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Digitalization for resilience and sustainability during the Covid-19 pandemic: an explorative event study

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Abstract. This paper reports on an initial explorative investigation on the relationship among resilience, digitalization, sustainability practices, and operations performance following the outbreak of Covid-19. It builds on literature survey and event study based on news items from international outlets. The findings indicate the need for holistic perspectives to leverage from different efforts in manufacturing firms to drive competitiveness with as little impact on other measures especially considering manufacturing companies.

Keywords: Digital transformation, disruption, industrial sustainability.

1 Introduction

The financial and social burden of the Covid-19 pandemic has been felt by manufacturing companies globally. Despite government support, a large number of SMEs are in the verge of or have already been out of business, leaving millions jobless. Only those that could leverage some form of resilience in managing the disruptive consequences of the pandemic seem to be able to continue their operations. There are reports that emission levels during the pandemic have decreased in many parts of the world. Likely causes include- reduced transportation and mobility of people as well as reduction in manufacturing activities. However, we need to understand if such reductions on environmental impact is spontaneous consequence or related to established sustainability practices in manufacturing firms.

Use of digital technologies has been intensified in the fight against the pandemic. The competitive implications of such efforts both in relation to the pandemic as well as in relation to other aspects of interest such as resilience and sustainability. Embarking on digitalization, building resilience capabilities to keep or recover performance affected by disruption and having better sustainability all require investment and consume valuable and limited company resources. If we are able to identify possible synergies between practices towards resilience against disruptive events, and sustainability achievement it could help us devise ways of enhancing operational performance over time with limited compromise on other objectives and resource consumption.

This paper is primarily concerned with understanding the existence and nature of relationships among the constructs: digitalization, disruption management capabilities,

and subsequent possible impact on manufacturing competitiveness following the Covid-19 outbreak. The paper sets to answer the research questions:

RQ1: What relationships exist among resilience, sustainability, and digitalization upon prevalence of unanticipated disruption?

RQ2: Are there differences among these relationships for SMEs and other manufacturing companies?

2 Theoretical background

In this section, a brief presentation of the conceptual underpinnings of the constructs of interest in this study is provided.

2.1 Digitalization

Digitalization refers to enabling, improving, and transforming operations, functions, models, processes, or activities by leveraging digital technologies [1]. It can also be understood as the application of digital information and means to fundamentally change intra- and inter-organizational decision structure, processes, and architectures [2]. Digitalization is changing the way data and communication flows in the workplace including manufacturing shop floor. “Almost real-time” data is providing possibilities for more proactive decisions, augmented reality and human robot collaboration is being experimented in manufacturing setting.

Digital technologies enabling industry 4.0 are regarded to provide immense opportunities for better value creation, that SMEs could advance manufacturing productivity, flexibility and competitiveness [3–5]. For example, the most dominant benefits reported in literature include better quality measured as reduction in errors, better logistics and time saving [4]. Famously mentioned challenges of digitalization include data security issues and the commitment to keep up with high technical requirements.

2.2 Disruption management – resilience

Disruptions can be triggered by unanticipated incidents that critically affect the normal flows (materials, information or cash flow) in a manufacturing setting [6], leading to severe unwanted consequences. A disruption can be an outcome of a chain of events. Natural disasters, supply shortages, financial crises demand shifts, quality problems and labour disputes have been mentioned as popular triggering events for disruptions of manufacturing supply chains [7]. The negative financial and social consequences from Covid-19 disruption have been felt globally. It revealed flaws of system interdependencies, disrupted logistics flows, and forced manufacturers to downsize operations.

Risk management literature suggests that companies, big or small need to build proactive and reactive capabilities to be resilient in managing unpredictable disruptions which they will inevitably experience somehow in some form [8, 9]. Creating different flexibilities and redundant assets and capabilities are generally regarded to enhance resilience of firms to disruptions [9, 10]. A key element in the discussion of resilience in manufacturing enterprises is how different organisations make synergistic arrange-

ments not only to deal with disruptions but also to positively influence different performance dimensions, be it environmental sustainability or operational output, [11] during “normal” circumstance [12, 13].

