 2. The Rasch research method is described in Section 3. Then, Section 4, followed by the results, presents the findings of workforce resilience in terms of both the manufacturing–service orientation and firm size. Section 5 then expands the discussion in terms of the theoretical and managerial implications. Finally, the conclusion, recommendations, and study limitations are addressed in Section 6.

2. Theoretical Background

2.1. Workforce Resilience and Manufacturing–Service Orientation

The lessons on crisis and workforce management that worked earlier seem to be faltering now (Bargavi, James Daniel Paul and Samuel, 2016; Starr, 2020). Despite the large body of literature on the post-COVID-19 era, studies on workforce resilience are lacking, especially those that directly compare the manufacturing and service sectors in a similar country setting (Aldianto et al., 2021; Ali and Govindan, 2021). Dynamic capabilities theory states that organisations purposefully create, extend and modify their resource bases (Arend and Bromiley, 2009; Teece and Pisano, 1994). According to this theory, workforce resilience in service firms is better than it is in manufacturing firms, as service firms can modify their resource bases more efficiently and faster. During the COVID-19 lockdowns, the business opportunities for service firms significantly increased as service firm business operations ran without significant disruption (Lintz, 2020). Employees in service firms had more chances to take advantage of the pandemic, which improved workforce resilience in the service sector, particularly in terms of change perceptions, flexible decision-making, business continuity, and agility. Therefore, service firms have higher workforce resilience than do manufacturing firms

(Manfield and Newey, 2018; Salehzadeh, 2019). Although most manufacturing firms survived the pandemic, service firms survived, adapted, and grew in the face of turbulent changes related to the pandemic.

The COVID-19 pandemic has hurt all economic sectors, including the manufacturing and service industries, in developed and developing countries (Aldianto et al., 2021; Shin and Park, 2021). Workforce resilience is vital, as recovering from a crisis such as COVID-19 requires extra productivity and performance (Lintz, 2020; Hillmann and Guenther, 2021). Naturally, employees with high resilience levels were better motivated to return to normalcy. There are theoretical differences between how manufacturing and service organisations responded and were affected by COVID-19 from internal organisational and output perspectives.

Manufacturing firms produce physical products, which require physical labour (Han, Chong, and Li, 2020; Shani, 2020). When the extended lockdowns were introduced to mitigate COVID-19, staff and labour mobility was a challenge and forced the firms to be more flexible and to exercise redundancy (Vanany et al., 2021). Manufacturing firms have very little room for flexibility in their product offerings, as the COVID-19 disruption was sudden and novel. The time needed for product development is lengthy and not feasible to a large extent. The changes in the product may not meet consumer demands or workforce knowledge, skillsets, and abilities (Lorenz et al., 2018). At the same time, service firms during the pandemic could easily change their course and processes to match the severity of COVID-19 restrictions. Another example is that manufacturing firms have been victims of delayed deliveries, which were unable to operate as usual due to the unavailability of raw materials (Bustinza et al., 2019). On the other hand, service companies experienced the converse situation. Service firms that do not require a physical interface have earned more revenue than ever through remote deliveries (Powell et al., 2018). In terms of competition, manufacturing firms and products with lower technological dependence are relatively easy for competitors to imitate, and workers in the manufacturing sector generally struggle to achieve sustainable competitive advantages (Khan, Farooq, and Rasheed, 2019; Näswall et al., 2019). A service standard is difficult to copy, but the trained workforce in service firms found it easier to change course, if needed, during the pandemic (Duchek, 2020).

2.2. Workforce Resilience and Firm Size

SMEs and large firms exhibit stark differences, particularly regarding the output tangibility, labour intensiveness, operational automation, and resource access, which have had a significant effect on workforce resilience during the pandemic (Oosthuizen, 2016; Cho, Lee and Cho, 2017). The World Health Organization (WHO) announced that COVID-19 is a global pandemic, causing significant economic shocks worldwide as nations exerted efforts to contain the virus (Aldianto et al., 2021). As per dynamic capabilities theory, organisations adopt, implement and change their internal and external firm-specific competencies into new competencies based on the environment. In this regard, workforce resilience in the post-COVID-19 era can be strengthened by developing new competencies for the firm and its people (Chowdhury and Quaddus, 2017).

SMEs have endured the worst of this situation, as they have limited budgets and slimmer margins (Li, Li and Dalgic, 2004). In terms of workforce resilience, among the SMEs, start-up businesses have suffered the most, as the training and education of the workforce is not a priority for start-ups, and they are less prepared to deal with unfavourable external situations (Aldianto et al., 2021). Large companies, on the contrary, have robust

organisational structures and well-defined processes, which help them be readier in terms of bouncing back from adversity and hence to have a workforce that is more resilient (Tan et al., 2012; Gottman et al., 2018; Lucy and Shepherd, 2018). The global business environment has become increasingly complex due to this pandemic. Moreover, business resilience in the SME sector has become a challenge in terms of business continuity (Papagiannidis, Harris, and Morton, 2020). Business continuity is better for large businesses, and workforce resilience is vital. Leadership style also plays a significant role (Aldianto et al., 2021). SMEs mostly have an autocratic leadership style, whereas large businesses have distributed leadership due to diversity. When leadership has a wider span of decision-making, the workforce is more resilient due to its speed and the variety of decision-makers.

In terms of resources and infrastructure, SMEs are struggling, and difficult circumstances such as COVID-19 add another layer of threats to their business operations (Kittipanya-Ngam and Tan, 2020; Kuntz, 2021; Queiroz, Fosso Wamba, and Branski, 2021). Likewise, due to the entrepreneurial nature of SMEs, financial investments are on the low side for small businesses, which gives them less leverage to take advantage of emerging technologies such as 3D printing, artificial intelligence, machine learning, and big data (Tan et al. 2015; Hizam-Hanafiah, Soomro and Abdullah, 2020; Soomro, Hizam-Hanafiah and Abdullah, 2020). The COVID-19 pandemic has eliminated many SMEs in various countries, mainly because they could not join the digitalisation initiative and join the digital economy. Scale-ups similar to start-ups in these pandemic times have also struggled, as they received funds from investors who demanded returns that were frequently not achieved during these difficult times. Moreover, in terms of innovation, large organisations have for a greater ability to research and develop, and their workforce adaptability is better in terms of resilience (Corrales-Estrada et al., 2021; Kuntz, 2021). Overall, workforce resilience is the ability to deal with challenging conditions, and SMEs have mainly been vulnerable to survival. Hence, their response towards uncertain situations has been the least workable.

3. Methodology

3.1. Data Collection

Malaysia is an emerging economy with a good representation of manufacturing and service concerns. In addition, Malaysia has a fair share of both SMEs and large organisations. As per the Federation of Malaysian Manufacturers (FMM), Malaysia has over 3,000 manufacturing companies. The private sector is a significant contributor to Malaysia's economy, with industrial zones spread across the country, especially in states such as Penang, Johor, and Selangor. In terms of services, the banking, insurance, and education industries have a significant footprint in Malaysia's economy. Firm sizes vary across the country. However, according to the Malaysia Statistical Business Register (MSBR), the SME landscape is witnessing massive growth.

A Rasch analysis performs equally well on smaller sample sizes (Linacre, 2009). A sample of 50 targeted respondents is sufficient for obtaining a useful estimate through Rasch modelling (Linacre, 2002, 2004). In another study, 30 respondents were sufficient from a logit scale perspective to conclude the findings of the Rasch analysis (Andrich, 1978; Wolins, Wright and Rasch, 1982). Similarly, another study stated that at least 20 sample sizes should be considered for establishing decisions about respondents with sufficient certainty (Fisher, 2006). However, the current study used 65 firms as the sample size, which is satisfactory and sufficient based on the various Rasch standard studies.

