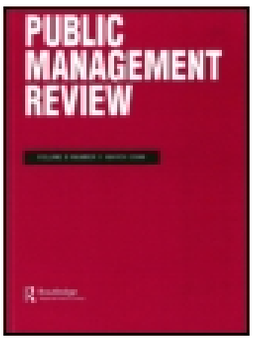

Public Management Review

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rpxm20

Responding to information asymmetry in crisis situations: innovation in the time of the COVID-19 pandemic

Wendy Phillips, Jens K. Roehrich & Dharm Kapletia

To cite this article: Wendy Phillips, Jens K. Roehrich & Dharm Kapletia (2021): Responding to information asymmetry in crisis situations: innovation in the time of the COVID-19 pandemic, Public Management Review, DOI: 10.1080/14719037.2021.1960737

To link to this article: https://doi.org/10.1080/14719037.2021.1960737

Published online: 06 Aug 2021.

PUBLIC MANAGEMENT REVIEW
https://doi.org/10.1080/14719037.2021.1960737

Routledge
Taylor & Francis Group

Responding to information asymmetry in crisis situations: innovation in the time of the COVID-19 pandemic

Wendy Phillips[a], Jens K. Roehrich[b] and Dharm Kapletia[a]

[a]Bristol Business School, The University of the West of England, Bristol, UK; [b]HPC Supply Chain Innovation Lab, Information, Decisions and Operations Division, School of Management, University of Bath, Bath, UK

ABSTRACT

Crises test the resilience of public service organizations. Healthcare providers must respond and innovate within tight constraints to address challenges. Presenting COVID-19 as a knowable unknown (black swan event), we adopt information processing theory to investigate how healthcare providers and their suppliers address information asymmetry to support decision-making. Building on primary and secondary datasets, we demonstrate managers were innovating internal structural responses. For black swan events, in-house 'intelligent clients' are intrinsic not only in managing information uncertainty associated with early stages of the crisis, but also in addressing information equivocality and joint decision-making with other organizations associated with implementing solutions.

KEYWORDS Crisis situation; information processing; information asymmetry; public services; pandemic; innovation

Introduction

The twenty-first century has seen several pandemics, including SARS, MERS, H1N1, and most recently COVID-19 (Kim 2020). The last is on an unprecedented scale and may ultimately infect upwards of a billion people, disrupting the lives of most of the World's population (IRC 2020). Catastrophic events, such as economic and humanitarian crises, can change the way in which organizations do business (Rosenberg 1969; Martin-Rios and Pasamar 2017; Ansell and Torfing 2020), shifting the 'rules of the game' requires organizations to 'do things differently' rather than 'doing things better' (Bryson 1981; Phillips et al. 2006). Shocks to the system, such as COVID-19, force organizations to alter the way they work and make decisions, and creating the urgency to innovate (Li and Tallman 2011).

Managing such shocks, or black swan events (Taleb 2010), or before their occurrence -'unknown unknowns' (Rumsfeld 2002; Feduzi and Runde 2014), presents major problems for organizations, but prior work has shown innovation may be an effective response (Wenzel, Stanske, and Lieberman 2020). Significant research has investigated 'known unknowns' (Ramasesh and Browning 2014), but less is known about

CONTACT Wendy Phillips wendy.phillips@uwe.ac.uk

mitigation against '*knowable* unknowns', which organizations could have foreseen but for some reasons have not (yet) (Ramasesh and Browning 2014; Feduzi and Runde 2014). Here, managers need to be swift decision-makers and embrace organizational innovation – undertake new-to-the-organization management activities to motivate employees, coordinate activities (internally and with other organizations), and use, gather and distribute relevant information (Damanpour, Walker, and Avellaneda 2009). This is especially challenging for public service organizations (PSOs), which are government-owned and face additional burdens of navigating, for instance, regulatory frameworks, public safety standards, and often hierarchical, siloed, and bureaucratic processes that may hinder rapid and effective responses (O'Flynn 2020).

We argue COVID-19 is a knowable unknown – many organizations and governments were warned and aware of the catastrophic impact of a possible major global pandemic (e.g. Cabinet Office 2017; Office of the Director of National Intelligence 2019). PSOs have faced other such 'wicked problems' such as terror attacks, climate events, and a global financial crisis, raising the question of how public innovation, cross-boundary collaboration and more resilient governance strategies can be achieved (Weber and Khademian 2008; Ansell and Torfing 2020) to address future black swan events. These events are characterized by information asymmetry; faced with the need to act swiftly, an organization may lack appropriate amount and quality of information (uncertainty) or must deal with information messiness (equivocality) (Galbraith 1974; Dahlmann and Roehrich 2019; Aben et al. forthcoming).

Currently, limited theoretical and empirical insights exist into how organizations address information asymmetry in black swan events. Research is needed to help underpin solutions leading towards more adaptable forms of governance in PSOs. Our study addresses this gap by drawing on information processing theory (IPT), an under-explored (but powerful) theoretical lens for exploring how PSOs address information asymmetry in black swan events to drive innovative decision-making. Thus, this paper contributes to calls for further research to understand the impact of turbulent events (such as black swans) on effective public service governance (Ansell and Torfing 2020; O'Flynn 2020) by investigating the following research question: *How do public service organizations innovate to address information asymmetry and drive decision-making in a black swan (knowable unknown) event such as COVID-19?*

We examined the UK healthcare sector, a crucial sector tackling COVID-19, that throughout the pandemic has been confronted with information asymmetry (Flanagan and Collins 2020). Within healthcare organizations, the importance of effective information and knowledge management was apparent as pharmaceutical companies searched databases for relevant treatments, and medical device manufacturers struggled with processing requests as demand for their products increased exponentially (BSI 2021, 21). We primarily focused on the practices of healthcare PSOs and included insights from private sector suppliers to healthcare PSOs to develop our understanding of information asymmetry during the pandemic. Our research approach draws on datasets including interviews, organizational and government reports. The UK healthcare sector offers a revelatory sector to study information asymmetry in a black swan situation (COVID-19), highlighting some of the principal innovative responses associated with addressing information asymmetry and the need for rapid decision-making.

Building on prior studies highlighting failings in public sector policy, strategy, and practice, our study calls for a systematic organizational response to crisis decision-

making, highlighting the lack of a so-called (internal) 'intelligent client' capability (Czerniawska 2007). The intelligent client can establish their organization's needs and select the right supplier(s), effectively managing the suppliers to ensure an appropriate response is delivered. Using the 'management of information' as a proxy, our contribution highlights the important role of the intelligent client in black swan events, going beyond extant studies which have cited its utility for business-as-usual procurement and complex projects (Aritua, Male, and Bower 2009). In contrast to 'business-as-usual' decision-making situations, crisis situations are characterized by decision-making in which information uncertainty is addressed first by collecting information to allow initial and individual organization's decision-making, while later phases address information equivocality and joint decision-making with other organizations.

Literature review

Innovation in public service provision

Categorizing organizations' strategic responses to crises, Wenzel, Stanske, and Lieberman (2020) positioned four different approaches: retrenchment, persevering, innovating, or exit. While *retrenchment* refers to a decrease in an organization's scope of activities (e.g. reductions in costs, products, assets, and product lines), *persevering* is a 'business-as-usual' approach, which although effective in the medium term, may depend upon the availability of slack resources that can be drawn upon during the crisis. *Exit* is unlikely to be an option for PSOs, yet it may form the basis for 'strategic renewal' (Wenzel, Stanske, and Lieberman 2020, 6). The final approach is *innovating* in which firms identify opportunities arising from the crisis. This approach may be an effective response if the crisis persists into the long-term, but requires substantial use of resources and capabilities that may have petered out if organizations have initially adopted retrenchment or persevering responses. Our study's focus is on the innovating approach in crisis situations when organizations need to ensure public service delivery.

Drawing on recent public management research, we adopt the following definition of public service innovation '[. . .] the development and implementation of a novel idea by a Public Service Organization (PSO) to create or improve public value within an ecosystem' (Chen, Walker, and Sawhney 2020, 1677). The debates on the extent to which PSOs are engaged in innovation (from minimal efforts to systematic institutionalizing of innovation activities) leads us to consider whether such entities accept and engage in risk-taking, rather than seeking to minimalize risk or its effects (Brown and Osborne 2013; Hjelmar 2021). Such debates may be seen in a new light when responding to a crisis event or taking decisions to ensure a better response in the future. In such events, public and private organizations must operate within a time-compressed situation to deliver what Bessant, Rush, and Trifilova (2015) term 'crisis-driven innovation'; organizations undertake an agile approach: acceptance of fast failure, rapid experimentation, and learning and deployment of 'scrum teams' (Morris et al. 2014). Such agility may call for organizations to operate virtually, as opposed from 'bricks-and-mortar' sites, to quickly acquire dispersed and differing information (Wilson and Doz 2011).