2.3 Sustainability practices

Sustainability can be viewed from either a practice or a performance perspective. When sustainability is viewed as practice, it is about initiatives, structures, routines, or even strategic items such as awareness improvement and sustainability management system that are actively undertaken by a company [14, 15]. Most of these practices are internally focused while others could be induced from external pressure such as customers or regulators [16]. Companies seem to better engage in sustainability practices when they perceive associated competitive advantage.

Sustainability as performance [e.g. 17] is essentially a set of metrics to measure what has been achieved in terms of important targets ex-post (i.e. items under the triple bottom line). Typically, part of the economic sustainability is captured in traditional operations performance measures such as cost. Distinction can be made between local (e.g. manufacturing plant) and global sustainability measures. Manufacturing firms with better competences are likely to use more (sustainability) practices successfully and subsequently drive better competitive performance [18].

3 Methodology

3.1 Literature review

The study started with a systematic literature review. Using Scopus® database, the search query shown in Table 1 has been used. The query included aspects of sustainability, digitalization, operational performance and prevailing context. In this search context has been prescribed as a form of disruption or pandemic having implication on business activities. The intent is to explore if extant literature has identified some relationship among the parameters of interest in prevalence of pandemic or disruption.

The search resulted in an initial list of 181 papers (as of 22 February 2021). Manual picking by reading titles enabled to identify 38 papers. By skimming through the abstract, a shortlist of 20 relevant papers has been produced for more detailed review. These papers have been published in the years 2018 (3 papers), 2020 (13) and 2021 (4).

Table 1. Literature search query

Subject	String (<i>search in title, abstract, keywords</i>)
Sustainability:	<i>(Sustainab* AND (economic OR environment* OR social) AND</i>
Digitalization:	<i>Digital* OR innovation OR "advanced manufacturing" OR tech-</i>
Performance:	<i>nolog*) AND ("operation* Performance" OR quality OR cost OR</i>
	<i>flexibility OR dependability) AND</i>
Context:	<i>(disruption OR pandem* OR outbreak OR lockdown)</i>
Include only:	Articles, chapters, reviews, books, editorials; written in English

Some of the reviewed papers from the shortlist are presented in Table 2 with synthesized relationships among constructs.

3.2 Event study in the Covid-19 context

The potential relationships among the constructs of interest identified in extant literature have been synthesised through the literature review. A subsequent event study based on news items published about businesses in relation to the pandemic in international media has been employed. The event study aimed at empirical exploration for possible relationships among the four parameters of interest in the context of Covid-19 that is considered the preliminary trigger of decisions and actions by companies.

Initially Financial Times®, Reuters® and a few local business news outlets have been the primary considerations. Integrated search capabilities and easier classification of business news items in FT was a main reason for the choice. More than 100 news items have been collected in the initial round. Almost half have been excluded after reading each item for the lacked attributable relationships at least between two constructs. Each news item could have addressed multiple relationships between constructs or even multiple companies and industry sectors exhibiting possibly different relationships that were accounted for in the study.

Coding of the constructs followed measurement items identified from the literature review. For example, operational performance has been coded using 9 items such as operating cost, revenue, flexibility, lead time/speed, quality, and productivity, see [e.g. 19]. Resilience has been coded using 14 proactive and reactive capability practices as proposed in Dabhilkar *et al.*, [9]. Sustainability has been captured using items that reflect social (e.g. fair working conditions, equal opportunity, work-social life balance), environmental (e.g. efficient energy and material use, recycling, decarbonisation, afforestation actions) and economic (e.g. fair economic gain/income) dimensions. There were two issues here: (1) some of economic sustainability items have been covered in operational performance that duplication had to be avoided, (2) differentiating between sustainability as performance and as practice has been somehow difficult. Digitalization was coded using items of technology and organisation including robotics and artificial intelligence (AI), work place automation, use of data connectivity and e-commerce platforms, digital technology as core business. The trigger event of Covid-19 has been captured using major observable indicators as identified in public media and government other organisational communications (9 items). These included movement restrictions/logistics hindrance, work from home, limited service availabilities, infection spread and so on. This way, it was possible to establish relationships among items prescribed under each of the constructs brought together in the study.

4 Findings

4.1 Findings from literature

Extant literature provides some episodes of relationships among the constructs represented by the three sub-domains mentioned. The empirical sources for these relationships have mainly been big companies.