Two selection criteria were designed to identify and select respondents for the survey of the subject study: (a) senior manager with organisation-wide understanding and (b) at least one year of experience working in that company. Similarly, the respondents who became part of this research stud were primarily directors and department heads, all of whom had work experience in their company of more than three years. The data collection was performed across the different Malaysian states. As a result, 65 firms were studied on the research aims of this study, of which 22 were manufacturing firms (34 percent), 43 were service firms (66 percent), 27 were SMEs (42 percent), and 38 were large firms (58 percent). A diverse range of service companies were studied for this survey, which included banks, insurance companies, courier companies, utility companies, business consultancy firms and technology support firms. No single industry occupied a dominant share of the service sector. In terms of firm age, most of the firms (40 percent) were over 30 years old. The definition was followed of the SME Corporation Malaysia based on the number of employees to distinguish SMEs from large firms within the manufacturing and service sectors. As a result, 22 manufacturing firms consisted of 13 SMEs (number of employees =< 200) and 9 large firms (number of employees > 200), and 43 service firms consisted of 14 SMEs (number of employees =< 75) and 29 large firms (number of employees > 75). Details of the sample structure are presented in Table 1.

Table 1. Description of the Sample

		Number of firms
Firm orientation	Manufacturing firms	22
	Service firms	43
Firm size	SMEs	27
	Large firms	38
Firm age	< 5 years	4
	6-10 years	10
	11-20 years	17
	21-30 years	8
	> 30 years	26
Manufacturing firms split	SMEs	13
	Large firms	9
Service firms split	SMEs	14
	Large firms	29
Total		65

3.2. Rasch Measurement Theory

Rasch measurement theory (RMT) is grounded in latent-variable probabilistic models (Rasch, 1982). RMT is based on item response theory, a mathematical model explaining the latent traits of unobservable characteristics (Marais and Andrich, 2008) and their observed outcomes (Thissen & Orlando, 2021). Rasch's mathematical features for psychometric testing and measurement enable the model to explain a range of possibilities (Andrich, 1978). In past empirical studies, RMT has been used in workforce management (Boone, Yale, and Staver, 2014; Aziz, Wee, and Mahmud, 2015) and resilience (Alavi, Isa, and Palpanadan, 2020; Papini et al., 2021). However, work on the subject using Rasch Measurement Theory is needed that is more extensive, such as finding differences between two samples studying various phenomena.

Andrich (1978) and Rasch (1982) formulated a model for dichotomous items, which resulted in the Rasch Rating Scale Model (RRSM). The RRSM helps to define the latent variable through polytomous items in ordered categories (Azizan *et al.*, 2020). The Naiperian expression of this model is:

$$L_n\left(\frac{P_{nij}}{P_{ni(j-1)}}\right) = \beta_n - \left(\delta_i + \tau_j\right)$$

where

$P_{nij} =$ probability of the observed category j

$P_{ni(j-1)}$= probability of the observed category j-1

$\beta_n =$ measurement of the ability of subject n

$\delta_i =$ measurement of the difficulty of item I

τ_j= differential of the difficulty of observed category j in relation to j-1.

The adoption of Rasch measurement theory is appropriate for this study because Rasch supports the analysis of differential item functioning (DIF). Rasch models have an invariance feature that is inherent to their structure and that establishes support for some items that perform a different function in measuring the construct (Andrich, 1978). For this, differential item functioning (DIF) is used to confirm the presence of a bias when a group of subjects, with some common feature, significantly obtains a different calibration from that of another group in an item's difficulty (Schauberger and Mair, 2020). The RRSM is ideal for measuring latent variables such as workforce resilience, as it is the result of the measurements assessed by the respondents from different firm topologies. Workforce resilience items are positioned on the linear continuum, allowing them to be measured according to their ability and difficulty, from left (less) to right (more). Similarly, a DIF analysis can identify difficulty levels between two pairs of differentiated groups: manufacturing vs. service firms and SMEs vs. large firms.

3.3. Measurement Scale and Fit Diagnosis

The resilience literature varies, with some studies focussing on change (Higgs and Rowland, 2000), team management (Förster and Duchek, 2017), and foresight (O'Brien and Robertson, 2009); likewise, certain studies focus on functions such as supply chain (Baryannis et al., 2019), operations (Grotan and Vorm, 2015) and logistics (Nayak and Choudhary, 2020). In this study, the construct of workforce resilience is based on five elements: propensity (PRO), attitude (ATT), perception (PER), preferences (PRE), and management (MAN). These five elements broadly cover the personality, characteristics and competencies of employees in workforce resilience, which makes these elements a suitable fit for this study. The measurement was adapted from Bargavi, James Daniel Paul, and Samuel (2016) and measures resilience through 5 constructs and 25 items. Overall, with its constructs and items, this study is suitable for the current research, as the 25-item instrument used is reliable and valid, relates to contemporary times of leadership and organisational styles, and explores a wide range of employee characteristics in the context of resilience. Furthermore, as the measures (25 items) can reflect significant variance between teams and organisations, the differences in workforce resilience can be better identified and analysed, which is the main objective of this study.

The adapted items relate to employees' personalities, characteristics, and competencies, which can be exhibited differently based on firm type and size. For example, the stress level in aviation companies (service sector) (Oliveira and Roth, 2012) is different from that in automobile companies (manufacturing sector) (Prause and Atari, 2017). These differences can result in variable emotional control for employees service vs. manufacturing firms when measuring perception (PER) as a construct of workforce resilience. Likewise, employees' personalities, characteristics, and competencies for workforce resilience can exhibit differences between SMEs and large firms due to the complexity of and resources available in the organisational structure (Dassisti et al., 2017).

A 1-5 point scale was adopted to measure the ratings. This 5-point Likert-type scale had the following levels: 1 ('very little extent'), 2 ('little extent'), 3 ('some extent'), 4 ('great extent'), and 5 ('very great extent'). Winsteps version 4.4.7 was used for the data handling. Table 2 shows the main specifications of this study. The measurement items for workforce resilience are listed in Table 3.

Table 2. Technical Specifications

Context	**Malaysia**
Information Type	Primary
Data Collection Method	Survey
Temporal Scope	September 2021–November 2021
Sample Size	65 firms
Data Handling	Rasch Winsteps software, version 4.4.7

Table 3. Construct Items for Workforce Resilience

Construct		**Items**
This study is undertaken to understand the workforce resilience characteristics important in the post-COVID-19 era. In the context of COVID-19, on a scale of 1-5, to what extent do you agree with the below statements?		
Propensity	PRO1	Our employees tend to have flexible personalities.
	PRO2	Our employees avoid uncertainties.
	PRO3	Our employees dislike knowing what will happen.
	PRO4	Our employees give preference to health and safety.
	PRO5	Our employees view chances as challenges.
Attitude	ATT1	Our employees try out new ideas.
	ATT2	Our employees see events as opportunities.
	ATT3	Our employees do things in new ways.
	ATT4	Our employees challenge others' points of view.
	ATT5	Our employees find it easy to make business decisions.
Perception	PER1	Our employees value positive thinking.
	PER2	Our employees are good at cognitive processes (sensation, attention, and perception).
	PER3	Our employees have control over their emotions.
	PER4	Our employees maintain good relationships with others.
	PER5	Our employees feel a sense of responsibility.
Preferences	PRE1	Our employees wish to be different from others.
	PRE2	Our employees show a high degree of involvement.
	PRE3	Our employees face opportunities confidently.