Providing a useful means of distinguishing relevant forms of innovation and how they impact PSO strategy, capacity, and operations, Chen, Walker, and Sawhney (2020) proposed six types of public service innovation. The six types are divided

between an *internal* (mission, management, service), and *external* (policy, partner, citizen) innovation locus. Focusing on an internal PSO orientation, *mission innovations* involve the introduction of a new purpose or worldview, for example, large-scale transformation to address the current climate and ecological emergency. *Management innovations* include the adoption of a new (to the organization) practice, process, structure, or technique (technological or administrative) to improve the PSO's ability to further organizational goals (Walker, Damanpour, and Devece 2010; Roehrich et al. 2019). This type of innovation is likely to underpin the ability to marshal internal staff and resources quickly and effectively to an unexpected event. *Service innovations* are described as the visible result of public service innovations which may be the result of how all other types of innovation are applied and experienced by the clients of PSOs.

Where PSOs are ill-equipped to tackle black swan events, it is critical to work closely with external organizations. Chen, Walker, and Sawhney (2020) argued that *policy innovations* can deliver new obligations and benefits to citizens, directing a PSO's resources to a relevant ecosystem, which in an emergency situation, can provide critical direction and support to where it is needed most (Torfing and Ansell 2017). *Partner innovations* provide PSOs with the ability to leverage competencies that exist outside the organization, which avoids having to replicate those assets in-house. Crisis situations rely on effective sharing of information, skills, resources, and the combined effect of whole systems working together (Ansell and Torfing 2020). Lastly, *citizen innovations* establish new platforms to facilitate collaboration between citizens and PSO managers, and if the citizen are involved in the innovation process, they have also become an active co-creator of services (e.g. calls for the greater use of citizen assemblies by environmental activist groups and the importance of public service co-production of environmental outcomes; Alonso et al. 2019). Although useful for this study, we argue the need for further research to better understand how these innovation types are initiated and deployed in crisis situations, where the challenge of accessing and collecting relevant information may hinder innovative decision-making within PSOs.

Decision-making during black swan events: managing information asymmetry

Prior studies have investigated how to manage 'known unknowns' (e.g. costs and duration of defined activities), but provide limited insights into how organizations manage black swan events (Ramasesh and Browning 2014). Known unknowns are 'uncertainties which can be described probabilistically and addressed through the conventional techniques of risk management' (Ramasesh and Browning 2014, 191). In line with Taleb's notion of 'black swans' (Taleb 2010), unknown unknowns are situations 'when unexpected, surprising outcomes are encountered resulting in potentially catastrophic outcomes'.

Feduzi and Runde (2014) delineate such black swan events into two further categories: (i) 'knowable unknowns' or 'knowable black swans" are events that could have been foreseen by an organization, and had the potential to be known unknowns; and (ii) 'unknowable unknowns' are unknown unknowns that cannot be foreseen or known and, despite access to all possible information, could not be transformed into known unknowns. Feduzi and Runde (2014) go on to offer 9/11 as an example of a knowable black swan event, or knowable unknown. Although for most individuals, 9/11 was an unknowable black swan event it was knowable for some. Two years prior to

9/11, the North American Aerospace Defence Command (NORAD) had contemplated the use of airliners as missiles, going so far as to simulate such attacks on both the World Trade Centre and the Pentagon (Feduzi and Runde 2014).

We argue that for the COVID-19 pandemic, governments were warned and aware of the catastrophic impact of a possible major global pandemic but demonstrated limited preparedness. For instance, in response to the 2009 Swine Flu outbreak, the UK government created a national pandemic stockpile of healthcare supplies (Channel 4 News, 7 May 2020) and the most recent UK national risk register identified a pandemic as having the highest impact with one of the highest likelihoods to occur (Cabinet Office 2017). Given all this, one might expect a high level of preparedness by those most likely to be affected (e.g. the UK's National Health Service (NHS), care services and providers – Flanagan and Collins 2020), but this was not the case – over the last decade the UK pandemic stockpile was greatly reduced and much of the remaining stock out-of-date (Channel 4 News, 7 May 2020).

Black swan events (knowable unknowns) are characterized by information asymmetry- an organization either lacks relevant information (uncertainty) or needs to deal with information messiness (equivocality) in order to make decisions in a time-bound manner (Galbraith 1974; Turner and Makhija 2012). In the UK and beyond, healthcare organizations responsible for developing a COVID-19 response are not limited to the public sector and include, for instance, private healthcare providers and suppliers of essential equipment and services, often resulting in misalignments in terms of policy and objectives (Caldwell, Roehrich, and George 2017). Moreover, organizations are often confronted with conflicting information that may not be aligned to achieve a shared goal (Dahlmann and Roehrich 2019; Aben et al. forthcoming), which is necessary if quick decisions must be made to save lives. For this research we focus on implications for PSOs and how they manage information internally, and where relevant, collaborate with external organizations in the provision of public services.

Based on information processing theory (IPT), an organization's abilities to process information in a more accurate and timely manner manifests in superior performance (Galbraith 1974; Yu et al. 2019). For this study, these abilities result from an organization's knowledge and skills in collecting, interpreting, and transferring relevant information to the characteristics of the black swan event. Reducing information asymmetry (uncertainty and equivocality) within and between organizations is vital to achieve high performance (Corner, Kinicki, and Keats 1994; Zhao, Feng, and Shi 2018). The more uncertainty and equivocality organizations are exposed to (which is high in black swan events), the more information needs to be gathered and processed to realize a given performance level (Burns and Wholey 1993; Dahlmann and Roehrich 2019). Whereas collecting more information and starting to make sense of it following an intelligent client approach reduces an organization's information uncertainty, equivocality requires cognitive skills by managers and organizations and an analytical ability to distinguish novelty, likely utility, and opportunist market behaviours (Taylor 2019). Collected data are often ill-structured, potentially difficult to evaluate, requiring more than one organization to make sense of it (Daft and Lengel 1986; Bode et al. 2011). In the context of complex public services, information also needs to be transferred to other key organizations to ensure collaborative decision-making and a coordinated response.

In past studies, IPT has, for example, been used to assess the impact of internal manufacturing complexity on the organizations' triple bottom line (Wiengarten et al.

2017), and to study the mechanisms managers can use to create internal strategic consensus (Rosado Feger 2014). Recent work has extended IPT to an inter-organizational level, addressing how organizations develop information-processing capabilities to deal with supply chain disruptions (Bode et al. 2011) and sustainability-related uncertainty (Dahlmann and Roehrich 2019). So far, limited attention has been paid to information asymmetry in black swan events, and how organizations address information asymmetry to deliver public services (an exemption is the study by Aben et al. forthcoming). Black swan events are typified by some information being available, often outside the organizations. For instance, for COVID-19, information on pandemics could be found in the UK's national risk register (Cabinet Office 2017). This information is often quite messy, and must be interpreted for the specific informational needs of an organization. For the healthcare sector to offer a more concerted response to COVID-19, critical information must be shared between organizations.

Methods

Research setting and design

We conducted an in-depth case design of key UK healthcare organizations, allowing us to address the question of how public service organizations innovate to address information asymmetry, and drive decision-making in a black swan (knowable unknown) event such as COVID-19. Consistent with our objective of identifying an explanation of a complex phenomenon in its natural context (Eisenhardt and Graebner 2007), we adopted a case study approach which yielded multiple observations of complex decision-making challenges.

While the multiple case organizations we investigated do not provide the confidence of a large *n* sample (as given in a survey), multiple factors deemed the adopted approach particularly appropriate. First, the UK healthcare sector was identified as an ideal case setting due to its inherent information asymmetry and required innovative decision-making in confronting a black swan situation (viz COVID-19). Second, our study focused on public and private organizations to deliver vital public services (namely healthcare services). Over the past 20 years, several parts of the UK healthcare sector have been privatized (similar situations can be found in healthcare sectors around the world – Barlow, Roehrich, and Wright 2013; Wright, Barlow, and Roehrich 2019) and services affected by COVID-19 are also delivered by the private sector or through public-private relationships (e.g. General Practice (GP) surgeries, older people's services and end-of-life care – (Roehrich, Lewis, and George 2014; The King's Fund 2019; The Health Foundation 2020). Relationships between public and private organizations often experience information asymmetry due to different objectives and goals of public and private organizations (Roehrich and Kivleniece forthcoming).

Third, accessing such a commercially sensitive topic (information processing) by interviewing front-line managers and directors during a live black swan event is rare. Previous studies have focused on 'disasters' caused or created by organizational failures (e.g. Gephart 1993; Labib et al. 2019). For instance, Weick (1993) analysed the 1949 Mann Gulch fire to 're-examine our thinking about temporary systems, structuration, non-disclosure intimacy, intergroup dynamics, and team building' (p. 628). Similarly, the emergence of the sub-field of supply chain risk, for example, has been directly

influenced by the impact of events such as the 2008 economic crisis or the Japanese Tsunami or Mattel's problems with lead paint (e.g. Chopra and Sodhi 2014). These studies often relied (solely) on secondary and retrospective data collected where were analysed by somebody other than the researcher (e.g. Brown 2004; Kalra, Lewis, and Roehrich 2021). In contrast to previous studies on crisis events, we had the unique opportunity to collect 'live' data during COVID-19.

