Keeping a lower profile: how firms can reduce their digital carbon footprints

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The pursuit of net-zero presents significant and real challenges to how businesses must operate going forward. While the global net-zero agenda has typically focused attention on the tangible activities of businesses, such as production processes for decarbonization, much less attention has been paid to the impact of the digitalization process.

The digitalization of businesses has grown rapidly, with some describing its growth as a fourth industrial revolution. We see, for instance, the increasing dominance of the Internet of Things (IoT) technologies with associated data volume predicted to be 79 zettabytes worldwide by 2025 (Statista, 2020). The large and ever-increasing amounts of data being generated and used require greater storage and additional energy usage, resulting in the growing production of carbon emissions (EcoAct, 2021). Nevertheless, knowledge of the damaging impact digitalization may be having on the environment is still in its infancy. If businesses are to be proactive in their collective pursuit of net-zero, they must incorporate digital best-practices in any sustainability strategy.

In this article, we introduce the concept of digital decarbonization and present a new model of knowledge (re)use in organizations. Pioneering the shift from "single-use" knowledge toward effective and efficient reuse of data and knowledge, the article presents a new model to enable organizations to reduce their digital carbon footprint and meet the ambitious net-zero goals of governments across the globe.

Decarbonization and its impact on business

In the USA, the policy paper "The Long-Term Strategy of the United States – Pathways to Net-Zero Greenhouse Gas Emissions by 2050" sets out the policy strategy to decarbonize US industry. The aim cited is to reduce net greenhouse gas emissions by 50%–52% by 2030 Similarly, the UK government's "Industrial decarbonisation strategy" seeks to reduce emissions by approximately two thirds come 2035, and by as much as 90% by the year 2050 (Great Britain. Department for Business, Energy and Industrial Strategy (2021), *Policy paper Industrial decarbonization strategy* 2021).

In the transition toward net-zero, both the USA and the UK policy strategies make clear that this should not compromise the competitiveness of businesses but contribute to a thriving industrial sector. It is not surprising, therefore, that a common feature of discussions across boardrooms is the need to adapt business practices to align with the decarbonization policy agenda.

The immediate questions facing businesses, however, are how can this be achieved? And can it be achieved at low-cost? There has been much attention directed at those technological and digital innovations that may assist organizations to this end (e.g. electrification, low-carbon

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hydrogen and carbon storage), and whilst these have much merit, they will involve significant costs. Alongside these transformational developments, organizations must increase their awareness of where and how they might be contributing to the carbon footprint in daily business practices. With the huge expansion of digital technologies and integration of digital data in the day-to-day operations of most businesses, the role digital practices might be playing in the production of emissions is an area for examination.

What is digital decarbonization?

Reducing the digital carbon footprint should be a critical feature of any sustainability strategy pursued by organizations. The concept of digital decarbonization is largely absent from the wider academic literature, with only a few references to the concept in the "grey" literature. When presenting the term, authors refer to the role of digital technologies in reducing greenhouse emissions (Doleski *et al.*, 2022) or digital innovations for clean energy systems (Sivaram, 2018). Similarly, Ernst young, a leading management consultancy, refers to digital technologies that can create socio-cultural and ecological change, but they comment that "digitalization in itself is neither good nor bad for achieving climate targets. It depends on what we make of it" (Teuful and Sprus, 2020). While digital innovations are often heralded as a means to help meet net-zero targets, rarely is it recognized that digitalization in itself can increase a firm's carbon footprint, and this is our meaning of the concept.

Far from being carbon-neutral, as might be assumed, digitalization currently accounts for four percent of global greenhouse gas emissions (Teuful and Sprus, 2020). With 5G capabilities becoming common place in firms' operations, the already large volume of data being handled is on an exponential rise. To date, our best estimates suggest that at least 2.5 quintillion bytes of data are produced every day by organizations, and rather worryingly, 55% of these data are deemed "Dark Data" (Statista, 2020). Dark data is defined as "the information assets organizations collect, process and store during regular business activities, but generally fail to use for other purposes (for example, analytics, business relationships and direct monetizing)" (Gartner, 2022).

The need for digital storage and processing solutions subsequently requires even greater energy use, a by-product of which is increased greenhouse gas emissions (EcoAct, 2021). This generates a significant threat to the pursuit of net-zero because the energy sector already accounts for a large percentage of total global emissions. The key to digital decarbonization may, therefore, lie in how knowledge and data are used, and reused, by organizations and their employees in daily activities and operations.

