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Re-imagining Technology Adoption Research Beyond Development and Implementation: ITOps as the New Frontier of IS Research

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Abstract. IT operations (ITOps) is a key function in IS organisations. To manage and ensure the availability and reliability of the plethora of new/emerging and complex technologies that organisations increasingly adopt, ITOps had undergone significant changes and is currently going through major transformations. This paper assesses the current status of ITOps research. It reviews the literature across the AIS basket of eight journals, specifically over the last four decades. The analysis highlights the key areas in need of updating and research effort. The paper concludes that ITOps is ripe for further research and it is timely for IS research to update its knowledge base on the management of IT including ITOps, considering the significance of emerging technologies in the IT landscape.

Keywords: IT adoption, IT operations, ITOps, IT infrastructure, IT availability, IT reliability, predictive maintenance, data analytics.

1 Introduction

Information systems adoption and diffusion research covers a broad area, from conceptualisation to development through to use and operations (Dwivedi et al., 2010). While much of research on IS/IT adoption focuses on development and use, keeping IS/IT operational; i.e available, reliable, resilient and responsive to users, after its initial installation is critical to organisations. However, it is widely recognised as challenging and expensive (Swanson, 1999, Tambo and Filtenborg, 2019). It consumes more than half of application software development cost and IT decision-makers are under pressure to escalate their spending even more on IT services and hardware, to ensure operational continuity and success (Reisinger 2013, Tsunoda et al., 2017). It is also challenging, as transitioning IT from development to operations and ensuring its continuous availability involves complex technological and organisational processes, various stakeholders/teams and a wide range of technologies that offer round the clock system monitoring and real-time interactions between different organisational functions.

It also involves a wide range of activities including system maintenance, configuration management, change/risk management, incident management, service management, process management, customer support, system audit, tools management and knowledge/skillsets management among others (Abeck and Mayerl, 1999, Taylor et al., 1997, Goldstein et al., 2011, Jamieson and Low, 1990, Edwards, 1984, Banker and Slaughter, 2000, Krishnan et al., 2004, Nelson et al., 2000, Shaft and Vessey, 2006). Thus, as a function within IS organisations, IT operations (ITOps) constitute a complex knowledge ecosystem that cuts across several social and technical domains (Ramakrishnan et al., 2018a). It is also considered as one of the dynamic capabilities of organisations that help to rely on IT for business (Cetindamar et al., 2009).

Currently, ITOps is undergoing major transformation and innovation. Including deployment of AI, IoT, digital platform technologies, data analytics and intelligent software, in addition to developing new methodologies such as DevOps to improve its integration with software development functions. In this regard, the ITOps management market has increased by 10% in 2019 from the previous year to reach a total of over \$30 billion and the IT performance analysis software market alone has reached over \$12 billion (Gartner, 2020). Importantly, ITOps have shifted from domain-centric applications focusing on one area such as network traffic for example to a more product-centric view of applications and services that show the impact of performance on end-users and business outcomes (ibid).

Considering its importance in keeping IT up and running in organisations and the major transformation it is going through, this study aims to assess the status of IS research in IT operations. It questions how IT operations have been treated and which aspects had been studied in IS research? To answer the research questions, we conducted a literature review of AIS Senior Scholar Journals Basket of eight over the last four decades from 1980 to 2020. The literature review reveals the level of research and key areas of focus which provided the ground for suggesting future research. The rest of the paper is structured as follows. The next section provides an overview of the key elements of IT operations followed by a description of the method employed for the literature analysis. A summary of the findings is then presented followed by a discussion of the relevance and implication of these findings for the IS and future research. The paper concludes that ITOps is an area ripe for further IS research and it is timely for IS research to update its knowledge base on the management of IT including ITOps.

2 IT Operations

2.1 Key Aspects

IT operations is responsible for the smooth functioning of IT infrastructure and the operational environments that support IT service delivery and application deployment, including network management and customer support (Hetvik, 2014). It is part of IS life cycle and follows the development phase as depicted in figure 1 below.