Data collection and sources

We used a two-stage recursive strategy. In stage 1 (April 2020), we interviewed a crisis expert to understand key aspects of information asymmetry and particular challenges of a black swan event, as well as collecting and analysing over 40 external policy and industry reports (Gibbert, Ruigrok, and Wicki 2008) including the UK National Risk Register for National Emergencies, Channel 4 News reporting on personal protective equipment (PPE) shortages, and OECD investigation into industry response to the 2008 crisis. This helped us to develop a storyline of the pandemic including, but not limited to, the initial awareness of the threat of a global pandemic, evidence of information asymmetry in the sector and the challenges posed by these asymmetries.

In stage 2 (April – May 2020), we conducted, recorded, and transcribed ten additional semi-structured interviews with informants to help us better understand an organization's specific information asymmetry, innovative responses, as well as the how information was collected, interpreted and transferred to make decisions. An interview protocol facilitated our semi-structured interviews, and included general questions oriented towards understanding the particular challenges of information uncertainty and equivocality, before delving deeper into the key activities and innovative responses by the organization. Collecting data in real-time (i.e. during the ongoing COVID-19 situation) helped to minimize respondents' biases (Golden 1992) as we spoke to key decision-makers in the UK healthcare sector during the early stages of the COVID-19 pandemic.

Across both stages, we collected over 65 pages of interview transcripts (single spaced), putting great effort into gathering reliable and objective information from informants (Alvesson 2003) primarily involved in procurement, where the major challenge was to develop innovative responses to deliver immediate support and equipment to healthcare workers. We interviewed ten senior experts with established careers in the UK healthcare sector (Heads and Directors), across disparate hierarchical and functional roles (covering procurement, finance, and human resources) from key PSOs and their public service suppliers (Table 1) to access diverse perspectives, allowing data triangulation. Organizations and interviewees were selected based on their first-hand experience of managing their organization's response to COVID-19 and visibility of sector-wide interventions. Individual interviewees represented functions with either local, regional, national and, in some cases, international responsibility. Data gathering continued until an in-depth understanding of the phenomena under investigation was reached and additional data were not relevant to the development of new insights.

We applied specific criteria and measures to ensure validity and reliability of our findings (Gibbert, Ruigrok, and Wicki 2008) including, but not limited to, deriving a research framework from extant literature, and offering clarity about how data were collected and analysed. All interviews were recorded and transcribed, and subsequently

Table 1. Profile of interviewees and their representative organizations (incl. interviewee's functions and scope of responsibility) *(NB: Due to request for anonymity, the specific job titles for each interviewee have been omitted).*

		Interviewee's function			Interviewee's scope of responsibility			
Organization	Public or private	*Procurement*	*Finance*	*HR*	*Local*	*Regional*	*National*	*International*
A. Local Government Authority • Involved in the sourcing and distribution of PPE	public							
B. Healthcare Service Purchasing Consortium • Provides purchasing services to support local Trusts and Healthcare Providers.	public							
C. Healthcare Service Purchasing Consortium – Complex Regional Project • Provides purchasing services to support complex regional project	public							
D. Healthcare Aviation Platform Service Support • Provides purchasing services support to Air Ambulance services	private							
E. Marine Engineering Service • Provides purchasing services to blue light services	private							
F. Infrastructure Investment Service • Investment funding for UK infrastructure projects (cross-sector, includes healthcare)	private							
G. Hospital Procurement Service • Single service acquisition of medical supplies/resources for a university hospital	public							
H. Healthcare Service Regional Hub • Shared service acquisition of medical supplies/resources for healthcare system institutions	public							
I. Healthcare Service City Hub • Shared service acquisition of medical supplies/resources for healthcare system institutions	public							
J. Healthcare Service City Hub – workforce • Shared service acquisition of medical supplies/resources for healthcare system institutions	public							

reviewed by the respective informants. Finally, we maintained a database with all interview data and documents used in the analysis to increase transparency and reliability.

Data analysis

Data collection and analysis processes were conducted in parallel based on how data matched existing or emerging understanding of the phenomena under study (Strauss and Corbin 1990). This 'ground-up' approach helped to develop theory which is closely linked to our data (Golden-Biddle and Locke 2007). The data were carefully analyzed in a multi-stage process. In the first stage, we analyzed our rich archival data and initial interviews. This helped us to understand better the healthcare industry, and the current challenges facing the industry during COVID-19. This step was vital before analyzing in-depth the remaining interviews with key informants. In Stage 2, we analyzed interview data to understand the details of information asymmetry, and how organizations addressed them by collecting, interpreting, and transferring information to drive innovative decision-making.

Analysis included broader codes such as case organization, background information, and more specific codes focusing on the concepts of our study such as information uncertainty and equivocality, innovative responses, information gathering, sensemaking, and transferring. Each researcher initially created a list of first-order codes based on extant literature which was then compared with each other. Differences were jointly discussed until finalizing a working coding scheme to individually code the first interview. We also added to the coding scheme key information processing practices that arose from the data analysis, but which had not appeared in extant literature. All our findings were discussed across all co-authors to aid understanding of key concepts and relationships. Differences were resolved by trying to reconcile differing interpretations. Thus, our coding was not completed until we reached consensus on each construct, forcing 100% interrater reliability. The analysis focused on investigating patterns across organizations in addressing information asymmetry in the healthcare sector when faced with a knowable black swan situation. Our findings were later cross-checked with key informants and archival data.

Findings

This section presents the case analyses, supported by empirical evidence presented in Tables 2 and 3. First, we uncover key challenges organizations faced during COVID-19 and how they responded. Then, we unpack the key activities organizations conducted in addressing information asymmetry.

Responding to challenges posed by COVID-19: public service innovation

Based on all interviewees, few public and private organizations were ready for the global pandemic. Although pandemics were identified as a high risk at the UK country-level (Cabinet Office 2017), Interviewee F suggested this appeared to have not translated into high-level industrial planning: '*We have assets of about £1.2bn invested in UK healthcare projects, schools, renewables and social housing. [. . .] I cannot recall one of*

Table 2. Overview of challenges and innovation responses across interviews.

Case	Key challenges due to the COVID-19 crisis	Related challenge quotes	Public service innovation						
			Response	I	II	III	IV	V	VI
A	Rapidly changing supply chain – needed to react quickly to changes to prices and secure stock before it disappeared	*'It is such a fast-moving supply chain literally stop within like 10–15 minutes- you lose it – the prices are going up all the time. That is why we have created a virtual procurement hub to purchase PPE. That's the main project that we have done major changes on.'*	Established a virtual procurement hub for the procurement of PPE						
B	Needed to switch from reactive to proactive position; also provided support to other organizations lacking healthcare procurement expertise	*'We have had to change the entire structure of our team. Previously we had a team based on very broad categories, but it was more aligned to the structure of the hospitals we serve. We have had to change it into a proactive team which was trying to understand supply chain and investigate how things come in to us'.*	Alter organizational structure from category-focused to supply and need focus, working in remote teams						
C	Reduced lead time from 2–3 weeks to next day to deliver project on time and address potential surge in COVID patients	*'Where we would normally be happy to accept a lead time of a week or two weeks. It has been "Can you get it dropped off this afternoon?"'*	COVID-19 procurement process – Lighter touch procurement process, autonomy to make major decisions and employ team's skill sets						
D	Procured critical consumables for air ambulance services across Europe – needed to react rapidly in changes in price and demand – air ambulances flying less due to diverting of resources e.g. medical crew to supporting land-based hospital staff	*'Not least now because of COVID – we are flying less. So, there could be an additional risk to fixing and committing to buying critical consumables in the future So, understanding that pattern and the demand, clearly and quickly enough, is crucial'.*	Established small team to enable rapid responses and swift decision-making						
E	Procured PPE for blue light services and other production sites and was unable to source PPE from contracted supplier	*'We were where the supply chain through that one supplier became stifled in fact it was the, the NHS has effectively directed all of their priorities into their support and quite rightly. So, we've basically not had any support for PPE on those product lines of all types of respirator masks, surgical masks, protective coveralls and nitrile gloves are the key product lines that we've that we had to react to – globally.'*	Change in sourcing strategy from one contracted supplier to strategic tactical and global sourcing						

(*Continued*)

Table 2. (Continued).