	PRE4	Our employees face threats confidently.
	PRE5	Our employees maintain a healthy work–life balance.
Management	MAN1	Our employees can control changing behaviours.
	MAN2	Our employees can predict the damage level of fluctuating behaviours.
	MAN3	Our employees have a fixed mindset that can reduce variation.
	MAN4	Our employees can identify events demanding different behaviours.
	MAN5	Our employees can confidently ascertain consequences.

Diagnosis of the fit was carried out following the recommendations of Linacre (2009) by establishing a structure with five categories. The estimates of the Andrich threshold parameters guaranteed the absence of disorders in the difficulty levels of the items, confirming the effectiveness of the category structure. Furthermore, the latent traits of workforce resilience reflected only one reality. Three analysis types were carried out to confirm the operational requirement of the RRSM: (1) principal component analysis of Rasch residuals (PCAR), in which the values of the indicators obtained (variance explained, 46.2 percent; unexplained variance in first contrast, 6.05 percent) allowed the multidimensionality tensions to be discarded (Linacre, 2009); (2) the point–measure (PTM) correlation positive sign confirmed the adequacy of the measurements, as shown in Table 4; and (3) the reliability and validity analysis was assessed by using the Rasch estimators of measurement for subjects and items. The 65 measures and 25 items have Person Reliability of 0.87 and Item Reliability of 0.95, respectively. The Cronbach's alpha for the measures was 0.92. As the values were above 0.70, they satisfied the Rasch standard levels, confirming the reliability and validity of the measurement. Regarding the individual validity analysis, the outfit mean square of residuals (MNSQ) for item PRO3, 'Our employees dislike knowing what will happen', was above the recommended level (Wright and Linacre, 1994), with an outfit MNSQ of 1.91 and an outfit ZSTD of 3.60, as shown in Table 4. After checking, this item was removed. The diagnosis confirmed the fit of the data to Rasch measurement theory; hence, the measures obtained adopt the properties of the model.

Table 4. Item Calibration

S.N	Measurement	STD ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTM
PRO1	.20	.14	.74	-1.48	.70	-1.64	.58
PRO2	1.01	.13	1.17	1.03	1.43	2.28	.53
PRO3	1.93	.14	1.93	4.19	1.91	3.60	.56
PRO4	-.70	.18	1.15	.74	1.11	.53	.41
PRO5	-.15	.15	1.49	2.23	1.50	2.17	.44
ATT1	-.64	.18	1.09	.48	1.05	.27	.45
ATT2	-.55	.17	.80	-.95	.77	-1.03	.48
ATT3	-.20	.16	1.02	.16	1.12	.63	.46
ATT4	.32	.14	1.22	1.23	1.20	1.06	.46
ATT5	.94	.13	.95	-.26	.92	-.41	.64
PER1	-1.36	.22	1.19	.83	.95	-.09	.35
PER2	-.46	.17	.71	-1.49	.69	-1.48	.50

PER3	.22	.14	.85	-.84	.80	-1.03	.55
PER4	-.55	.17	1.17	.85	.98	-.02	.47
PER5	-1.22	.21	1.13	.60	.84	-.52	.39
PRE1	-.46	.17	1.13	.69	1.07	.38	.41
PRE2	-.46	.17	.93	-.27	.93	-.27	.42
PRE3	-.49	.17	.81	-.91	.75	-1.15	.47
PRE4	-.11	.15	1.14	.74	1.43	1.91	.41
PRE5	.22	.14	1.31	1.62	1.16	.83	.56
MAN1	.39	.14	.97	-.12	.96	-.14	.57
MAN2	.47	.14	.81	-1.12	.75	-1.45	.62
MAN3	.68	.13	.82	-1.09	.90	-.55	.61
MAN4	.37	.14	.55	-3.02	.49	-3.30	.64
MAN5	.58	.13	.67	-2.18	.66	-2.10	.64

4. Results

The responses from 65 firms were grouped according to their manufacturing–service orientation (22 manufacturing and 43 service firms) and firm size (27 large firms and 38 SMEs). These groups were analysed using the RRSM of the DIF to identify whether workforce resilience exhibited significant differences among the two comparative pairs (Linacre, 2009). The statistical Welch's t test of difference in means was used, and the indicators of a differential behaviour were interpreted (Bond and Fox, 2003). The hypothesis of differences in the item's differential behaviour is accepted when the significance value is under 0.05. In addition, the differences were considered based on the DIF contrast value: a DIF contrast less than 0.43 is deemed small, a DIF contrast between 0.43 and 0.64 is deemed moderate, and a DIF contrast greater than 0.64 is considered large (Wright and Linacre, 1994; Linacre, 2002).

The DIF analysis was conducted in two stages. In the first stage, the manufacturing–service orientation was compared in terms of workforce resilience. Table 5 shows the workforce resilience item's significance value and DIF contrast for a probability under 0.05. The results confirm the existence of differences between the manufacturing and service groups for three items: PER1, 'positive thinking'; PER2, 'emotional control'; and PER5, 'sense of responsibility'. The first intergroup difference of PER1, 'positive thinking', probability value was 0.0063 (significant at $P < 0.05$), and the DIF contrast value was 1.30, indicating a large difference. The positive direction of the comparison from the manufacturing to the service sectors revealed that achieving workforce resilience in terms of PER1, 'positive thinking', was more difficult in manufacturing vs. service firms. The second intergroup difference of PER3, 'emotional control', had a probability of 0.0074 (significant as $P < 0.05$) and a DIF contrast of 0.82, indicating a large difference. Regarding the positive comparisons, the findings reveal that achieving workforce resilience in terms of PER3, 'emotional control', was more difficult in manufacturing vs. service firms. Likewise, the third intergroup difference of PER5, 'sense of responsibility', had a probability of 0.0101 (significant at $P < 0.05$) and a DIF contrast of 1.15 (also categorised as a large difference). The positive direction of the comparison from the manufacturing to the service sectors, the third finding of the study, reveals that achieving workforce resilience in terms of PER5, 'sense of responsibility', was more difficult in manufacturing vs. service firms.

In the second stage, the SMEs and large firms were compared in terms of workforce resilience. As shown in Table 6, the workforce resilience item is based on the responses

analysed using the significance value and DIF contrast, which has a probability of less than 0.05. The results obtained confirmed the differences between these two firm groups for eight workforce resilience items: ATT3, 'innovation'; ATT5, 'decision-making'; PER1, 'positive thinking'; PER2, 'cognitive processes'; PER5, 'sense of responsibility'; PRE1, 'differentiation'; PRE2, 'degree of involvement'; and PRE5, 'work–life balance'. Correspondingly, the firm size difference results showed the probability value (significant at $P < 0.05$) of ATT3, 'innovation' (0.0356); ATT5, 'decision-making' (0.0161); PER1, 'positive thinking' (0.0074); PER2, 'cognitive processes' (0.0170); PER5, 'sense of responsibility' (0.0350); PRE1, 'differentiation' (0.0030); PRE2, 'degree of involvement' (0.0030; significant at $P < 0.05$); and PRE5, 'work–life balance' (0.0090). The DIF contrast values of 0.68, 0.66, 1.30, 0.83, 0.93, 1.06, 1.06, and 0.81 for the respective workforce resilience items indicated a large difference. Furthermore, the positive direction of comparison from SMEs to large firms indicated that all these workforce resilience items were more challenging for SMEs vs. large firm except for ATT5, 'decision-making', and PRE5, 'work–life balance'.