The culture of digital knowledge and knowledge reuse

Knowledge reuse refers to identifying and exploiting available knowledge in organizations and is an activity aimed at managing disposable knowledge in an organization (Markus, 2001). Yet many organizations fail to recycle knowledge. We have explored one reason why dark data is growing, due to the growth in IoT sensors, but could there be a more fundamental, cultural aspect to how the workforce operates that could be fueling dark data?

Empirical data indicates that information workers in western Europe are losing 50% of their time every week searching for, governing and preparing data (30%) and duplicating work (20%) (IDC, 2018). This equates to 10 h a week, every week, building knowledge and information assets that already exist in the organization. The consequence is a huge and unnecessary draw on critical power and energy (IDC, 2018), where knowledge is not reused, serving a one-time purpose only.

Identifying ways to facilitate knowledge reuse in organizations can reduce the repetition of data searches, use of data infrastructures and knowledge storage, thereby reducing the amount of power and energy being used by organizations. Taken collectively, these actions will reduce the digital carbon footprint of organizations. The challenge is that there are no clear guidelines about how this might be accomplished.

Managing the digital carbon footprint

We have developed a model that examines the role digitalization plays in supporting decision-making processes and information processing. Though digitalization significantly accelerates data analysis and enables access to large data sets, it can also, in some cases, limit reflection and in-depth dialogue, providing just-in-time single-use knowledge. This type of knowledge can, in turn, increase the digital carbon footprint by reducing knowledge reuse in organizations, which may explain the rapid rise in the volume of dark data that unnecessarily adds to the carbon footprint. We explore the implications of our model from a sociotechnical perspective.

According to Pasmore *et al.* (1982), "the sociotechnical system view contends that organizations are made up of people that produce products or services using some technology," and that each "affects the operation and appropriateness of the technology as well as the actions of the people who operate it" (p. 1182). This sociotechnical perspective emphasizes the interconnecting social and technical factors in the way people work in searching for information and use knowledge. We apply this perspective to examine the current and future implications of artificial intelligence-enhanced information brokers on knowledge waste and knowledge reuse. Applying this sociotechnical perspective to digital data systems aids in understanding those issues linked to using artificial intelligence technology in knowledge management.

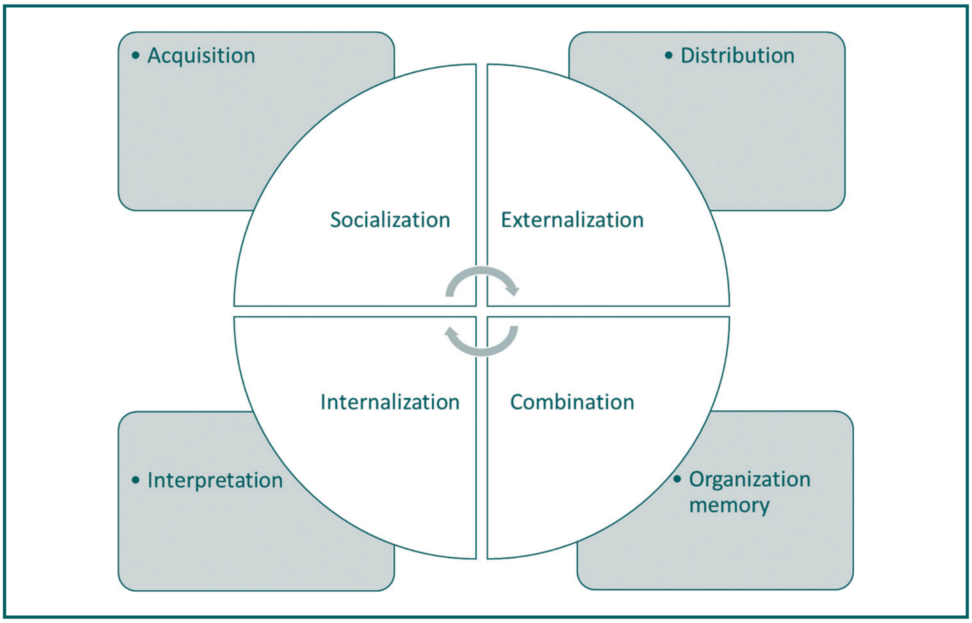
The technical subsystem comprises devices, tools and techniques needed to transform inputs into knowledge outputs in a way that enhances the economic performance of the organization. For instance, an employee requires information to complete a task and requests information through an information broker for the required task. Examples of AI-enhanced information brokers are search engines like Google and Bing, through to the more sophisticated brokers like IBM Watson.