Case	Key challenges due to the COVID-19 crisis	Related challenge quotes	Public service innovation						
			Response	I	II	III	IV	V	VI
F	Pandemics are not considered at board level risk profiles and investments. Limited contingency plans were in place.	*'They [funding recipient of investment] decided that they should suspend operations and put the project on hold and we [the investor] have agreed to an extension. They have reduced the amount of activity but have not suspended the structure. They have had difficulty to seriously execute'.*	Large organizations have quickly changed policy and reconfigured operations utilizing existing technology to overcome challenges, such as remote asset monitoring and virtual working and collaboration						
G	Lack of an optimal configuration between centralized and decentralized procurement	*'There is also a massive tension between local decision-making versus the central procurement office. It is the center that is perceived to fail [. . .] in terms of resilience, there is a massive question'.*	Organizational and process transformation and reconfiguration to respond rapidly; systematically adapt decision-making and redeployment of staff; adapt to negotiations/terms with new suppliers						
H	Dealing with a volatile marketplace around availability of products and services	*'Primarily, we were only dealing with COVID cases and doing nothing, as business as usual apart from key cancer services. [. . .] One minute we were delivering products on a very regular basis to a point of no longer requiring that product, because those procedures were not going on'.*	Organizational and process transformation and reconfiguration, with support from use of national analytics service and advanced inventory systems						
I	How do we know if the supplier and its products and services will exist tomorrow, how do we ensure continuity of supply?	*'Help them [healthcare service providers] in terms of contacting all of their vendors with regards to business continuity plans to make sure that none of the vendors are going to fold or have issues in terms of service and sustainability'.*	Repurposing and reconfiguration of assets and services, thinking laterally to find solutions						
J	Significant disruption to human resourcing on-the-ground, and managing sudden spikes in reductions and increases in demand	*'What we have been doing is being a lot more collaborative in how we work'.; 'I think the speed at which things got done centrally at times, did not meet the pace of where it was needed locally on the ground with the people managing that information'.*	Speed of contracting, and the speed of engagement with diverse groups/ communities – overcoming bureaucratic obstacles						

Innovation response type, based on the typology proposed by Chen, Walker, and Sawhney (2020):

I	Mission innovation
II	Policy innovation
III	Management innovation
IV	Partner innovation
V	Service innovation
VI	Citizen innovation

Table 3. Additional examples of data.

Themes	Supporting representative quotes
(1) *Addressing information uncertainty by collecting relevant information*	*'Working with PHE [Public Health England, a central body] we have had lots of issues with changes in guidance etc. from that point of view. That has caused lots of issues. Certainly, sometimes I have had to get information from our military liaison forum and through the local resilience forum which has been interesting'.* (Interviewee A) *'It is challenging to secure new information, because there are not any local sources of information to browse through, although there are things like insolvency databases. There is a Cabinet Office tool being developed around how to manage new suppliers and risk assessing them. [. . .] We do work with other organizations to share information'.* (Interviewee G)
(2) *Making sense of information to address information equivocality*	*'Having a broader reach on a full group is vital [. . .] A system that is able to pull real time data from each of the different areas of the business would have been advantageous. Because I have to plug the gap by having individuals in each of the business facilitate the information exchange. Which is time- and resource-consuming. [. . .] You could almost circumvent that by having real time data again which is presented to us centrally in a dashboard view'.* (Interviewee E) *'In terms of technology, on the data side of things are pretty archaic. I mean, there has been some tools to capture data [. . .] I mean it is so far behind, not to anywhere near where it needs to be [. . .] but COVID-19 has speeded things up. [. . .] We have now source coding and other things which normally would be held up by red tape or debates on the specification and interoperability. There has been a lot of that stuff signed off and we have been told "just get on with it"'.* (Interviewee I)
(3) *Transferring information to make joint decisions*	*'I probably have about three conference calls a day. I know that the director in purchasing has many more. Where we are talking individually with either Trusts or the command group within the Trust. We talk through where we are with our work. So, they have a national PPE call, they have a local PPE call, they have a local [hierarchy] Bronze command, Silver command and then it goes up to Gold command which is then all the execs and the chairs discuss it. There are lots of different boards that everybody is talking to. I would probably say there is more communication going on at the moment than there has ever been'.* (Interviewee C) *'Where decisions have been made in the light of something centrally, the central message comes out and it is different to [our approach]. I think for us we gather all of those different sources and information that that we would be able to bring together with decisions on how we can best support our Trusts. [. . .] We are trying to take a view across everything. And then help to make a decision that way for our Trusts'.* (Interviewee J)

the board meetings, or in any risk matrix, ever having anybody raising a discussion about pandemics'.

All interviewees confirmed the unprecedented nature of the COVID-19 pandemic and pointed to limited, immediate, preparation beyond three-months emergency stockpiling for Brexit, which is particular to the UK at this point-in-time. Raising the broad question of systemic resilience, Interviewee C argued: '*If you imagine if we had not had that three months' worth of stock already in the warehouses, where would we have been? I think that is quite fascinating how we have all gone very lean procurement. But actually, when you are running an essential service, is that the right solution? [. . .] We again were on the back foot because Germany who was a big provider of ventilators and PPE were using it themselves.*'

Yet, despite forewarnings, participants expressed frustration regarding the lack of preparedness and speed of response despite awareness of the oncoming pandemic: '*I would probably say – and this was something that surprised me was how slow the NHS and senior management were to respond. The COVID-19 was not a surprise to everyone because it happened in China, and we know it is slowly creeping across the globe*' (Interviewee C). This was reiterated by two recent reports from the UK House of

Commons Public Accounts Committee (the UK's spending watchdog) and The National Audit Office. At the outset of the pandemic the UK lost a 'crucial month'; the sourcing of additional ventilators occurred more than a month after the World Health Organization declared the pandemic a public health emergency (House of Commons 2020). According to the National Audit Office, the UK's slow response to the sourcing of PPE resulted in the UK paying extortionate prices for new equipment which, for the most part, arrived after the first wave of infections, the delay costing the UK £10 billion (Comptroller and Auditor General 2020).

Table 2 illustrates some key challenges faced by interviewees' respective organizations. Interviewees mentioned innovation was needed to reprioritize and reconfigure staff and resources, ensure rapid acquisition of essential stock through new channels, and build relationships with local, regional, and national stakeholders within and across the sector. Our findings are also categorized according to the innovation typology developed by Chen, Walker, and Sawhney (2020). Given the professional profile of our participants (procurement, finance, and human resources), it was expected that the emphasis across almost all cases was on management innovation (type III in Table 3), resulting in a transformational step-change in how PSOs and their suppliers responded to the crisis. Furthermore, the internal orientation and focus on building internal competence (as an intelligent client) was found to be critical where coordination across PSO boundaries and where external partners was required. In terms of future planning, PSOs might consider leveraging novel approaches within other types of innovation, such as type IV (partner innovation) and VI (citizen innovation), where data and information sharing with the public might improve desired outcomes to crisis situations (i.e. decentralized, co-production of PPE to required standards using 3D printers).

Information asymmetry and processing when making decisions

The following sections uncover how organizations addressed information asymmetry during COVID-19 (see Table 3).

Addressing information uncertainty by collecting information

Interviewees involved in supporting healthcare services mentioned, at the early phases of the crisis, issues of coordination, a lack of information and a need to respond to their immediate stakeholders: '*One of the challenges with information [to support making] decisions is that links between what is happening locally and what is happening centrally at times have not been very clear*' (Interviewee J). This appears to support data from news reports (as reported by BBC News on 12 April 2020, Channel 4 News, 7 May 2020). In the UK, healthcare services are delivered locally, but receive guidance, annual budgets, and central government directives from the Department of Health (DoH). Interviewee B argued: '*Government should be able to obtain certain information for the centrally procured stuff and an understanding of the true availability of products. If we were told "this is the national picture – which is why you cannot get some products". We would use that information to give people a bit of reassurance and understanding*'.

Interviewees pointed towards some decision-making which was not explained to organizations, causing further information uncertainty: '*The Centre has made some panic decisions which means the level of confidence has been reduced significantly*' (Interviewee G). This was also reinforced by a report in The Telegraph (7 May 2020) on the procurement of PPE from Turkey. Similarly, in the context of information gaps

and effective decision-making, interviewee B mentioned: '*We cannot rely on the central provision – it just does not work for us. It has been hugely beneficial in some areas but without a team on the ground working well, the difficulties would be much more acute*'.

In this fast-moving crisis, key information can have limited time value, creating uncertainty through lack of relevant information, as noted by Interviewee H:

> We [healthcare service procurement team] still have to follow the process and we do not, avoid that we buy from contracts [established agreements], we do all these sorts of things but if I need masks and they are in China, and I need to source those masks. I have not got time to obtain three quotes [established procedures], because as soon as I go to the three quotes these products that were available have gone.

Similarly, rapid decision-making was critical: '*You would like to have more comparative offers from different sources, but there simply was not enough time to get them*' (Interviewee D). This led to situations where many organizations were '*making decisions quicker and potentially based on more imperfect information as you would have otherwise*' (Interviewee D).