Table 5. DIF of the Manufacturing–Service Orientation

No.	Groups		DIF Contrast	t of Welch	Probability	Items
PER1	Manufacturing	Service	1.30	2.83	.0063	Our employees value positive thinking
PER3	Manufacturing	Service	.82	2.80	.0074	Our employees have control over their emotions
PER5	Manufacturing	Service	1.15	2.66	.0101	Our employees feel a sense of responsibility

Table 6. DIF of the Firm Size

No.	Groups		DIF Contrast	t of Welch	Probability	Items
ATT3	SMEs	Large firms	0.68	2.15	.0356	Our employees do things in new ways
ATT5	Large firms	SMEs	0.66	2.48	.0161	Our employees find it easy to make business decisions
PER1	SMEs	Large firms	1.30	2.78	.0074	Our employees value positive thinking
PER2	SMEs	Large firms	0.83	2.46	.0170	Our employees are good at cognitive processes (sensation, attention, and perception)

PER5	SMEs	Large firms	.93	2.16	.0350	Our employees feel a sense of responsibility
PRE1	SMEs	Large firms	1.06	3.10	.0030	Our employees wish to be different from others
PRE2	SMEs	Large firms	1.06	3.10	.0030	Our employees show a high degree of involvement
PRE5	Large firms	SMEs	.81	2.72	.0090	Our employees maintain a healthy work–life balance

5. Discussion

The present study contributes to the literature on workforce resilience with a specific view on the post-COVID-19 era by comparing manufacturing and service firms as well as SMEs and large firms. This study further empirically evidenced the differences in workforce resilience, specifically through three main findings on the differences between manufacturing and service firms, followed by eight main findings on the differences between SMEs and large firms. Based on these findings, the proposed framework of workforce resilience for the post-COVID-19 era is presented in Figure 1.

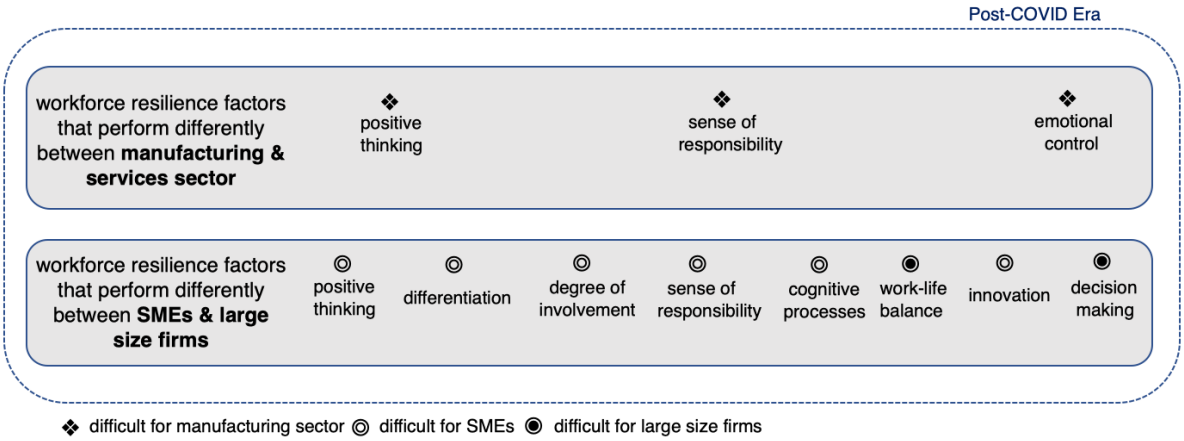

Figure 1. Proposed Workforce Resilience Framework in the Post-COVID-19 Era

5.1 Post-COVID-19 Workforce Resilience in the Manufacturing vs. Service Sectors

Personal characteristics and organisational culture differ considerably between manufacturing and service firms. In manufacturing firms, technical skills dominate primarily, whereas in service firms, soft skills take the lead (Cotet, Balgiu and Zaleschi (Negrea), 2017). In terms of people leadership, cost leadership takes precedence over differentiation in manufacturing vs. service firms (Gottman et al., 2018). Employees in manufacturing firms experience more stress due to physical production and floor assembly line pressure, whereas service firm employees' targets are less stressful in terms of turnaround time (Vivares, Sarache and E. Hurtado, 2018). The findings confirm that workforce resilience in terms of PER1, 'positive thinking', is significant and more complex in manufacturing vs. service firms.

This finding resonates with Corrales-Estrada *et al.* (2021) and Gabriele Sauberer, Andreas Riel (2008). The primary reason is that disruptions such as COVID-19 paralysed many manufacturing firms' supply chain and business operations, particularly with extended lockdowns. A sizable number of manufacturing firms declared bankruptcy and were not allowed to operate production and physical sales, as opposed to service firms that thrived by remote delivery and sales. Hence, the resilience of the workforce in terms of thinking positively has been a challenge in manufacturing firms.

PER3, 'emotional control', is more difficult in manufacturing vs. service firms, echoing the workforce management literature (Kuntz, 2021, Gottman *et al.,* 2018). Difficulty in controlling emotions among the manufacturing workforce can be explained because they have taken a significant brunt of the hardships in terms of job losses and production halts; hence, the workplace culture has deteriorated, although transitionally, for manufacturing firms. Based on business opportunities and competition, manufacturing (vs. service) firms have struggled more, and the same frustration can be generally seen in the workforce. This study further confirms that workforce resilience in terms of PER5, 'sense of responsibility', exhibits difficulties in manufacturing firms, which resonates with Jiang, Ritchie, and Verreynne (2019) and Lagowska, Sobral, and Furtado (2020). Manufacturing firms mostly have complex operations spreading over the different stages of production. Thus, a sense of responsibility is shared but collectively increased. In service firms, employees mostly have individual contributor-based roles; hence, the importance of accountability is easier to manage, as responsibility is the lowest in a collective culture.

In comparing manufacturing and service firms, this study also confirmed that other characteristics—such as PRO1, 'flexibility'; ATT4, 'challenging others'; and PRO4, 'concern for health and safety'—regarding workforce resilience are insignificant. This finding implies that firm orientation does not play a key role in employee flexibility, as it is different in manufacturing firms compared to service firms (Bargavi, James Daniel Paul and Samuel, 2016). Likewise, the attributes of challenging others' points of view in the workplace and concern for the health and safety of are is not dealt with differently in manufacturing compared to service firms (Starr, 2020; Stefan and Nazarov, 2020). In summary, the results indicate three workforce resilience factors (positive thinking, sense of responsibility, and emotional control) that are difficult to overcome in the manufacturing sector.

5.2 Post-COVID-19 Workforce Resilience in SMEs and Large Firms

Likewise, personal characteristics and organisational culture differ fundamentally in SMEs and large firms. Employees in large firms have better time management skills due to better corporate planning than do those in SMEs (Cho, Lee and Cho, 2017). Employees in large firms are also comfortable making decisions due to systematic structures and centralisation (Välikangas and Romme, 2013). In terms of culture, SMEs struggle with research and development initiatives and drive, whereas large firms find it relatively easy to promote an enterprising culture of research and innovation (Aldianto et al., 2021).

In the context of the SME vs. large firm dichotomy, eight valuable findings were found. In general, workforce resilience in SMEs is more challenging than in it is larger firms. Even though the myriad of the previous literature has highlighted this connotation in a broader resilience discussion (Polyviou, Croxton and Knemeyer, 2020; Vanany *et al.*, 2021), this study identified differences in the workforce resilience context. This study confirms that attitude-related workforce resilience differs vastly between SMEs and large firms. ATT3, 'innovation', is more challenging for SMEs, a finding that complements the studies by Queiroz, Fosso

Wamba, and Branski (2021) and Corrales-Estrada *et al.* (2021). Large companies have more funds, resources, and room to experiment with their products, services designs, and workforce. Hence, innovation is a challenge for the SME workforce in particular (Sharma *et al.*, 2021). ATT5, 'decision-making', among the SME workforce highlights an exciting finding that is not found in the extant literature. Some possible arguments for this finding may best be explained by the fact that SMEs are commonly run by a single person or by few people who manage most of the business's operations. Decision-making, in this case, is faster for SMEs vs. large firms.