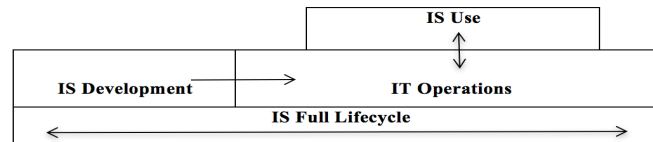


Fig. 1. relationship between IS development and operations

IT operations thus cover a wide range of knowledge base and activities that could be categorised into day-to-day operational tasks, problem-solving/error handling and processing user change requests (Abeck and Mayerl, 1999). Day-to-day operational tasks include system performance monitoring, user support and software/hardware support. Problem-solving/error handling tasks includes error detection/troubleshooting, incident management, software code validation, system audit and corrective/adaptive maintenance. Processing user change requests include attending to service complaints and performing preventive maintenance to address risks. It could also be categorised as technical, application development and system maintenance (Nelson et al., 2000). Here, technical tasks include system configuration and capacity management. Application development tasks include system requirement analysis and code validation. System maintenance tasks include adaptive, corrective and preventive/perfective maintenance that improve system performance (Nelson et al., 2000). ITOps tasks had also been categorised as proactive, preventive and reactive (Jamieson and Low, 1990, Charette et al., 1997, Caralli et al., 2010, Garcia et al., 2010). Proactive tasks include monitoring system performance and process management to improve systems performance. Reactive tasks include incident response and emergency changes. Table 1 enumerates the differences between IS development and ITOps.

Table 1. Differences between IS development and operations

	IS Development	IT Operations
1.	Responsible for IT design and development by producing new artefacts	Responsible for operating old/new IT Also retires legacy/defunct artefacts
2.	Delivers new IT artefacts to operations to run in production	Receives new IT artefacts from development to run in production
3.	Focus on producing new technical artefacts/systems	Focus on running existing systems at optimal levels and non-stop
4.	Design and builds technical artefacts in non-prod environment	Manages and troubleshoots failures in systems designed by others
5.	Commissions a small group of users to test system functionality	Services are deployed to a large constituent of end-users
6.	Failures in functionality of artefacts may be oblivious to end-users as there are no SLAs, SLOs or OLAs	IT services are strictly monitored and active SLAs, SLOs or OLAs are in place. Thus, failures are noticeable by users
7.	Focus on developing one or few systems/services at a time.	Operates and manages multiple systems/services at any given time
8.	Teams competence focus on emerging/new technologies	Teams competence focus on both established and emerging technologies

9	Recognised project delivery model/structure is followed to produce new artefacts	Best practices, experience, good judgment and customised operating procedures are used to tackle issues
10	Requirements are well-defined	Requirements are fuzzy
11.	Does not operate the technical artefacts they design and develops	Operates technical artefacts that were designed and developed by others
12	Tolerant non-production environment for development activities	Unforgiving production environment with live systems running
13	Could easily modify or discard problematic artefacts as user-base is small and doesn't need growing	Performs tedious problem analysis and maintenance on existing artefacts to support growing user-base
14	Developments are often time bounded and budgeted for based on defined requirement.	Tasks are difficult to budget for and problems are unplanned, even scheduled maintenances that may fail.
15	Working hours are usually sufficient for development activities since services are not live	Require round the clock coverage as failure could occur anytime due to real-time delivering of services
16	Failures are predictable and could wait for next available engineer	Instant failure detection, tracking and management are required
17	Configuration changes/upgrades are often planned in advanced	Configurations changes/upgrades may be urgent to counter failures
18	Tasks are often linear/clearer	Tasks are often non-linear/complex
19	Success/failure are predictable	Success/failures are unpredictable
20	Development of artefacts could be cancelled without impact on users	Abandoning production systems/artefacts have implications for users
21	Performance benefits could be projected with relative ease	performance benefits are difficult to predict due to mix of old/new kits
22.	Artefact development strategy and design could easily be changed	Artefact designs are inherited from development and thus locked-in

In practice, IT operations is guided by industry frameworks like ITIL, COBIT, ISO27000, TOGAF and Six Sigma (Berrahal and Marghoubi, 2016, Herrera and Van Hillegersberg, 2019) that focus on procedures, processes and governance. Although, organisations are increasingly paying more attention to ITOps automation and optimisation to improve operational reliability and control costs.