At the outset of the crisis, interviewees indicated that they adapted their processes and decision-making: '*We are normally risk-averse in terms of contract terms and making sure that we covered ourselves in case the supplier does not deliver. [. . .] Procurement went back to the basics of contract as it means nothing unless we can get the goods and services*' (Interviewee J). A noticeable trend was, over time, various interventions allowed organizations to respond with more confidence, utilizing decision-support tools: '*Although the market is very volatile. For example, you are paying 30p for something and next minute 60p and then £1.20. [. . .] We have quite a lot of analytic tools as we are now collecting details on a weekly basis. [. . .] We now know who is buying what around the country. We then started to find out who is buying things outside the national system*' (Interviewee H). Additionally, the development of new collaborative relationships with key stakeholders, even competitors, was vital:

> There is a lot more transparency with regards to our various relationships. [. . .] For instance, we noticed some product shortages, and we talked to people who run the airports. Before the crisis, I would never have gotten involved with airports, but we both had a similar need for something. [. . .] There is the general willingness to share more information as well. We have started working with some people who you might consider competitors (Interviewee I).

There was general consensus that, as a result of COVID-19, interviewees' respective organizations had set about developing more efficient information collection processes, which they hoped would remain in place post-pandemic:

> In terms of the way that we capture it [information] the way we use it. The way that we work online through MS Teams and share electronically rather than, printing out paper. I think this is absolutely something that will probably stay with us because I do not think we should be going back. We have learned a lot from all this (Interview H).

Making sense of information to address information equivocality

Interviewees reported on various approaches for making sense of information; some perceived as a critical enabler, underpinning organizations' capability to respond effectively. For instance, interviewee I referred to the use of a software platform:

> A nation-wide 'live' programme called 'Mutual Aid' uses a software platform that allows any Trust [a devolved regional healthcare PSO] that is short of products to pull down products from another Trust that has surplus of that particular product. That has all been new, when COVID started, people were working with spreadsheets.

Relational approaches, focusing on better coordination were used too:

> Having weekly checkpoints with every Trust, having conversations over the web about where other organizations are seeing demand, where are we seeing the problems, is anyone else seeing those problems. You now have an open forum where people can share and help each other. You want to avoid situations where one hospital was provided with an excess of student nurses to help from a healthcare assistance perspective, while another hospital had a real shortage. [. . .] This information is vital and needs to be processed by one organization and passed on to others in a timely manner (Interviewee J).

Likewise, at the national level, the 'Parallel Supply Chain' (an organization set up by the UK Department of Health (DoH) in March 2020 to address mounting issues relating to the sourcing and distribution of critical healthcare supplies) had limited information regarding PPE held by local organizations. This involved undertaking daily engagement with stakeholders from NHS regions, local resilience forums, and the National Supply Disruption Response team (an emergency helpline for delivering to organizations struggling to source PPE) which helped improve the distribution process. From 4 May 2020 this was further improved to include information collected from local Trusts (Comptroller and Auditor General 2020).

Adapting internal processes was an important feature across interviewees to ensure information was *'correctly and timely'* interpreted: '*We just made our board meetings more frequent and shorter. We have changed our communication processes including more frequent touchpoints so that those key decisions get discussed'* (Interviewee I). Similarly, '*in some cases, you report after rather than before you would do something. It is just about having a process around that speeds up information processing and decision-making'* (Interviewee H). Some, changes were even more structural as Interviewee H went on to report: '*We have brought up a completely new team that runs an internal supply chain to speed up decision-making and processes'.*

Transferring information to make joint decisions

Throughout the crisis, information flows and feedback between end-users, buyers, and suppliers were significantly affected, testing '*organizational resilience and speed of adaptation'* to the crisis situation. Interviewees A, C, F and J reported challenges reaching staff who were no longer operating in their usual offices, or on furlough, and of having to convince contractors to return on-site. Meetings (from exec board to operational levels) were more frequent, ensuring timely engagements and updates within and across organizations.

Whereas these new ways of working may not have occurred in the short-term prior to COVID-19, the knowable black swan situation has tested what tasks can be executed and monitored remotely. Some interviewees anticipated their organization and key stakeholders may not completely revert back to former pre-pandemic practices. This aligns with reports suggesting crises like COVID-19 drive innovation and new ways of operating (OECD 2009; Entrepreneur Europe 2020). Interviewee G commented: '*Just over two months ago, we shifted to MS Teams and Zoom. We already had an electronic tendering system and databases, but now we are also*

homeworking quite extensively'. Similarly, Interviewee B stated that the organization has '*information drops going out into organization-wide huddles [information sharing platforms], interlinking with logistics command structure for the region'* to improve collaboration with stakeholders. There are challenges in transferring information and working with other organizations in knowable black swan events: '*The scale of some of the decisions we are having to make, and the money we are having to spend, suddenly people step back and think this is actually more difficult than you think'* (Interviewee A).

Looking across organizational boundaries, the importance of collaboration was strongly argued by most, even with competitors, as evidenced by Interviewee I: '*There is a general willingness to share more information as well. We have started working with some people you might consider competitors'*. Also, interviewee C pointed out: '*One of the things that has made us realize how important collaboration is was where there are national failures. We realized how on a regional basis we could be more collaborative and transfer information for joint decision-making*'. Table 3 provides an overview of additional quotes across key themes.

At a national level, the Cabinet Office also relied on a range of solutions. In discussing the success of the 'Ventilator Challenge' in promoting the scale-up in UK production of ventilators, a report by the House of Commons Public Accounts Committee (2020) attributed the programme's success to the chief commercial officer's experience of managing engineering and product development companies. This put him in a strong position to instigate the 'Ventilator Challenge'. Also, the report highlighted the support from cross-functional teams drawn up form NHS clinicians, the Medical and Healthcare products Regulatory Agency (MHRA), other government departments, medical device testing experts, and PA Consulting. Correspondingly, the Department of Health and Social Care drew on the Department for International Trade and the Foreign and Commonwealth Office connections to help purchase and secure ventilators directly from China more rapidly. The Cabinet Office too worked with the Ministry of Defence's Cost Assurance and Analysis Service to assess orders and ensure that they were close to market value (House of Commons 2020).

Discussion

This research contributes to the under-researched and under-theorized study of public sector innovation, and in particular strategies for more effective governance in crisis scenarios (Ansell and Torfing 2020; Chen, Walker, and Sawhney 2020). Drawing on IPT, we posited that information uncertainty and equivocality in a crisis situation is addressed by information gathering, sense-making, and transferring. Exploring public and private organizations in the healthcare sector during a live black swan event, we explored how managers at the front-line innovated to address information asymmetry to aid decision-making.

Theoretical contributions

This study theoretically underpinned and empirically investigated black swan events which are less explored in prior studies (Ramasesh and Browning 2014). More specifically, we answer the question of how PSOs innovate to address information asymmetry

Table 4. Challenges facing organizations under 'business-as-usual' and 'knowable black swan event' conditions.

	'Business-as-usual'	'Knowable black swan event'
Innovative response	Generally incremental innovation	Agile, time compressed organizational innovation focused on doing things 'quicker' as opposed to 'better'
Information uncertainty & equivocality	Some uncertainty, but organization has some foresight of market demand and contracts in place with preferred suppliers; organizations have more time to interpret messy information	No certainty, messy information from a range of sources, no clear information on stock levels, staff resourcing or demand. Need to quickly find new suppliers or partners
Information gathering	Methodical, traditional tendering process, over several weeks gathering information from a range of suppliers	Rapid over 1 – 2 days, 'good is good enough'. Information gathered from suppliers, often local, and based on information from trusted network
Information processing	Tightly governed and hierarchical with major decisions made by a board and senior executives	Simplified decision-process, decisions made by a small select team on the day and more autonomy given to teams/ managers to make decisions based on their individual skillsets
Information transferring	Fed out weekly or monthly through traditional sources, e.g. newsletter, group, or team emails	Daily to key stakeholders – key stakeholders by phone, others through emails. Internal stakeholders through daily updates and conference calls

and drive decision-making in a black swan (knowable unknown) event such as COVID-19. This study presents a novel use of the IPT lens to illustrate how organizations deal with information asymmetry in these knowable unknown situations (Table 4).

Our findings show, at the initial stages of a black swan event, PSOs are tasked with delivering immediate support, in our case to key healthcare workers, but within significant constraints (e.g. lockdown, demand uncertainty) and under time-compressed conditions (e.g. dramatically reduced lead times – from three weeks to next-day delivery). We observed how PSOs focused on management and organizational innovation (Damanpour, Walker, and Avellaneda 2009), rather than radical and technological innovation, exploring ways of doing activities 'differently' as opposed to 'better' (Bessant et al. 2005). Organizations in our study were undertaking not new-to-the-world but certainly new-to-the-organization approaches which, based on our findings, will be sustained post-pandemic. For many, this required a cultural, as well as organizational, shift including, but not limited to, moving from a '9–5′ desk-based mindset towards virtual teams and highly flexible work patterns, and more sophisticated collaborative information sharing across boundaries.

Within this context, organizations were confronted with significant time constraints; failure to source healthcare equipment would have significant, high profile consequences for the spread and containment of COVID-19. Organizations were charged with finding ways to speed up and improve communications internally and to key stakeholders. Thus, organizations moved from structuring around specific healthcare categories towards structures able to deal with: (i) the immediate fallout from the knowable black swan event; (ii) preparation for the situation as it evolved; and (iii) learning new practices, gaining a better understanding of what the 'new normal' would be, and its organizational implications.