Workers' perceptions are also an essential resilience measure in times of disruption. Workforce resilience in terms of PER1, 'positive thinking', is more challenging for SMEs than it is for large firms. Large firms are more sustainable, and their organisational strength is higher, which translates into more positivity among their workforce and, eventually, higher workforce resilience. Furthermore, the findings highlight that PER2, 'cognitive processes', are more challenging for SMEs. Cognitive processes deal with sensation, attention, and perception, and in large companies, employees generally have better cognitive processes because the companies place more focus on learning and education. PER5, 'sense of responsibility', is more challenging for the SME workforce. SMEs are commonly flatly structured and more organic; thus, the duties held by the workforce are larger and more interfunctional. In contrast, large firms have a better sense of responsibility, as they have structured processes and well-defined operations.

This study also confirms that SMEs have difficulty attaining workforce resilience. Large firms have technological resources, particularly in Industry 4.0 technologies, which can offer differentiated product offerings, especially when dealing with the novel COVID-19 disruption. For the SMEs that are not endowed with these advantages to provide differentiation, being different from the others is not a characteristic of the SME workforce. This factor explains the PRE1, 'differentiation', findings as being more challenging for SMEs, in alignment with Schauberger and Mair (2020) and Nastacă (2020). Similarly, SMEs' lack of resources and technologies limits the number of employees, who have multiple responsibilities. Often, an individual is expected to perform numerous roles at once. Although the workforce roles in SMEs are multifunctional, attaining PRE2, 'degree of involvement', is more challenging for SMEs when they are not assisted by the technologies (Papadopoulos, Baltas, and Balta, 2020). Interestingly, PRE5, 'work–life balance', is more challenging for large firms vs. SMEs, which corresponds with the study by Gottman *et al.* (2018) and Hodges (2017). In SMEs, employees and entrepreneurs take charge and are flexible with their personal and professional obligations. In contrast, large firms mostly have fixed work timings, resulting in less of a work–life balance.

This study comparing SMEs with large firms also confirmed that workforce resilience in terms of other characteristics—such as PRO2, 'uncertainty avoidance'; PER3, 'emotional control'; and ATT4, 'challenging others'—was insignificant. This finding suggests that firm size does not play a significant role in employees' approaches to avoiding uncertain and ambiguous events. Therefore, the SME and large firm workforces deal with volatility in a similar fashion (Fletcher and Griffiths, 2020). Furthermore, the attributes of emotional control in the workplace and the conduct of challenging others frequently are not dealt with differently in SMEs vs. large firms (Gottman et al., 2018; Starr, 2020).

In summary, six workforce resilience factors (positive thinking, differentiation, degree of involvement, sense of responsibility, cognitive processes, and innovation) are challenging for SMEs, and two workforce resilience factors (work–life balance and decision-making) are

challenging for large firms. Finally, the workforce resilience factor that does not differ between the two firm types is not discussed at length in this study, as it is readily available and well discussed in the literature. The focus of this study is to highlight the findings that have a large DIF contrast, implying a large significant difference for each of these eleven items between the two pairs of firm typologies.

5.3 Theoretical Contributions

This study complements and extends the research on workforce resilience in the following nine aspects. First, the categorisation of manufacturing and service firms in the workforce resilience area has made it possible to reconcile the empirical evidence in this regard, which is lacking. Second, the classification of SMEs and large firms in the workforce resilience area has added further empirical evidence, which is scarce.

Third, the study identifies differences in positive thinking, sense of responsibility, and emotional control between two sectors: manufacturing and service. Fourth, the study identifies differences in innovation, decision-making, positive thinking, cognitive processes, sense of responsibility, differentiation, degree of involvement, and work–life balance between SMEs and large firms. Fifth, this study supports and extends the findings of Aldianto et al. (2021), Kuntz (2021), Lintz (2020), (Senna et al., 2021), and Näswall et al. (2019). Sixth, it introduces a measuring instrument that has not been previously used to compare the workforce resilience for the post-COVID-19 era between manufacturing–service orientations and firm size.

Seventh, the results indicate three workforce resilience factors (positive thinking, sense of responsibility, and emotional control) that are difficult to overcome in the manufacturing sector. Amongst them, positive thinking is most critical (Nayak and Choudhary, 2020; Fügener et al., 2021). More efforts are needed to improve employees' mental and psychological states by giving them hope to deal with a crisis such as COVID-19, which helps to develop workforce resilience (Seville, 2018). Eighth, the findings of this study confirm that six workforce resilience factors (positive thinking, differentiation, degree of involvement, sense of responsibility, cognitive processes, and innovation) are difficult for SMEs. For example, one major challenge SMEs face is differentiation (Ekanayake, Shen, and Kumaraswamy, 2021; Ivanov and Dolgui, 2021). Workforce resilience can be significantly improved by promoting flexibility and agility among employees to offer new and modified product and service offerings, allowing SMEs to seize new opportunities and counter threats in difficult times such as COVID-19 (Nayak and Choudhary, 2020). However, SMEs can find it challenging to gain that agility and introduce differentiated offerings (Förster and Duchek, 2017; Hodges, 2017; Teo, Lee, and Lim, 2017).

Last, the results indicate that two workforce resilience factors (work–life balance and decision-making) are complicated for large firms. In terms of decision-making, large firms make decisions that are more significant, resulting in more severe consequences and benefits. To improve workforce resilience, organisations should increase their employees' sense of being decisive (Ekanayake, Shen and Kumaraswamy, 2021; Senna et al., 2021). However, large firms struggle more in decision-making, as their processes are often lengthy and slow, adversely affecting decision-making ability and hence workforce resilience (Ali and Govindan, 2021). In the COVID-19 era, work from home demands better decision-making and resilience (Gottman et al., 2018; Lucy and Shepherd, 2018). In summary, this study adds theoretically to

the literature on crisis and workforce management, especially in extending the studies of Lintz (2020), Shani (2020) and Starr (2020).

5.4 Managerial Implications

This study has three managerial implications. The first is for manufacturing companies, which should pay more attention to positive thinking, a sense of responsibility, and emotional control to improve their workforce readiness for the post-COVID-19 era. As part of their production plan, managers in manufacturing companies should promote a culture of positivity and a sense of responsibility (Nayak and Choudhary, 2020; Fügener *et al.*, 2021). Developing and executing corporate training in emotional intelligence can also improve resilience.

The second implication is for SMEs. In SMEs as well, positive thinking helps, as training the workforce to be more optimistic in times of crisis signifies hope and well-being, which positively impacts resilience. For innovation, SMEs should partner with large firms to collaborate externally for intrinsic innovation (Ekanayake, Shen and Kumaraswamy, 2021; Senna *et al.*, 2021). Open innovation—relying on external knowledge for the internal innovation of products and services—can improve SME resilience in manifold ways. This will enable SME employees to do things in new ways.

Finally, the third set of implications is for large firms. Using the findings of this study, large firms can improve the work–life balance of their workforce by designing worker-friendly policies. Particularly after COVID-19, the flexibility of work from home and the four-day workweek concept can be capitalised upon. Furthermore, the drive for digitalisation among large firms makes it possible to manage a decent work–life balance (Ali and Govindan, 2021; Ivanov and Dolgui, 2021). The government can also play an active role in helping large firms better promote the work–life balance philosophy. Moreover, large firms can better utilise Industry 4.0 technologies such as big data, machine learning, and artificial intelligence to make faster and more streamlined decisions, eventually resulting in stronger resilience (Fügener *et al.*, 2021; Gibson *et al.*, 2021). In practice, within the industry, collective guidelines from working groups in best practices can further motivate large firms to strengthen their workforce resilience for the post-COVID-19 era.