2.2 Organisational Reliance on ITOps and its Critical Importance

As organisations and society increasingly rely on complex IT systems and infrastructures, ITOps had become more critical. The financial and social losses that are experienced during IT failures force organisations to escalate investments in IT operations. Here, there is an abundance of cases where IT outages had resulted in millions of dollars in loss. These include high profile cases in many countries such as WhatsApp's global IT outage in July 2020 (Warren, 2020), Garmin's global IT outage in July 2020 (Sweeney, 2020), Lloyds Bank's IT outage in January 2020 (Reuters, 2020), Travelex's global IT outage in January 2020 (Isaac and Ostroff, 2020), Delta, Southwest, American Airlines' IT outage in December 2019 (Gilbertson, 2019), Sydney trains' IT outage in February 2019 (Grubb, 2019), Air India's IT failure in April 2019 (Reuters, 2019),

Amtrak's Signal System Failure in March 2019 (NBC, 2019), Amazon's IT outage in June 2019 (Voytko, 2019), Google's login system outage in April 2019 (Lyons, 2019), Visa's IT outage in June 2018 (Collinson, 2018), Telstra's IT outage in May 2018 (ARN, 2018), Microsoft's Azure outage in September 2017 (Thomson, 2017), New York Stock Exchange, United Airlines and Wall Street Journal's IT outages (Pagliery, 2015) and Bloomberg's IT failure (Popper and Gough, 2015). Table 1 presents three cases in the UK to highlight the scale of negative impact and financial loss.

Table 2. Financial costs of three recent incidents in the UK

IT Incident	User impact	Financial impact
1. RBS IT incident in June 2012 (Financial Conduct Authority, 2014)	<ul style="list-style-type: none"> - 6.5 million customers were unable to access ATMs and online accounts. - Prevented some from making timely mortgage payments. - Prevented business account holders from honouring their payroll. 	<ul style="list-style-type: none"> - A total of £42 million fine was imposed on RBS, NatWest and Ulster Bank by the UK's financial regulator (Financial Conduct Authority, 2014)
2. TSB IT incident in April 2018 (Financial Times, 2018)	<ul style="list-style-type: none"> - Botched migration of database affected 1.9 million customers who lost access to online bank accounts. - Business account holders were unable to fulfil their payroll responsibilities on time. - CEO resignation (BBC News, 2018b) 	<ul style="list-style-type: none"> - Facing FCA investigations (BBC News, 2018c). - Compensation for customers totaling £176.4 million (TSB Bank, 2018), including cancelling £10 million overdraft fees, waiving April's interests rates to the tune of £30m.
3. O2 and Ericsson IT Outage in Dec 2018 (Reuters, 2018, Ericsson, 2018)	<ul style="list-style-type: none"> - 25 million O2 and 7 million Sky, Giffgaff & TalkTalk data customers - 8,500 time schedule displays on London buses (Bloomberg, 2018) - 11,500 bikes connected to O2 payment terminals (Bloomberg, 2018) - Deliveroo (Bloomberg, 2018) 	<ul style="list-style-type: none"> - Projected compensation of about £100 million from Ericsson (Telegraph, 2018) - Offered 2 days air time credit for contract holders and 10% off credit for affected pay as you go users (BBC News, 2018a)

3 Methodology

To address the research question, we conducted a literature review that focused on publications from 1980 to 2020. Whilst selection of journals play a key role in the assessment of past research, "there are no established criteria that govern the choice of journals" (Robey et al., 2008; Straub, 2006). However, we followed Robey et al (2008) criteria of selecting IS journals based on reputation in the IS field. Hence, we selected the AIS senior scholars' basket of eight journals that are recognised for their rigorous reviewing processes. This includes MISQ, ISR, JIT, JMIS, EJIS, JAIS, JSIS and ISJ.

We identified the initial set of articles through a combination of title and keyword searches, as well as inspection of abstracts and research questions. We used keywords like IT operations and maintenance to search across publication titles, author-specified keywords and abstracts. The inclusion criteria were for the papers to directly examine one of the ten aspects of ITOps. This approach yielded 29 papers from the AIS Senior

Scholars basket of eight IS journals. Table 3 shows a breakdown of the reviewed papers.

Table 3. IT operations literature organised by Journal (between 1980-2020)

Journals (AIS Basket of Eight)	No. of Papers	Percent
MIS Quarterly (MISQ)	7	24.14%
Information Systems Research (ISR)	4	13.79%
Journal of Information Technology (JIT)	6	20.69%
Journal of Management Information Systems (JMIS)	6	20.69%
European Journal of Information Systems (EJIS)	5	17.24%
Journal of the Association for Information Systems (JAIS)	1	3.45%
Journal of Strategic Information Systems (JSIS)	0	0
Information Systems Journal (ISJ)	0	0
Total	29	100%

Regarding analysis, we analysed the identified articles in two phases. In the first phase, we distilled, from the literature, the activities associated with IT operations. This resulted in the identification of ten broad activities. We then classified all the 29 articles based on the ten identified categories. This is consistent with Melville et al (2004) and Glass et al (2004) who developed a working definition/classification scheme to guide the coding process (Glass et al., 2004, Melville et al., 2004).