The time-compressed conditions have also given rise to major changes in the decision-making process, resulting in a significant shortening of the chain of

command – managers have been given more flexibility and discretion. Quick decision-making was considered important as major decisions needed to be made almost immediately, but through the creation of smaller boards and flatter hierarchies, organizations learned to manoeuvre more quickly and flexibly as the knowable black swan event evolved.

At the outset of the pandemic, organizations spent some time and resources locating information from external sources (e.g. Public Health England, NHS England) to address a lack of information (i.e. information uncertainty) within the organization and to 'define the problem at hand and its boundaries'. Interviewees stressed the nature of the situation did not allow sufficient time to collect all relevant and required information – individuals had to make decisions based on what was available at that point-in-time. In other words, decisions had to be made on 'some information', which was relevant now, rather than aiming for a 'complete picture' with potentially outdated information later.

The time-compressed nature of the crisis did not allow organizations sufficient time to collect all required information. Often information was not available from one single source, but a myriad of sources: a time- and resource-consuming process. The early phase of the knowable black swan event was also characterized by organizations spending very limited time making sense of collected information, and sparse information was passed on to other organizations. We argue, at the outset, organizations have limited time and resources to address information uncertainty completely, forcing them to neglect making sense of messy information to address equivocality, and often having to ignore an approach that would call for collecting all relevant information to address information uncertainty (as suggested by prior work; e.g. Bode et al. 2011). This then hinders joint decision-making as any relevant information was not passed on to partnering organizations. These findings contrast to prior studies using IPT which mainly explored information processing in settings where addressing information uncertainty and equivocality supersedes quick decision-making (e.g. Dahlmann and Roehrich 2019).

In later phases of black swan events, individual organizations have mainly satisfied their initial need to collect information to address their information uncertainty (switching to a focus on new, and different, information uncertainty such as emerging equipment requirements for post-lockdown). The findings show organizations developed more efficient information collection processes, and were able to deal with information equivocality. Whilst decisions had to be made in a fairly time-compressed manner, we found organizations went on to interpret information for the organization's own decision-making, and then transferred relevant information to other organizations.

Our analysis suggests, for black swan events, information processing is by no means a linear process, nor does it include all information processing activities to make decisions. In contrast to 'business-as-usual' decision-making situations (Wolf and Egelhoff 2002; Koufteros, Verghese, and Lucianetti 2014), knowable black swan events are characterized by decision-making in which information uncertainty is addressed first by collecting some degree of information to allow initial and organization-specific decision-making, while later phases address information equivocality, and joint decision-making with other organizations, supporting a more collaborative approach to tackling such crisis situations (Premkumar, Ramamurthy, and Saunders 2005; Hartley, Sørensen, and Torfing 2013; Tee, Davies, and Whyte 2019).

Boundary conditions and further research

We closely examined how organizations address information asymmetry to drive innovative decision-making in knowable black swan situations. The study focused on data collected during a live black swan event. Future research should compare our findings with the same black swan event, namely COVID-19, in other sectors and countries, exploring how organizations address information asymmetry, and explore whether the innovative processes employed during the pandemic have persisted, or whether organizations have reverted back to 'the same old procedure'. While we believe many of our findings are relevant for other organizations in other contexts, the impact of different regulations and legal systems should be further explored.

Understanding the dynamic nature of information asymmetry and processing needs throughout the whole crisis situation warrants further research. Future studies may use behavioural experiments to uncover the role that different individuals play in addressing information asymmetry at different stages of the crisis situation. For instance, further research should explore who, at what level (e.g. business, corporate, subsidiary) and in what job role (e.g. legal, management, operation) uses what type of governance mechanism (contractual or relational – Howard et al. 2019; Roehrich et al. 2020) to gather, analyse, and transfer information. Future research may also unpack different levels of service complexity, and its impact on the use of governance mechanisms to address information asymmetry (e.g. Kreye, Roehrich, and Lewis 2015).

Implications for practice and policy

Our study has important implications for organizations and managers seeking to manage information asymmetry during knowable black swan events. Organizations should first address information uncertainty by collecting information from internal and external sources. In black swan events, it is important to collect some information, rather than seeking to gain a complete picture as decisions need to be made quickly. Later phases of the black swan event should be used to interpret information, consider innovative ways of doing so, and collaboration with other organizations (potentially even competitors) to interpret and transfer information for quick and joint decision-making.

For policymakers, we argue that in order to implement a rapid and effective innovative response, there is a need for a reciprocal transfer of information between organizations operating at the national level through to local health and social care organizations. As our study shows, the lack of such end-to-end sharing and processing of information led to costly mistakes, major delays in the sourcing and distribution of essential medical supplies, and contributed towards the UK's inability to mount an innovative response to COVID-19 during the early stages of the pandemic.

Our research strengthens the case for PSOs to develop an intelligent client capability, as the basis for addressing information uncertainty and equivocality, and to rapidly direct efforts towards an innovative response in a crisis situation. With an *internal* orientation in mind, we expect public leadership at board-level to radically reconsider their approach to risk and innovation; incentivize managerial behaviours and structures that build resilience; and invest in collaborative information sharing platforms and practices designed to assure public service continuity. PSOs can also direct through an e*xternal orientation*, how they can open up data, and sharing of

current operational challenges to work flexibly and horizontally with other sectors as a matter of driving innovation policy. Similarly, PSOs will benefit from new formal innovation pathways that attract solutions from external partners and others in the complex public service ecosystem.

Conclusions

This paper explored how organizations address information asymmetry in a black swan event by using information-processing activities. We adopted IPT to explore how PSOs innovate to address information asymmetry and drive decision-making in a black swan event (COVID-19). Building on a rich dataset, including detailed interviews with frontline managers during COVID-19, we contribute to innovation research in crisis situations by specifically investigating knowable crisis situations. We illustrate how PSOs focused on management and organizational innovation rather than radical and technological innovation, exploring ways of doing activities 'differently' as opposed to 'better'. Thus, this study offers one of the first theoretically informed and empirically grounded investigation of information asymmetry in knowable crisis situations using IPT. In contrast to 'business-as-usual' decision-making situations, crisis situations are characterized by decision-making in which information uncertainty is addressed first by collecting some degree of information to allow initial and individual organization's decision-making, while later phases address information equivocality and joint decision-making with other organizations. We hope that our findings will encourage further research to augment our understanding of how organizations address information asymmetry in black swan events to drive innovative decision-making.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the UK's Engineering and Physical Sciences Research Council (EPSRC) under Grant EP/M017559/1 and EP/T014970/1.

Notes on contributors

Wendy Phillips is Professor of Innovation at Bristol Business School UWE. Wendy has spent over 15 years advancing the disciplines of innovation studies and supply chain management. Prior joining UWE, she worked at the ESRC Centre for Innovation and Competition at the University of Manchester and the Centre for Research in Strategic Purchasing and Supply (CRiSPS) at the University of Bath, School of Management. Wendy's research impacts policy and practice in procurement in complex public sector supply networks such as the NHS, the Welsh NHS, and UK Higher Education Institutions (HEIs). Wendy currently leads a large scale EPSRC funded collaborative network funded supporting research into redistributed manufacturing (RDM) in healthcare with a focus on deployed operations.

Jens Roehrich is Professor and HPC Chair in Supply Chain Innovation at the University of Bath, School of Management, UK. Before joining Bath, Jens was a researcher at Imperial College London, UK. Significant strands of his research agenda explore, for instance, the long-term interplay of

contractual and relational governance mechanisms in public-private relationships and complex public projects as well as the management of public-private partnerships. His research has been published in journals such as Journal of Management Studies, International Journal of Operations & Production Management, British Journal of Management, Social Science & Medicine, and Industrial Marketing Management, among others.

Dharm Kapletia is Senior Research Fellow at UWE Bristol in the UK, specialising in Technology and Innovation Management. He is also a Fellow of the Schumacher Institute think tank for sustainable systems. He has worked in various research and consulting roles at ADS Group, Hewlett–Packard Laboratories and UK Ministry of Defence. He has contributed to innovation and transformation programmes and agendas in healthcare, defence and cybersecurity. He holds an industry-sponsored PhD from the Engineering Department at the University of Cambridge and his main research interests include managing innovation in complex systems, as well as science and engineering policy and industrial transformation. He also holds an MSc (Distinction) from the Science Policy Research Unit, University of Sussex.

ORCID

Wendy Phillips http://orcid.org/0000-0003-0056-2524
Jens K. Roehrich http://orcid.org/0000-0002-0940-6846

References

Aben, Tom A.E., Wendy van der Valk, W. Jens, K. Roehrich, and Kostas Selviaridis. forthcoming. "Managing Information Asymmetry in Public-Private Relationships Undergoing a Digital Transformation: The Role of Contractual and Relational Governance." *International Journal of Operations & Production Management*.