6. Conclusion, Limitations and Future Research Directions

The COVID-19 situation has been challenging because it is difficult to predict how things will develop as circumstances change rapidly (Fügener *et al.*, 2021; Kuntz, 2021). The problems of social isolation, disrupted work and family routines, economic instability, and mental health suffering have added layers of complexity for individuals and organisations in business today (Brusset and Teller, 2017; Senna *et al.*, 2021). However, the lessons learned during the COVID-19 disruption should not be wasted and should be well utilised in preparation for the post-COVID-19 era. This study, through its findings, has identified the critical areas of workforce resilience important for dealing with the post-COVID-19 scenario, especially from two bases: manufacturing–service orientation and firm size.

This study has some limitations. The current study chose Malaysia as the geographic context by analysing 65 firms operating in the manufacturing vs. service sectors and who were SMEs vs. large firms. As all the firms were from Malaysia, this context adds to the study limitations of this paper. However, Malaysia is an excellent case to study, as it witnessed a prolonged lockdown and strict restrictions for almost 1.5 years starting in March 2020. The

study instrument of this paper will be beneficial for evaluating workforce readiness in other countries, regions, and territories to enhance cross-cultural learning on workforce readiness. The responses for this study were captured from senior managers with management control on behalf of employees, which adds to the limitation of generalisability.

Workforce resilience is a skillset that can be cultured (Breen, 2017), implying that with reasonable effort, one can learn to resist challenges when preparing for the post-COVID-19 world (Gottman et al., 2018). Employing people who are more resilient is no assurance that the workforce will be resilient. Having resilient people does not inevitably translate into having a resilient organisation or team, although they are related (Aldianto et al., 2021). Therefore, the mechanics of how individuals come together can create a team that is either more or less resilient, which can be a focus area for future research (Seville, 2018).

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References

Alavi, K., Isa, K. and Palpanadan, S. T. (2020) 'Application of rasch model on resilience in higher education: An examination of validity and reliability of Malaysian academician happiness index (mahi)', *International Journal of Higher Education*, 9(4), pp. 261–271. doi: 10.5430/IJHE.V9N4P261.

Aldianto, L. *et al.* (2021) 'Toward a business resilience framework for startups', *Sustainability (Switzerland)*, 13(6), pp. 1–19. doi: 10.3390/su13063132.

Ali, I. and Govindan, K. (2021) 'Extenuating operational risks through digital transformation of agri-food supply chains', *Production Planning and Control*. doi: 10.1080/09537287.2021.1988177.

Andrich, D. (1978) 'A rating formulation for ordered response categories', *Psychometrika*, 43(4). doi: 10.1007/BF02293814.

Arend, R. J. and Bromiley, P. (2009) 'Assessing the dynamic capabilities view: Spare change, everyone?', *Strategic Organization*, 7(1), pp. 75–90. doi: 10.1177/1476127008100132.

Arntz, M., Gregory, T. and Zierahn, U. (2017) 'Technology and Jobs in the Fourth Industrial Revolution', *Labor Productivity and the Digital Economy*, p. 6.

Aziz, N., Wee, S. H. and Mahmud, Z. (2015) 'Exploring the Attitude of Managers towards Key Performance Indicators (KPIs) in Response to Public Sector Change: A Rasch Analysis', *Journal of Economics, Business and Management*, 3(1), pp. 119–124. doi: 10.7763/joebm.2015.v3.166.

Azizan, N. H. *et al.* (2020) 'Rasch Rating Scale Item Estimates using Maximum Likelihood Approach: Effects of Sample Size on the Accuracy and Bias of the Estimates', *International Journal of Advanced Science and Technology*, 29(4s).

Bargavi, N., James Daniel Paul, P. and Samuel, A. A. (2016) 'Quantifying Resilience in the

651 Personality of Millennial leaders', *Indian Journal of Science and Technology*, 9(22). doi:
652 10.17485/ijst/2016/v9i22/92799.

653 Baryannis, G. *et al.* (2019) *Revisiting Supply Chain Risk*, *Supply Chain Virtualization: Facilitating*
654 *Agent Trust Utilizing Blockchain Technology*. Springer International Publishing. doi:
655 10.1007/978-3-030-03813-7.

656 Birkie, S. E., Trucco, P. and Fernandez Campos, P. (2017) 'Effectiveness of resilience
657 capabilities in mitigating disruptions: leveraging on supply chain structural complexity',
658 *Supply Chain Management*, 22(6), pp. 506–521. doi: 10.1108/SCM-01-2017-0009.

659 Bond, T. G. and Fox, C. M. (2003) 'Applying the Rasch Model: Fundamental Measurement in
660 the Human Sciences', *Journal of Educational Measurement*. doi: 10.1111/j.1745-
661 3984.2003.tb01103.x.

662 Boone, W. J., Yale, M. S. and Staver, J. R. (2014) *Rasch analysis in the human sciences*, *Rasch*
663 *Analysis in the Human Sciences*. doi: 10.1007/978-94-007-6857-4.

664 Breen, J. M. (2017) 'Leadership Resilience in a VUCA World', *Visionary Leadership in a*
665 *Turbulent World*, pp. 39–58. doi: 10.1108/978-1-78714-242-820171003.

666 Britt, T. W. *et al.* (2016) 'How much do we really know about employee resilience?', *Industrial*
667 *and Organizational Psychology*, 9(2), pp. 378–404. doi: 10.1017/iop.2015.107.

668 Brusset, X. and Teller, C. (2017) 'Supply chain capabilities, risks, and resilience', *International*
669 *Journal of Production Economics*. Elsevier, 184(October 2015), pp. 59–68. doi:
670 10.1016/j.ijpe.2016.09.008.

671 Bustinza, O. F. *et al.* (2019) 'Technological capabilities, resilience capabilities and
672 organizational effectiveness', *International Journal of Human Resource Management*, 30(8),
673 pp. 1370–1392. doi: 10.1080/09585192.2016.1216878.

674 Carroll, N. and Conboy, K. (2020) 'Normalising the "new normal": Changing tech-driven work
675 practices under pandemic time pressure', *International Journal of Information Management*.
676 Elsevier, (June), p. 102186. doi: 10.1016/j.ijinfomgt.2020.102186.

677 Caza, B. B. and Milton, L. P. (2012) 'Resilience at Work: Building Capability in the Face of
678 Adversity', *The Oxford Handbook of Positive Organizational Scholarship*, (May 2018), pp. 1–
679 30. doi: 10.1093/oxfordhb/9780199734610.013.0068.

680 Cho, I., Lee, E. and Cho, H. (2017) 'How Should Techno Parks Innovate to Support Start-ups
681 and Small and Medium-Sized Enterprises Effectively in the Era of the Fourth Industrial
682 Revolution ?', *World Technopolis Review*, pp. 1–15.

683 Chowdhury, M. M. H. and Quaddus, M. (2017) 'Supply chain resilience: Conceptualization and
684 scale development using dynamic capability theory', *International Journal of Production*
685 *Economics*. Elsevier B.V., 188, pp. 185–204. doi: 10.1016/j.ijpe.2017.03.020.

686 Corrales-Estrada, A. M. *et al.* (2021) 'Sustainability and resilience organizational capabilities
687 to enhance business continuity management: A literature review', *Sustainability*
688 *(Switzerland)*, 13(15). doi: 10.3390/su13158196.

689 Cotet, G. B., Balgiu, B. A. and Zaleschi (Negrea), V. – C. (2017) 'Assessment procedure for the
690 soft skills requested by Industry 4.0', *MATEC Web of Conferences*, 121, p. 07005. doi:

10.1051/matecconf/201712107005.