The social subsystem refers to the process of learning and is based on four interactions: knowledge acquisition, information distribution, information interpretation and organizational memory (Huber, 1991). Knowledge acquisition is based on a mechanism for obtaining information, the primary driver of which is attention. Attention influences what is being highlighted in organizations, what aspects or problems are the most important and the challenges organizational activities focus on. In contrast, information distribution refers to the sharing and exchange of knowledge within an organization. The interpretation of information includes giving meaning to knowledge held, whereas organizational memory refers to the use of new knowledge (Huber, 1991).

Most business departments have a sociotechnical environment, and it is in this space where knowledge is acquired, processed and stored. The effectiveness of the knowledge environment depends on four factors to maximize its usefulness. These are socialization (tacit to tacit), where tacit knowledge is the knowledge that we possess garnered from personal experience and context and then passed onto another employee; externalization (tacit to explicit) involves transferring the knowledge in our minds onto paper or into digital form; combination (explicit to explicit) involves organizing and integrating knowledge where different types of explicit knowledge are merged and internalization (explicit to tacit) involves individuals taking the knowledge created throughout an organization and converting it into tacit knowledge (Nonaka and Takeuchi, 1995).

Figure 1 pulls these insights together and can be used to help illustrate how employees in organizations often seek out and (re)use new knowledge. We present three steps that employees may follow in their pursuit and use of required information. Each step comprises different decisions that might be taken by an employee or team. Depending on the decisions taken, we reveal pathways to the creation of ineffective and inefficient dark data

Figure 1 A knowledge creation framework



that should be avoided, as well as a route to the effective reuse of information and data and ultimately to reducing the digital carbon footprint of organizations.

Step 1: the search

To acquire new knowledge, the employee must decide between two different paths: (A) using only an information broker (e.g., Google, or internal Google like interface); or (B) using both existing human knowledge within the organization and the information broker in combination:

- Path A "information broker searching". In the acquisition of new information, the individual uses an information broker to search and retrieve data, information and knowledge. The broker can access information from the internet or company data stored in data lakes. Whilst the power of the brokers to provide just-it-time knowledge is immense, and there are potential issues. One example is Google's personalized search. If an individual searches the internet using Google, the search engine will use their browser cookie record to provide more relevant search results to the user. Search results presented are based on the relevance of each Web page in relation to the search term and which websites the user (or someone else using the same browser) visited through previous search results. This approach provides a personalized search that increases the relevance of search results, which many of us use today without knowing about the technology behind it. However, Path A assumes that the information broker is aware of all the data sets and the link between them and/or the end user is aware that the data set exists. However, due to the vast daily increase in data sets and the lack of metadata joining various data sets (poor information governance), this is seldom the case, and why we are seeing such an increase in dark data, which is adding to the carbon footprint.

→ *Acquiring new knowledge leads to Step 2.*

- Path B "hybrid searching". Within organizations, employees trying to complete a knowledge task start by combining existing information and calling upon existing human knowledge within the organization. They can also use existing stored knowledge to understand what has been done before and use an information broker to search and retrieve digital data, information and knowledge. Though socializing the task, helps the employee refine the question and increases their awareness of what to look for in the data and information.