Table 4. IT operations literature organised by research theme (between 1980-2020)

ITOps Aspects	1980s	1990s	2000s	2010s	Percent
1. System Maintenance	(Edwards, 1984) (Kim & Westin, 1988) (Ives & Vitale 1988) (Rozenstein & Minsky 1986)	(Dekleva, 1992) (Dekleva & Drehmer, 1997) (Hipkin, 1996) (Tan & Gable, 1997) (Kaasbøll, 1997) (Moreton, 1990)	(Swanson & Dans, 2000) (Shaft & Vessey 2006) (Banker & Slaughter 2000) (Krishnan et al, 2004) (Min Khoo & Robey, 2007)	(Choudhary & Zhang, 2015) (Dennis et al, 2014) (Edberg et al, 2012)	18 (62.1%)
2. Configuration Management					0%
3. Change/Risk Management			(Goldstein et al, 2011)		1 (3.5%)
4. Incident Management					0%
5. Service Management		(Rands, 1992) (Griffin & Sumichrast, 1994)		(Wiedeman et al, 2020)	3 (10.3%)

6. Process Management	(Paddock, 1985)				1 (3.5%)
7. Customer Support					0%
8. System Audit		(Jamieson & Low, 1990)			1 (3.5%)
9. Tools Management	(Moreton, 1992)				1 (3.5%)
10. Knowledge/Skillsets Management	(Goldstein, 1989)	(Taylor et al, 1997) (Shaft & Vessey, 1998)	(Nelson et al, 2000)		4 (13.8%)
Percent	7 papers (24.1%)	11 papers (37.9%)	7 papers (24.1%)	4 papers (13.8)	29 (100%)

In the second phase, all the 29 articles were re-categorised by publication year/decade in order to glean insight into whether particular aspects of ITOps or themes were dominant in each decade or not. Table 4 above shows the breakdown per decade.

4 Assessment of the Literature

4.1 Disproportionate Focus on System/Software Maintenance

The analysis as presented in table 4 above shows that across the four decades between 1980 and 2020, IT operations/maintenance articles that were published in the AIS Senior Scholars basket had a total of eighteen articles representing 62.1% focused on systems maintenance. Four articles representing 13.79% focused on Knowledge and Skillsets Management, three articles representing 10.34% focused on Service Management. One article each representing 3.45% focused on 1. Change/Risk Management, Process Management, and Tools Management respectively. As stated above, no articles were published in three key aspects of ITOps, notably Configuration Management, Incident Management and Customer Support.

4.2 Lack of Contemporary View of IT Operations

The analysis reveals that most of the literature on IT operations dates back to the 1980s and 1990s where IT systems and their functions were more simplistic, compared to today's complex and powerful IT systems and infrastructures whose operational and business environments are more complex. This pattern is evident across the last four decades. The 1990s witnessed the highest level of interest in ITOps with 11 articles representing 37.93% followed by the 1980s and 2000s in joint second with 7 articles, representing 24.14 each. The 2010s came last with 4 articles, representing 13.79%. This trend is particularly surprising considering that the vast majority of the innovations and advancements behind today's complex IT systems occurred within the last decade, with a corresponding increase in ITOps management software, budgets and demands on ITOps professionals (Gartner, 2016, Gartner, 2020). The 1980s and 1990s were characterised by much simpler and isolated systems. However, from the 2000s, complex

and integrated systems like ERP and CRM emerged, followed by mobile computing, virtualisation, digital platforms, and cloud computing alongside other modern technologies that changed the IT landscape (Gartner, 2016, Gartner, 2019).