Table 2. Summary of findings in extant literature

Ref.	Identified/implied findings	Relation
[20, 21]	Digitalization (industry 4.0) leads to better sustainability in the covid-19 lockdown situation	DIG→SUS
[22]	Covid-19 lockdown leads to carbon emission reduction	DIS→SUS
[23]	Digitalization helps to foster business networking which is enabler for improving operational performance during global technological shift	DIG→PER
[12]	Recovery of operations performance can be coupled well with sustainability improvement; Business model redesign is forced by the Covid-19 pandemic	RES→SUS
[24]	Infrastructural innovation (and digitalization) helps to foster post-pandemic green economy	DIG→SUS
[25]	Digitalization as a means to drive flexibility	DIG→PER
[26]	Performance in health care should adapt to accommodate for resilience and sustainability	(RES, SUS) → PER
[27]	Sustainable supply chain network (closed loop supply chain) should help to deal with disruption situations	SUS→RES
[13]	Covid-19 as opportunity to improve TBL; learning from covid-19 in energy sector for better resilience	DIS→(SUS, RES)
[28]	Flexibility and social aspects of sustainability become communication focus points after pandemic	SUS ↔ PER
[29, 30]	Positive environmental impact observed after Covid-19 lockdown; (better) waste management strategies observed in developing countries during Covid-19	DIS→SUS
[31]	Sustainability to reduce impact from future pandemic	SUS→RES
[32]	Covid-19 situation motivated more digital services	DIS→DIG

Note: DIG=Digitalization; DIS=Disruption; SUS=Sustainability; PER=Operational performance; RES=Resilience

Here are a few example relationships as compiled from extant literature (compilation presented in Table 2):

- (1) Digital transformation complements innovative capabilities leading to better sustainability performance achievement [e.g. 20]. However, the detail aspects of this relationship remains under-researched for manufacturing SMEs [33].
- (2) Sustainability can drive realisation of innovative approaches [34], including digitalization. Obviously, the conceptual abstraction of sustainability here is different from the aforementioned one.

- (3) Recent studies argue that digitalization implemented both in manufacturing core processes as well as across support organisation is more likely to create and channel superior or augmented value across a value chain [2].
- (4) Studies have contended that resilience practices and sustainability (either as practice or performance) could be positively correlated [e.g. 11].

Combining all these relationships of the three constructs of interest brings in a new perspective to look at prevailing circumstances that could help us better understand how manufacturing firms, continue to remain economically viable and keep on improving environmental impact from manufacturing activities post-pandemic.

One can notice that pandemic/disruption as context is the starting point/trigger for all actions or consequences. One directional relation is discussed in literature among most of the constructs, all leading to operational performance implications (except sustainability that could be affected due to changes in operations performance).

4.2 Findings from event study

The preliminary empirical exploration sheds light on some relationships noticed during the Covid-19 pandemic. Fig. 1 shows a depiction of initial analysis. In the figure, arrows represent the direction of causality as interpreted from analysed descriptions. The numbers in bold represent positive relationship while those in parenthesis represent negative relationship in the direction indicated by the corresponding arrow. The existence and the relative strength of relationships is more important than the actual number of reported events. The figure shows that empirical relations identified appeared to be on directional. This has not been prescribed except that of Covid-19 as the triggering event of disruption. Furthermore, while both positive and negative relationships could have been likely, only a few relations have shown both.

One can clearly observe that the pandemic has fostered or expedited the need for more digital integration in some form in several businesses. Dominant part of the digitalization related to either digital technology as core business (e.g. technological companies) or digital augmentation to sales and delivery aspects of business. Only a few companies reported on the application of robotics and AI in a manufacturing context.