Alonso, J M., Rhys Andrews, Judith Clifton, and Daniel Diaz-Fuentes. 2019. "Factors Influencing Citizens' Co-Production of Environmental Outcomes: A Multi-Level Analysis." *Public Management Review* 21 (11): 1620–1645. doi:10.1080/14719037.2019.1619806.

Alvesson, Mats. 2003. "Beyond Neopositivists, Romantics and Localists: A Reflective Approach to Interviews in Organizational Research." *Academy of Management Review* 28 (1): 13–33. doi:10.2307/30040687.

Ansell, Eva Sørensen, and Jacob Torfing. 2020. "The COVID-19 Pandemic as a Game Changer for Public Administration and Leadership? The Need for Robust Governance Responses to Turbulent Problems." *Public Management Review* 1–12. doi:10.1080/14719037.2020.1820272.

Aritua, B., S. Male, and D. Bower. 2009. "Defining the Intelligent Public Sector Construction Client." *Proceedings of the Institution of Civil Engineers - Management, Procurement and Law* 162 (2): 75–82. doi:10.1680/mpal.2009.162.2.75.

Barlow, James, Jens K. Roehrich, and Stephen Wright. 2013. "Europe Sees Mixed Results from Public-Private Partnerships for Building and Managing Health Care Facilities and Services." *Health Affairs* 32 (1): 146–154. doi:10.1377/hlthaff.2011.1223.

Bessant, John, Howard Rush, and Anna Trifilova. 2015. "Crisis-Driven Innovation: The Case of Humanitarian Innovation." *International Journal of Innovation Management* 19 (6). doi:10.1142/S1363919615400149.

Bessant, John, Richard Lamming, Hannah Noke, and Wendy Phillips. 2005. "Managing Innovation beyond the Steady State." *Technovation* 25 (12): 1366–1376. doi:10.1016/j.technovation.2005.04.007.

Bode, Christoph, Stephan M. Wagner, Kenneth J. Petersen, and Lisa M. Ellram. 2011. "Understanding Responses to Supply Chain Disruptions: Insights from Information Processing and Resource Dependence Perspectives." *Academy of Management Journal* 54 (4): 833–856. doi:10.5465/amj.2011.64870145.

Brown, Andrew D. 2004. "Authoritative Sensemaking in a Public Inquiry Report." *Organization Studies* 25 (1): 95–112. doi:10.1177/0170840604038182.

Brown, Louise, and Stephen P. Osborne. 2013. "Risk and Innovation." *Public Management Review* 15 (2): 186–208. doi:10.1080/14719037.2012.707681.

Bryson, John M. 1981. "A Perspective on Planning and Crises in the Public Sector." *Strategic Management Journal* 2 (2): 181–196. doi:10.1002/smj.4250020207.
BSI. 2021. *BSI Organizational Resilience Index Report*. London: British Standards Institution.
Burns, L. R., and D. R. Wholey. 1993. "Adoption and Abandonment of Matrix Management Programs: Effects of Organizational Characteristics and Interorganizational Networks." *Academy of Management Journal* 36 (1): 106–138. doi:10.2307/256514.
Cabinet Office. 2017. *National Risk Register of Civil Emergencies*. https://www.gov.uk/government/publications/national-risk-register-of-civil-emergencies-2017-edition
Caldwell, Nigel D., Jens K. Roehrich, and Gerard George. 2017. "Social Value Creation and Relational Coordination in Public-Private Collaborations." *Journal of Management Studies* 54 (6): 906–928. doi:10.1111/joms.12268.
Chen, Jiyao, Richard M. Walker, and Mohanbir Sawhney. 2020. "Public Service Innovation: A Typology." *Public Management Review* 22 (11): 1674–1695. doi:10.1080/14719037.2019.1645874.
Chopra, Sunil, and ManMohan S. Sodhi. 2014. "Reducing the Risk of Supply Chain Disruptions." *MIT Sloan Management Review* 55 (3): 73–80.
Comptroller and Auditor General. 2020. *The Supply of Personal Protective Equipment (PPE) during the COVID-19 Pandemic*. National Audit Office, November. Accessed 25 November 2020. https://www.nao.org.uk/wp-content/uploads/2020/11/The-supply-of-personal-protective-equipment-PPE-during-the-COVID-19-pandemic.pdf
Corner, Patricia Doyle, Angelo J. Kinicki, and Barbara W. Keats. 1994. "Integrating Organizational and Individual Information Processing Perspectives on Choice." *Organization Science* 5 (3): 294–308. doi:10.1287/orsc.5.3.294.
Czerniawska, Fiona. 2007. *The Intelligent Client: Managing Your Management Consultant*. London: Hodder & Stoughton Education, The Management Consultancies Association.
Daft, Richard L., and Robert H. Lengel. 1986. "Organizational Information Requirements, Media Richness and Structural Design." *Management Science* 32 (5): 554–571. doi:10.1287/mnsc.32.5.554.
Dahlmann, Frederik, and Jens K. Roehrich. 2019. "Sustainable Supply Chain Management and Partner Engagement to Manage Climate Change Information." *Business Strategy and the Environment* 28 (8): 1632–1647. doi:10.1002/bse.2392.
Damanpour, Fariborz, Richard M. Walker, and Claudia N. Avellaneda. 2009. "Combinative Effects of Innovation Types and Organizational Performance: A Longitudinal Study of Service Organizations." *Journal of Management Studies* 46 (4): 650–675. doi:10.1111/j.1467-6486.2008.00814.x.
Eisenhardt, Kathleen M., and Melissa E. Graebner. 2007. "Theory Building from Cases: Opportunities and Challenges." *Academy of Management Journal* 50 (1): 25–32. doi:10.5465/amj.2007.24160888.
Entrepreneur Europe. 2020. *COVID-19 Will Fuel the Next Wave of Innovation*. Entrepreneur Europe. https://www.entrepreneur.com/article/347669
Feduzi, A. and Runde. J. 2014. "Uncovering Unknown Unknowns: Towards a Baconian Approach to Management Decision-Making." *Organizational Behavior and Human Decision Processes*, 124(2): 268–283.
Flanagan, Kieron, and Brian Collins. 2020. *Giving Scientific Advice to Government during a Crisis*. WONKHE. https://wonkhe.com/blogs/giving-scientific-advice-to-government-during-a-crisis/
Galbraith, Jay R. 1974. "Organization Design: An Information Processing View." *Interfaces* 4 (3): 28–36. doi:10.1287/inte.4.3.28.
Gephart, Robert P. 1993. "The Textual Approach: Risk and Blame in Disaster Sensemaking." *Academy of Management Journal* 36 (6): 1465–1514. doi:10.5465/256819.
Gibbert, Michael, Winfried Ruigrok, and Barbara Wicki. 2008. "What Passes as a Rigorous Case Study?" *Strategic Management Journal* 29 (13): 1465–1474. doi:10.1002/smj.722.
Golden, Brian R. 1992. "Research Notes. The past Is the Past—Or Is It? The Use of Retrospective Accounts as Indicators of past Strategy." *Academy of Management Journal* 35 (4): 848–860. doi:10.5465/256318.
Golden-Biddle, K., and K. Locke. 2007. *Composing Qualitative Research*. 2nd ed. Thousand Oaks, CA: Sage Publications.
Hjelmar, Ulf. 2021. "The Institutionalization of Public Sector Innovation." *Public Management Review* 23 (1): 53–69. doi:10.1080/14719037.2019.1665702.
House of Commons. 2020. *Covid-19: Supply of Ventilators*. House of Commons Public Accounts Committee. https://publications.parliament.uk/pa/cm5801/cmselect/cmpubacc/685/685.pdf

Howard, Mickey B., Jens K. Roehrich, Michael A. Lewis, and Brian Squire. 2019. "Converging and Diverging Governance Mechanisms: The Role of (Dys) Function in Long-Term Inter-Organizational Relationships." *British Journal of Management* 30 (3): 624–644. doi:10.1111/1467-8551.12254.

International Rescue Committee. 2020. *World Risks up to 1 Billion Cases and 3.2 Million Deaths from COVID-19 across Fragile Countries*. https://www.rescue-uk.org/press-release/world-risks-1-billion-cases-and-32-million-deaths-covid-19-across-fragile-countries

Jean., Hartley, Eva Sørensen, and Jacob Torfing. 2013. "Collaborative Innovation: A Viable Alternative to Market Competition and Organizational Entrepreneurship." *Public Administration Review* 73: 821–830. doi:10.1111/puar.12136.

Kalra, Jas, Michael A. Lewis, and Jens K. Roehrich. 2021. "Manifestation of Coordination Failures in Service Triads." *Supply Chain Management: An International Journal* 26 (3): 341–358. doi:10.1108/SCM-03-2019-0115.

Kim, Pan Suk. 2020. "South Korea's Fast Response to Coronavirus Disease: Implications on Public Policy and Public Management Theory." *Public Management Review*, no. May: 1–12. doi:10.1080/14719037.2020.1766266.