4.3 Decline of IT Operations in Top IS Journals

Lastly, our analysis shows that each of the four decades between 1980 and 2020 witnessed significant interest in System Maintenance compared to the other aspects of ITOps. This is followed by Knowledge and Skillsets Management, which had publications in all decades, apart from the 2010s. This is followed by ‘Service Management’ which had publications in two decades, the 1990s and 2010s. However, in terms of total breakdown, as per table 5 below, the 1980s saw publications in four ITOps aspects (System Maintenance, Process Management, Tools Management, and Knowledge/Skillsets Management). The 1990s also saw publications in four ITOps aspects (System Maintenance, Service Management, System Audit, and Knowledge/Skillsets Management). The 2000s saw publications in three ITOps aspects (System Maintenance, Change/Risk Management, and Knowledge and Skillsets Management). Finally, the 2010s saw publications in two ITOps aspects (System Maintenance and Service Management). This pattern again points to a decline in ITOps research, particularly in recent times where there is a greater need for such researches.

Table 5. IT operations literature total breakdown (between 1980-2020)

IT Ops Aspects	1980s (40 years)	1990s (30 years)	2000s (20 years)	2010s (10 years)	Percent
1. System Maintenance	4	6	5	3	18 (62.1%)
2. Configuration Management					0%
3. Change/Risk Management			1		1 (3.5%)
4. Incident Management					0%
5. Service Management		2		1	3 (10.3%)
6. Process Management	1				1 (3.5%)
7. Customer Support					0%
8. System Audit		1			1 (3.5%)
9. Tools Management	1				1 (3.5%)
10. Knowledge/Skillsets Management	1	2	1		4 (13.8%)
Percent	7 papers (24.1%)	11 papers (37.9%)	7 papers (24.1%)	4 papers (13.8)	29 (100%)

5 Discussion: Assessing the Status of Current Research and Agenda for the Future

The previous section showed that there is an uneven pattern in IT operations research, where some aspects are overlooked. In this section, we discuss the possible reasons behind the general lack of research in ITOps and propose directions for future research.

5.1 Wider Perspective on IT Operations

The literature review revealed that research on ITOps disproportionately focus on software maintenance. One reason for this is that IS adoption research often considered systems development and use, with little attention for IT operations. This narrowed the research agenda. Another reason is that in practice most organisations do not acknowledge operational costs in their cost/benefit analysis when deciding on new systems (Berghout et al., 2011). Also, outsourcing and cloud computing have shifted some aspects of ITOps to third parties.

Since IT operations is at the forefront of IT adoption and use, it is a fertile ground for taking IT seriously and opening its blackbox as many researchers call for (Orlikowski and Iacono, 2001). In this regard, the context of ITOps provides a unique opportunity for sociotechnical and sociomaterial researches to explore the interactions between human and non-human actors from various perspectives. This could be achieved by targeting configuration management, incident management and customer support, which are key aspects of ITOps.

The scope of IT operations literature could also be widened to include other domains like IT incident management and associated technologies. This is needed because the majority of IT budget and resources within IT organisations are dedicated to ITOps activities (Goldstein et al., 2011). Also, the relationship between external vendors, contractors and internal operational teams is yet to be examined thoroughly. Although many organisations adopt smart IT systems and analytic tools developed by vendors to monitor and manage their complex organisational infrastructures.

5.2 IT Operations and Adoption of Intelligent Technologies

IT operations is undergoing major transformations, with the adoption of novel approaches for predictive data analytics and fast-speed IoT connected devices that are enabled by AI. This presents a high level of social and technological complexity worthy of examination, despite difficulties with site access. From our experience, access to such operational environments are often restricted by organisations owing to their sensitive nature and contractual agreements with clients, vendors and other third parties who have economic interests in protecting their innovative solutions, intellectual property and licenses. Similarly, they also have interests in ensuring that flaws in their solutions are not widely publicised, to give them a chance to address them without the prying eyes of researchers and other outsiders.

Nonetheless, it is important for IS research to pay attention to this domain considering that it is one of the most important fields where the majority of IT professionals ply their trade. Further, considering that ITOps environments are usually replete with advanced technologies, it becomes difficult to completely separate social and technological actors. From this perspective, IT is ubiquitous and manifestly act in ways that make a difference in the world. This should make it easier for IS researchers to also see and focus on various technologies like remote sensors and AI-based tools that pervade organisational environments (Orlikowski and Iacono, 2001).

Further, since ITOps environments are at the forefront of IT innovation and smart IT adoption and use, they provide an ideal context for IS researchers that are interested in technological innovation and its impact to broaden their scope beyond start-ups. By also exploring established IT organisations that are at the forefront of large-scale IT development and adoption to for instance explicate how new technologies are integrated with established technologies or how organisations transition from one technology to another and the latent forces that inform such transitions. Such an understanding would help to shed more light on why some IT adoption initiatives are successful whilst others fail. Such insight would also help to shift the focus of IT adoption research to the long-term, rather than just the short term as is typical when such researches solely focus on the development phase, which is relatively limited.