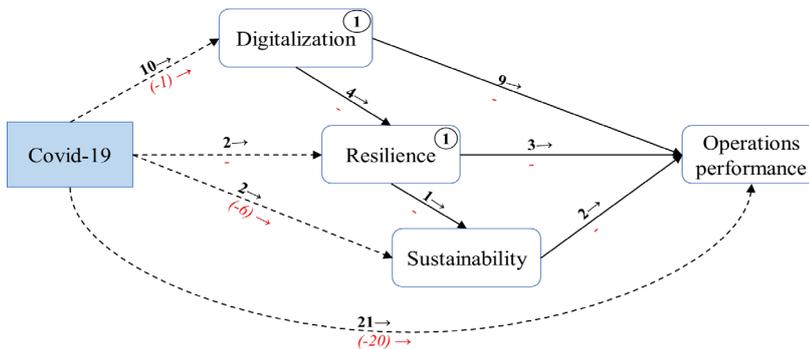


Fig. 1. Empirically identified relationships

The impact of the pandemic reported on performance has been mixed. In many cases, reduction in performance has been reported. This applies to, for example, reduction in revenue, increase in costs of manufacturing, and delays. On the other hand, a few sectors have reported pronounced increase in their revenue streams or demand for their products/services. Typical ones include the technology companies, logistics service providers and pharmaceuticals. It is also interesting to note that the increase in revenue streams has been coupled with increases in some form of digitalization.

The need and motivation for enhancing resilience capabilities of businesses has increased following the outbreak of the pandemic. Therefore, many companies scrambled to do something to get their affected business out of crisis.

Out of the items under each construct compiled from literature for observing the relationships, a portion have been over represented. For example, out of fourteen practices under resilience only four items were represented in the empirics. Most items in digitalization observed, indicating the strong potential it has to address several issues. Except for Covid-19 as trigger of disruption, the other constructs seemed to have positive influence on operational performance and among each other. Compared to what the literature review suggested, the empirical finding so far did not capture the possible link from operational performance to sustainability in the scope of this study.

5 Discussion

Consistent with the conceptual discussions, the economic benefits of digitalization during the pandemic have been apparent. The stress the pandemic put on existing technical and regulatory structures have revealed the need for improvement and changes. The (limited) environmental sustainability gains obtained did not seem to have resulted from systematically established practices. They came rather as “conjoint” effects. Despite the potential benefits understood, establishment of sustainability as systematic practice seems limited.

Even though uni-directionality of relations needs to be further explored, it has been noted that manufacturers and other businesses could exercise sustainability and resilience practices to keep up performance in multiple dimensions. In terms of social sustainability, multiple news items reported that productivity seemed to increase despite deteriorating social-work conditions due to lockdowns, which could be worrying from long-term perspective.

Large companies often report achievements in sustainability performance. And continued achievement of sustainability performance improvement requires employment of sustainability practices. Large companies impose demands for some sustainability performance on their suppliers, some of which may be SMEs. However, not every supplier SME is able to effectively address sustainability issues through implementation of coherent and comprehensive processes and practices. However, the implications of digital technology application in manufacturing cannot be just extrapolated from earlier studies. SMEs are often mentioned as lagging in extent of digitalization [35]. Even those that managed to do so, prioritize small scope technical solutions such as factory shop floor technologies [36, 37]. At the same time, changing industry circumstances

seem to favour towards pursuit of flexibility and digital transformation even in small companies [11, 38]. The empirical analysis seems to suggest that even with the limited resources, SMEs seem to be able to leverage synergies between resilience and sustainability when affected by the pandemic.

In terms of resilience, mostly reactive capabilities were exploited during the pandemic. Even so, companies that had the agility to take swift measures in response to the disruption situations gained prime-mover advantages. In line with the resilience discussion in earlier studies [9], empirics indicate that proactive resilience capabilities can support better reaction resilience upon disruptions.

6 Concluding remarks

The preliminary findings illustrate that it is possible and beneficial to create comprehensive view that jointly looks at resilience, sustainability and digitalization efforts in a manufacturing setting. Variations in the observed relations among the constructs (e.g. SMEs versus large firms) imply that more focused investigation is needed to understand underlying phenomena better.

With financial downturn following the Covid-19 pandemic, it is very likely that an increased number of SMEs may go bankrupt; besides, the ones that survive will have tough time to keep up practices and initiatives for better economic, social and environmental sustainability [16, 17]. These issues are cyclically connected in crisis situations: financial well-being of SMEs implies better social conditions; if social conditions deteriorate, people may take less (if not destructive) roles in combating environmental sustainability; and so on. This calls for further exploration.

As part of the limitation, more work is needed to scrutinise this initial event study through expanded database as well as a further structuring of content analysis from the news items. Statistical analysis on larger sample size could also help to identify areas of more significant relationship and impact for better sustainability and competitiveness of manufacturing organisations belonging to different size and sectors.

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