→ *Acquiring new knowledge leads to Step 2.*

Step 2: the sanity check

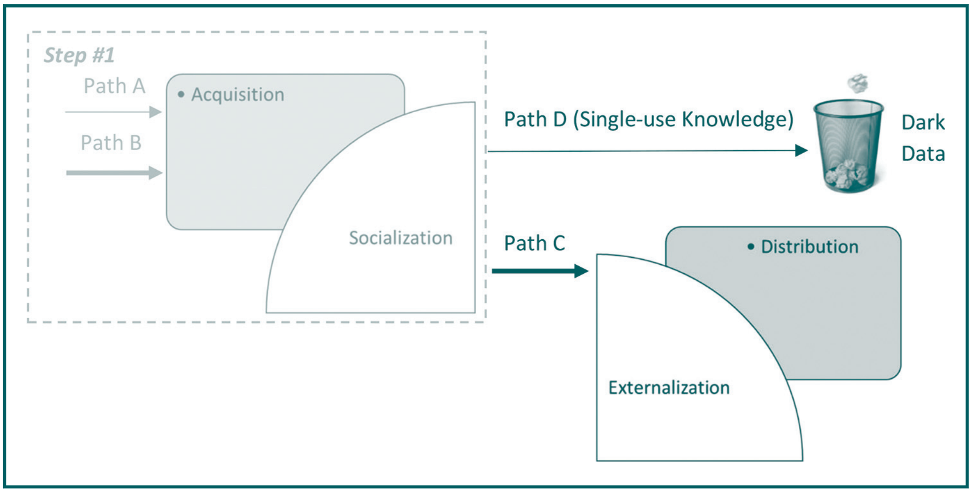
Having acquired new knowledge through either Path A or Path B, the employee chooses the degree to which socialization occurs. Depending on the level of socialization, two follow-on paths present themselves, with one continuing the route to knowledge reuse, the other leading to single-use and discarding the knowledge, which increases the volume of dark data (as presented in Figure 2):

- Path C "data consultation". On retrieving the data and information, the employee engages others with the new data and information as part of the socialization process. Socializing the information helps to get an understanding of what knowledge might help to address the task and involves discussing your thinking with colleagues to enable feedback. Through this process, externalization of the new knowledge occurs, where new information, data and insights gathered are distributed across the organization. This process of externalization is assisted by information governance structures and systems that enable new knowledge to be codified and distributed (e.g. information sharing processes like e-bulletins, e-newsletters, etc.).

→ *Enabling continuation to Step 3 and the possibility of knowledge reuse*.

- Path D Single-use Knowledge. Due to time restrictions and not being able to engage with colleagues, socialization of the new knowledge may not take place. When socialization does not occur, it can cause the creation of a peculiar information broker bubble. The bubble occurs when existing knowledge stops being challenged or changed. Here, we may see the biggest challenge to knowledge reuse in the business and the greatest amount of knowledge waste through single-use knowledge and disposal. If there has been little or no socializing of the ideas, most employees will decide not to distribute knowledge. This means they have opted not to share it with employees or to log findings (externalization), so the knowledge is "thrown-away." This

Figure 2 Step 2: the sanity check and single-use knowledge



could lead to a sharp rise in the percentage of dark data, as there will be no record that the data has been used or even exists.

→ *Enables continuation to Step 3 and the possibility of knowledge reuse..*

Step 3: knowledge reuse

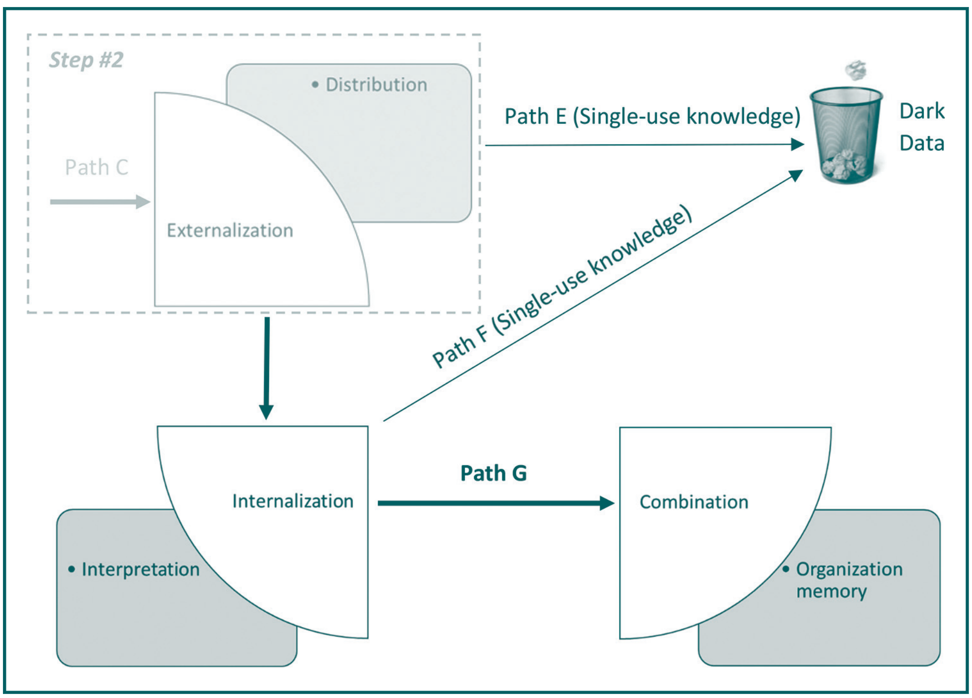
After acquiring new knowledge, socializing and externalizing this new knowledge through Path C, Step 3 presents a further three paths, two of which result in single-use knowledge generation and dark data, with the third leading to knowledge reuse and reduction of the digital carbon footprint (as presented in Figure 3):