5.3 Theorisation on IT Operations

The interactions that unfold between human and non-human actors and their respective agencies, and how these collaborate within AI, IoT and sensor-based systems that are currently on the rise had given rise to the phenomenon of ‘IT for IT management’. Whereby one form of IT manages another form of IT autonomously as is typical in IT operations, where intelligent IT tools and their underpinning sensors routinely scan the health of interconnected IT systems on a given organisational infrastructure to detect and report emerging signs of failure or performance abnormality. These reports inform other smart IT tools to intervene or alert operation engineers where necessary.

This pattern of ‘IT for IT management’ and other similar trends whereby instances of IT failure are sometimes addressed by smart IT without human intervention deserves research attention to help advance IS theorisation regarding the role of intelligent IT systems in organising. Indeed, examining IT operations in this context opens up opportunities for revisiting our understanding of concepts like ‘**organising**’ and ‘**work**’ and who performs them and how or for what purposes (Elbanna et al., 2020).

5.4 Complex/Multidisciplinary Knowledge Ecosystem

ITOps domain is rich in both organisational process and technical knowledge. This emanates from diverse disciplines and technological ecosystems that also makes ITOps “knowledge ecosystem” dynamic and circling between different stakeholders, organisational boundaries, knowledge domains and skillsets as depicted in fig 2 below

(Ramakrishnan et al., 2018b). This includes both open-source and proprietary knowledge that is tied to various network protocols and vendor products like application software and hardware products. From this perspective, the knowledge base of ITOps departments is distributive. Further, with every new product release or customer provisioning, comes new configurations that require existing knowledge to be updated to effectively integrate new configurations (Abeck and Mayerl, 1999).

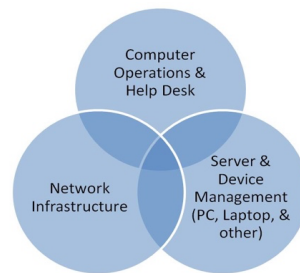


Fig. 2. ITOps knowledge domains (From: (Hetvik, 2014))

Today, the complexity, diversity and dynamism of organisational IT systems and infrastructures imposes additional demands in terms of the management of IT operations skillset and knowledgebase (Ramakrishnan et al., 2018b). This calls for further research in order to gain insight into how organisations could effectively manage their diverse and increasingly decentralised knowledge ecosystems. This is an important endeavour because whilst there is extensive literature on knowledge management (Armstrong and Sambamurthy, 1999, Hawk et al., 2009, Gupta et al., 2009, Kraaijenbrink, 2012, Orlikowski, 2006, Suchman, 2000, Thomas and Bostrom, 2010), these mainly assume that organisations have full control over their operational knowledge and could centralize its management.

However, as explained earlier, the complexity of modern IT systems and infrastructures partly stems from the fact that often different technology vendors and third-party solution providers with proprietary knowledge, inter-disciplinary teams with domain knowledge, clients and regulatory agencies need to collaborate to configure, deploy and operate these systems. From this perspective, the associated knowledge is very distributed. This opens up opportunities for exploring distributed work performance, work systems and organising for work and technology adoption/evolution from a modern perspective. Future research could also examine the associated complex and multidisciplinary ‘knowledge ecosystem’ to for instance address how reliable performance is attained within such complex organising contexts.

Also, whilst the traditional notion of teams generally refers to a collection of people, in the context of IT operations, this understanding seems limited because non-human actors also participant in the performance of many operational tasks. From this perspective, the constitution of teams in IT operations is unique and departs from the typical

human-centred views. This presents opportunities for IS researchers to revisit the notion of teams from the perspective of modern organisations that are equally reliant on intelligent technologies in the performance of their business activities.

6 Conclusion

IT operations is a critical function in modern organisations. Following a review of IT operations literature in eight top IS journals, the current paper revealed three main findings, notably the disproportionate focus on System/Software Maintenance, lack of contemporary view of ITOps, and a decline of ITOps in Top IS Journals. The paper proposes four main future research directions that would help enrich ITOps literature and make it more relevant to contemporary IS organisations.

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