Dassisti, M. *et al.* (2017) 'Industry 4.0 paradigm: The viewpoint of the small and medium enterprises', *7th International Conference on Information Society and Technology ICIST 2017 efficiency*.

Duchek, S. (2020) 'Organizational resilience: a capability-based conceptualization', *Business Research*. Springer International Publishing, 13(1), pp. 215–246. doi: 10.1007/s40685-019-0085-7.

Ekanayake, E. M. A. C., Shen, G. Q. P. and Kumaraswamy, M. M. (2021) 'A fuzzy synthetic evaluation of capabilities for improving supply chain resilience of industrialised construction: a Hong Kong case study', *Production Planning and Control*. doi: 10.1080/09537287.2021.1946330.

Fisher, J. W. P. (2006) 'Survey design recommendations', *Rasch Measurement Transactions*.

Fletcher, G. and Griffiths, M. (2020) 'Digital transformation during a lockdown', *International Journal of Information Management*. Elsevier, (June), p. 102185. doi: 10.1016/j.ijinfomgt.2020.102185.

Förster, C. and Duchek, S. (2017) 'What makes leaders resilient? An exploratory interview study', *German Journal of Human Resource Management: Zeitschrift für Personalforschung*, 31(4), pp. 281–306. doi: 10.1177/2397002217709400.

Fügener, A. *et al.* (2021) 'Cognitive challenges in human-AI collaboration: Investigating the path towards productive delegation', *Information Systems Research*, (Forthcoming), pp. 1–39.

Gabriele Sauberer, Andreas Riel, and R. M. (2008) 'Diversity and PERMA-nent Positive Leadership to Benefit from Industry 4.0 and Kondratieff 6.0', *Springer International*, 5(18), pp. 49–67. doi: 10.1007/978-3-319-64218-5.

Gibson, C. B. *et al.* (2021) *Sustaining Effectiveness in Global Teams: The Coevolution of Knowledge Management Activities and Technology Affordances*, *Organization Science*. doi: 10.1287/orsc.2021.1478.

Gottman, J. M. *et al.* (2018) 'Leadership resilience: The leadership perspective', *Organization Science*, 23(1), pp. 215–246.

Grotan, T. O. and Vorm, J. Van Der (2015) 'Training for Operational Resilience Capabilities', *The 6th Symposium on Resilience Engineering: Managing resilience, learning to be adaptable and proactive in an unpredictable world, June 22-25, 2015, Lisbon, Portugal.*, pp. 2–8.

Han, Y., Chong, W. K. and Li, D. (2020) 'A systematic literature review of the capabilities and performance metrics of supply chain resilience', *International Journal of Production Research*. Taylor & Francis, 0(0), pp. 4541–4566. doi: 10.1080/00207543.2020.1785034.

Higgs, M. and Rowland, D. (2000) 'Building change leadership capability: "The quest for change competence"', *Journal of Change Management*, 1(2), pp. 116–130. doi: 10.1080/714042459.

Hillmann, J. and Guenther, E. (2021) 'Organizational Resilience: A Valuable Construct for Management Research?', *International Journal of Management Reviews*, 23(1), pp. 7–44. doi:

10.1111/ijmr.12239.

Hizam-hanafiah, M., Soomro, M. A. and Abdullah, N. L. (2020) 'Industry 4.0 Readiness Models : A Systematic Literature Review of Model Dimensions', *Information*, 364(II).

Hizam-Hanafiah, M., Soomro, M. A. and Abdullah, N. L. (2020) 'Industry 4.0 Readiness Models: A Systematic Literature Review of Model Dimensions', *Information*. doi: 10.3390/info11070364.

Hodges, J. (2017) 'Building capabilities for change: the crucial role of resilience', *Development and Learning in Organizations*, 31(1), pp. 5–8. doi: 10.1108/DLO-07-2016-0064.

Ivanov, D. and Dolgui, A. (2021) 'A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0', *Production Planning and Control*, 32(9). doi: 10.1080/09537287.2020.1768450.

Ivanov, D., Dolgui, A. and Sokolov, B. (2018) 'The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics', *International Journal of Production Research*. Taylor & Francis, 0(0), pp. 1–18. doi: 10.1080/00207543.2018.1488086.

Jiang, Y., Ritchie, B. W. and Verreynne, M. L. (2019) 'Building tourism organizational resilience to crises and disasters: A dynamic capabilities view', *International Journal of Tourism Research*, 21(6), pp. 882–900. doi: 10.1002/jtr.2312.

Khan, T. Z. A., Farooq, W. and Rasheed, H. (2019) 'Organizational Resilience and Complex Systems', *Journal of Management and Research (JMR)*, 6(1), pp. 1–27.

Koh, M. Y. H. *et al.* (2020) 'How Leaders, Teams and Organisations can prevent Burnout and build Resilience: A thematic analysis'', *BMJ Supportive and Palliative Care*, pp. 1–10. doi: 10.1136/bmjspcare-2020-002774.

Kuntz, J. C. (2021) 'Resilience in Times of Global Pandemic: Steering Recovery and Thriving Trajectories', *Applied Psychology*, 70(1), pp. 188–215. doi: 10.1111/apps.12296.

Lagowska, U., Sobral, F. and Furtado, L. M. G. P. (2020) 'Leadership under crises: A research agenda for the post-covid-19 era', *BAR - Brazilian Administration Review*, 17(2), pp. 1–5. doi: 10.1590/1807-7692bar2020200062.

Li, L., Li, D. and Dalgic, T. (2004) 'Internationalization process of small and medium-sized enterprises: Toward a hybrid model of experiential learning and planning', *MIR: Management International Review*, 44(1), pp. 93–116. doi: 10.2307/40835979.

Lin, T. T. and Liao, Y. (2020) 'Future temporal focus in resilience research: when leader resilience provides a role model', *Leadership and Organization Development Journal*, 41(7), pp. 897–907. doi: 10.1108/LODJ-10-2019-0429.

Linacre, J. (2002) 'Understanding Rasch measurement: Optimizing Rating Scale Category Effectiveness', *Journal of applied measurement*.

Linacre, J. M. (2004) 'Rasch Model Estimation: Further Topics', *Journal of Applied Measurement*.

Linacre, J. M. (2009) 'Local independence and residual covariance: A study of olympic figure skating ratings', *Journal of Applied Measurement*, 10(2).

Lintz, T. J. (2020) 'Resilience and Leadership Development', *ProQuest Dissertations and*

Theses, p. 129.

Lorenz, R. *et al.* (2018) 'Applying User Stories for a customer-driven Industry 4.0 Transformation', *IFAC-PapersOnLine*. Elsevier B.V., 51(11), pp. 1335–1340. doi: 10.1016/j.ifacol.2018.08.345.

Lucy, D. and Shepherd, C. (2018) 'Organisational Resilience : Developing change-readiness', *Roffey Park Institute Journal*, pp. 1–24.

Manfield, R. C. and Newey, L. R. (2018) 'Resilience as an entrepreneurial capability: integrating insights from a cross-disciplinary comparison', *International Journal of Entrepreneurial Behaviour and Research*, 24(7), pp. 1155–1180. doi: 10.1108/IJEBR-11-2016-0368.

Marais, I. and Andrich, D. (2008) 'Effects of varying magnitude and patterns of response dependence in the unidimensional Rasch model', *Journal of Applied Measurement*, 9(2).

Nastacă, C. C. (2020) 'Leadership and resilience in Romanian public administration from county level', *Administratie si Management Public*, 2020(34), pp. 78–96. doi: 10.24818/amp/2020.34-05.

Näswall, K. *et al.* (2019) 'Employee resilience: development and validation of a measure', *Journal of Managerial Psychology*, 34(5), pp. 353–367. doi: 10.1108/JMP-02-2018-0102.