Koufteros, Xenophon, Anto John Verghese, and Lorenzo Lucianetti. 2014. "The Effect of Performance Measurement Systems on Firm Performance: A Cross-Sectional and A Longitudinal Study." *Journal of Operations Management* 32 (6): 313–336. doi:10.1016/j.jom.2014.06.003.

Kreye, Melanie, Jens K. Roehrich, and Michael A. Lewis. 2015. "Servitizing Manufacturers: The Importance of Service Complexity and Contractual and Relational Capabilities." *Production Planning & Control* 26 (14–15): 1233–1246. doi:10.1080/09537287.2015.1033489.

Labib, Ashraf, Sara Hadleigh-Dunn, Amr Mahfouz, and Marco Gentile. 2019. "Operationalizing Learning from Rare Events: Framework for Middle Humanitarian Operations Managers." *Production and Operations Management* 28 (9): 2323–2337. doi:10.1111/poms.13054.

Li, Sali, and Stephen Tallman. 2011. "MNC Strategies, Exogenous Shocks, and Performance Outcomes." *Strategic Management Journal* 32 (10): 1119–1127. doi:10.1002/smj.918.

Martin-Rios, Carlos, and Susana Pasamar. 2017. "Service Innovation in Times of Economic Crisis: The Strategic Adaptation Activities of the Top E.U. Service Firms." *R&D Management* 48 (2): 195–209. doi:10.1111/radm.12276.

Morris, L., M. Ma and P. Wu. 2014. *Agile Innovation*: *The Revolutionary Approach to Accelerate Success, Inspire Engagement, and Ignite Creativity*. New York, Wiley.

O'Flynn, Janine. 2020. "Confronting the Big Challenges of Our Time: Making a Difference during and after COVID-19." *Public Management Review*, no. Sept: 1–20. doi:10.1080/14719037.2020.1820273.

OECD. 2009. *Responding to the Crisis - Fostering Industry Restructuring, Renewal, and Innovation*. www.oecd.org/industry/ind/43387209.pdf

Office of the Director of National Intelligence. 2019. *Worldwide Threat Assessment of the US Intelligence Community*. Daniel R. Coats. Accessed 10 May 2020. https://www.dni.gov/files/ODNI/documents/2019-ATA-SFR—SSCI.pdf

Phillips, Wendy, Richard Lamming, John Bessant, and Hannah Noke. 2006. "Discontinuous Innovation and Supply Relationships: Strategic Dalliances." *R&D Management* 36 (4): 451–461. doi:10.1111/j.1467-9310.2006.00442.x.

Premkumar, G., K. Ramamurthy, and Carol Stoak Saunders. 2005. "Information Processing View of Organizations: An Exploratory Examination of Fit in the Context of Interorganizational Relationships." *Journal of Management Information Systems* 22 (1): 257–294. doi:10.1080/07421222.2003.11045841.

Ramasesh, Ranga V., and Tyson R. Browning. 2014. "A Conceptual Framework for Tackling Knowable Unknown Unknowns in Project Management." *Journal of Operations Management* 32 (4): 190–204. doi:10.1016/j.jom.2014.03.003.

Roehrich, Jens K., and Ilze Kivleniece. forthcoming. "Creating and Distributing Sustainable Value through Public-Private Collaborative Projects." In *Handbook on the Business of Sustainability: The Organization, Implementation, and Practice of Sustainable Growth*, edited by G. George, M.R. Hass, H. Joshi, A. McGahan, and P. Tracey, 1–45. Edward Elgar Publishing.

Roehrich, Jens K., Andrew Davies, Lars Frederiksen, and Natalya Sergeeva. 2019. "Management Innovation in Complex Products and Systems: The Case of Integrated Project Teams." *Industrial Marketing Management* 79: 84–93. doi:10.1016/j.indmarman.2018.10.006.

Roehrich, Jens K., Kostas Selviaridis, Jas Kalra, Wendy Van der Valk, and Feng Fang. 2020. "Inter-Organizational Governance: A Review, Conceptualisation and Extension." *Production Planning & Control* 31 (6): 453–469. doi:10.1080/09537287.2019.1647364.

Roehrich, Jens K., Michael A. Lewis, and Gerard George. 2014. "Are Public-Private Partnerships A Healthy Option? A Systematic Literature Review." *Social Science & Medicine* 113: 110–119. doi:10.1016/j.socscimed.2014.03.037.

Rosado Feger, Ana L. 2014. "Creating Cross-Functional Strategic Consensus in Manufacturing Facilities." *International Journal of Operations & Production Management* 34 (7): 941–970. doi:10.1108/ijopm-08-2012-0299.

Rosenberg, Nathan. 1969. "The Direction of Technological Change: Inducement Mechanisms and Focusing Devices." *Economic Development and Cultural Change* 18 (1): 1–24. doi:10.1086/450399.

Rumsfeld, D. 2002. *DoD News Briefing - Secretary Rumsfeld and Gen. Myers*. http://www.defense.gov/Transcripts/Transcript.aspx?TranscriptID=2636

Strauss, Anselm, and Juliet Corbin. 1990. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Newbury Park, CA: Sage Publications.

Taleb, Nassim Nicholas. 2010. *The Black Swan*. New York, NY: Random House Publishing.

Taylor, Trevor. 2019. "Artificial Intelligence in Defence." *The RUSI Journal* 164 (5–6): 72–81. doi:10.1080/03071847.2019.1694229.

Tee, Richard, Andrew Davies, and Jennifer Whyte. 2019. "Modular Designs and Integrating Practices: Managing Collaboration through Coordination and Cooperation." *Research Policy* 48 (1): 51–61. doi:10.1016/j.respol.2018.07.017.

The Health Foundation. 2020. *Improving Health by Tackling Market Failure*. https://www.health.org.uk/publications/long-reads/improving-health-by-tackling-market-failure

The King's Fund. 2019. *Is the NHS Being Privatized?* https://www.kingsfund.org.uk/publications/articles/big-election-questions-nhs-privatised

Torfing, J., and C. Ansell. 2017. "Strengthening Political Leadership and Policy Innovation through the Expansion of Collaborative Forms of Governance." *Public Management Review* 19: 37–54. doi:10.1080/14719037.2016.1200662.

Turner, Karynne L., and Mona V. Makhija. 2012. "The Role of Individuals in the Information Processing Perspective." *Strategic Management Journal* 33 (6): 661–680. doi:10.1002/smj.1970.

Walker, R. M., F. Damanpour, and C. A. Devece. 2010. "Management Innovation and Organizational Performance: The Mediating Effect of Performance Management." *Journal of Public Administration Research and Theory* 21 (2): 367–386. doi:10.1093/jopart/muq043.

Weber, Edward P., and Anne M. Khademian. 2008. "Wicked Problems, Knowledge Challenges, and Collaborative Capacity Builders in Network Settings." *Public Administration Review* 68: 334–349. doi:10.1111/j.1540-6210.2007.00866.x.

Weick, Karl E. 1993. "The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster." *Administrative Science Quarterly* 38 (4): 628. doi:10.2307/2393339.

Wenzel, Matthias, Sarah Stanske, and Marvin B. Lieberman. 2020. "Strategic Responses to Crisis." *Strategic Management Journal*. doi:10.1002/smj.3161.

Wiengarten, F., Ahmed, M.U., Longoni, A., Pagell, M. and Fynes, B. (2017). "Complexity and the triple bottom line: An information-processing perspective". *International Journal of Operations & Production Management* 37 (9): 1142–1163.

Wilson, Keeley, and Yves L. Doz. 2011. "Agile Innovation: A Footprint Balancing Distance and Immersion." *California Management Review* 53 (2): 6–26. doi:10.1525/cmr.2011.53.2.6.

Wolf, Joachim, and William G. Egelhoff. 2002. "A Reexamination and Extension of International Strategy-Structure Theory." *Strategic Management Journal* 23 (2): 181–189. doi:10.1002/smj.210.

Wright, S., J. Barlow, and J.K. Roehrich. 2019. "Public-Private Partnerships for Health Services: Construction, Protection and Rehabilitation of Critical Healthcare Infrastructure in Europe." In *Public Private Partnerships: Construction, Protection, and Rehabilitation of Critical Infrastructure*, edited by R. Clark and S. Hakim. New York: Springer.

Yu, Wantao, Roberto Chavez, Mark Jacobs, Chee Yew Wong, and Chunlin Yuan. 2019. "Environmental Scanning, Supply Chain Integration, Responsiveness, and Operational Performance." *International Journal of Operations & Production Management* 39 (5): 787–814. doi:10.1108/ijopm-07-2018-0395.

Zhao, Yunhui, Taiwen Feng, and Hongbo Shi. 2018. "External Involvement and Green Product Innovation: The Moderating Role of Environmental Uncertainty." *Business Strategy and the Environment* 27 (8): 1167–1180. doi:10.1002/bse.2060.