Nayak, R. and Choudhary, S. (2020) 'Operational excellence in humanitarian logistics and supply chain management through leagile framework: a case study from a non-mature economy', *Production Planning and Control*. doi: 10.1080/09537287.2020.1834135.

Ncube, L. K. *et al.* (2021) 'An overview of plasticwaste generation and management in food packaging industries', *Recycling*, 6(1), pp. 1–25. doi: 10.3390/recycling6010012.

O'Brien, E. and Robertson, P. (2009) 'Future leadership competencies: From foresight to current practice', *Journal of European Industrial Training*, 33(4), pp. 371–380. doi: 10.1108/03090590910959317.

Oliveira, P. and Roth, A. V. (2012) 'Service orientation: The derivation of underlying constructs and measures', *International Journal of Operations and Production Management*, 32(2), pp. 156–190. doi: 10.1108/01443571211208614.

Oosthuizen, C. (2016) 'Entrepreneurial intelligence: expanding Schwabs four-type intelligence proposition to meaningfully address the challenges of the fourth industrial revolution', *Proceedings of the 28th Annual Conference of the Southern African Institute of Management Scientists*, (2016), pp. 370–383.

Papadopoulos, T., Baltas, K. N. and Balta, M. E. (2020) 'The use of digital technologies by small and medium enterprises during COVID-19: Implications for theory and practice', *International Journal of Information Management*. Elsevier, (June), p. 102192. doi: 10.1016/j.ijinfomgt.2020.102192.

Papagiannidis, S., Harris, J. and Morton, D. (2020) 'WHO led the digital transformation of your company? A reflection of IT related challenges during the pandemic', *International Journal of Information Management*. Elsevier, (May), p. 102166. doi: 10.1016/j.ijinfomgt.2020.102166.

Papini, N. *et al.* (2021) 'Rasch calibration of the 25-item Connor-Davidson Resilience Scale',

Journal of Health Psychology, 26(11), pp. 1976–1987. doi: 10.1177/1359105320904769.

Parker, H. and Ameen, K. (2018) 'The role of resilience capabilities in shaping how firms respond to disruptions', *Journal of Business Research*. Elsevier, 88(December), pp. 535–541. doi: 10.1016/j.jbusres.2017.12.022.

Polyviou, M., Croxton, K. L. and Knemeyer, A. M. (2020) 'Resilience of medium-sized firms to supply chain disruptions: the role of internal social capital', *International Journal of Operations and Production Management*, 40(1). doi: 10.1108/IJOPM-09-2017-0530.

Powell, D. *et al.* (2018) *Towards Digital Lean Cyber-Physical Production Systems: Industry 4.0 Technologies as Enablers of Leaner Production*, *Springer Nature Switzerland*. Springer International Publishing. doi: 10.1007/978-3-319-99707-0.

Prause, G. and Atari, S. (2017) 'On sustainable production networks for industry 4.0', *Entrepreneurship and Sustainability Issues*. doi: 10.9770/jesi.2017.4.4(2).

Queiroz, M. M., Fosso Wamba, S. and Branski, R. M. (2021) 'Supply chain resilience during the COVID-19: empirical evidence from an emerging economy', *Benchmarking*. doi: 10.1108/BIJ-08-2021-0454.

Salehzadeh, R. (2019) 'The effects of leaders' behaviors on employees' resilience', *International Journal of Workplace Health Management*, 12(5), pp. 318–338. doi: 10.1108/IJWHM-02-2019-0016.

Salleh, M. R. M. and Zulkifli, H. (2020) 'Assessing Organizational Resilience of Private Higher Learning Institutions', *Malaysian Online Journal of Education*, 4(2), pp. 1–16.

Schauberger, G. and Mair, P. (2020) 'A regularization approach for the detection of differential item functioning in generalized partial credit models', *Behavior Research Methods*, 52(1). doi: 10.3758/s13428-019-01224-2.

Senna, P. *et al.* (2021) 'Healthcare supply chain resilience framework: antecedents, mediators, consequents', *Production Planning and Control*. doi: 10.1080/09537287.2021.1913525.

Seville, E. (2018) 'Building resilience: how to have a positive impact at the organizational and individual employee level', *Development and Learning in Organizations*, 32(3), pp. 15–18. doi: 10.1108/DLO-09-2017-0076.

Shani, O. (2020) 'Organizational Resilience: Antecedents, Consequences, and Practical Implications – for Managers and Change Leaders *', *Research in Organizational Change and Development*, 28, pp. 127–158. doi: 10.1108/s0897-301620200000028005.

Sharma, V. *et al.* (2021) 'A systematic literature review to integrate lean, agile, resilient, green and sustainable paradigms in the supply chain management', *Business Strategy and the Environment*, 30(2). doi: 10.1002/bse.2679.

Shin, N. and Park, S. (2021) 'Supply chain leadership driven strategic resilience capabilities management: A leader-member exchange perspective', *Journal of Business Research*. Elsevier, 122(July 2019), pp. 1–13. doi: 10.1016/j.jbusres.2020.08.056.

Soomro, M. A., Hizam-hanafiah, M. and Abdullah, N. L. (2020) 'Top-Down Orientation on Fourth Industrial Revolution : A Literature Review', *Sys Rev Pharm*, (October).

Soomro, M. A., Hizam-Hanafiah, M. and Abdullah, N. L. (2020) 'Digital readiness models: A systematic literature review', *Compusoft*.

Starr, J. P. (2020) 'On Leadership: Responding to COVID-19: Short- and long-term challenges', *Phi Delta Kappan Publishing*, 101(8), pp. 60–61. doi: 10.1177/0031721720923796.

Stefan, T. and Nazarov, A. D. (2020) 'Challenges and Competencies of Leadership in Covid-19 Pandemic', *Advances in Social Sciences*, 486(Rtcov), pp. 518–524. doi: 10.2991/assehr.k.201105.092.

Teece, D. and Pisano, G. (1994) 'The dynamic capabilities of firms: An introduction', *Industrial and Corporate Change*, 3(3), pp. 537–556. doi: 10.1093/icc/3.3.537-a.

Teo, W. L., Lee, M. and Lim, W. S. (2017) 'The relational activation of resilience model: How leadership activates resilience in an organizational crisis', *Journal of Contingencies and Crisis Management*, 25(3), pp. 136–147. doi: 10.1111/1468-5973.12179.

Thissen, D., & Orlando, M. in D. T. and H. W. (2021) 'Item Response Theory for Items Scored in More Than Two Categories', *Test Scoring*. doi: 10.4324/9781410604729-9.

Välikangas, L. and Romme, G. (2013) 'How to Design for Strategic Resilience: A Case Study in Retailing', *Journal of Organization Design*, 2(2), p. 44. doi: 10.7146/jod.7360.

Vanany, I. *et al.* (2021) 'A Supply Chain Resilience Capability Framework and Process for Mitigating the COVID-19 Pandemic Disruption', *IEEE Transactions on Engineering Management*. doi: 10.1109/TEM.2021.3116068.

Vivares, J. A., Sarache, W. and E. Hurtado, J. (2018) 'A maturity assessment model for manufacturing systems', *Journal of Manufacturing Technology Management*, 29(5), pp. 746–767. doi: 10.1108/JMTM-07-2017-0142.

Wolins, L., Wright, B. D. and Rasch, G. (1982) 'Probabilistic Models for some Intelligence and Attainment Tests.', *Journal of the American Statistical Association*, 77(377). doi: 10.2307/2287805.

Wright, B. D. and Linacre, J. M. (1994) 'Reasonable mean-square fit values', *Rasch Measurement Transactions*, 8(3).