- Path E “Single-use knowledge”. If employees across divisions do not internalize new knowledge, dark data will increase because there will be no record that the data exists as time passes, resulting in huge volumes of data being stored and forgotten. This lack of usage trackability can lead to the situation where all data and information is stored and labeled as “it might be useful in the future”, which adds to the dark data stockpile. With technology providing just-in-time knowledge at the click of a search button, this path may be a consequence of time pressures and employees not seeing the “bigger picture”, and the need to internalize knowledge for future purposes.

→ *Dark data is generated, and knowledge reuse does not occur.*

- Path F “Single-use knowledge”. Even when knowledge has been interpreted across the organization and internalized by employees across the organization, there is still the danger of it being forgotten and lost over time. This may be a consequence of staff turnover, system upgrades, poor knowledge capture, etc. Here, employees do not retain the newly gained knowledge, and so it is not kept alive as part of organizational memory. Consequently, this results in an increase in the volume of dark data and a

Figure 3 Step 3: knowledge (re)use and single-use knowledge



greater impact on the digital carbon footprint, as new knowledge has not been turned into reusable information or knowledge for the future.

→ *Dark data is generated, and knowledge reuse does not occur.*

- Path G "knowledge reuse" – The employee is granted enough time to develop wisdom, which can be derived from the process of externalizing and distributing new knowledge. Through distributing knowledge organization-wide, other employees (departments, divisions, etc.) can internalize the new information to extract meaning for themselves and their functions. It is at this point that the organization starts to learn by combining the new knowledge with existing data so it can be shared and reused in the future through organizational memory. So, rather than the same search process being repeated in the future at a cost to the digital carbon footprint, good information governance enables knowledge reuse (e.g. for similar scenarios). Following Path D will improve organizational knowledge and enable the critical evaluation of existing knowledge, which is essential for the successful application of knowledge and effective learning. It is the antithesis of superficial surface-learning and dark data production.

→ *Knowledge reuse happens, and dark data is reduced*.

Moving away from single-use knowledge and dark data production

Technological development and social change are accelerating digital advancement and changing the ways organizations obtain and use information. While digital tools are often perceived to be optimal for data use (e.g. adjusting the strategy to the algorithmic prediction) by enabling data and information to be accessed at the click of a button, where and how digital data is being stored is a critical consideration for sustainability practices. Without this, there is a real danger of single-use knowledge becoming commonplace at the neglect of knowledge reuse, which will have a detrimental impact on an organization's digital carbon footprint.

While single-use knowledge may be deemed a major step forward, as it enables decision-makers to operate quickly and provide prompt answers, it can lead to surface learning and an over-reliance on technology, creating significant volumes of dark data. A critical consequence of this is that employees and decision-makers within organizations will repeatedly search and store the same digital data over time, with data being duplicated and generating huge drains on power and energy. As we move further into the single-use knowledge mindset, organizations may become even more reliant on information resources with a "single-use" approach.

In contrast, pioneering organizations will adopt sustainable digital strategies that will focus on the effective reuse of existing knowledge resources and the conscious development of the knowledge pool for future knowledge (re)use. This will be achieved by consciously feeding in new knowledge acquired, so it continually evolves, as opposed to the single-use knowledge approach. Such a sustainable approach brings about long-term benefits where data becomes a renewable source reducing the impact on the digital carbon footprint. In contrast, single-use knowledge will only lead to superficial understanding and duplication of data at a huge energy carbon cost.

Spotlight observation

Single-use knowledge is a key challenge to sustainable business and digital decarbonization. Managers need to determine ways of using the strength of technological advancement without compromising the digital carbon footprint of their organization. Single-use knowledge promotes the throw-away approach to information and data: it can be obtained from large data sets, used one-time and quickly disposed of. It is within this approach that we are likely to see significant digital carbonization. For example, the large volumes of dark data sets rapidly grow through the likes of IoT sensors that are never evaluated or used by the organization. In contrast, effective knowledge reuse reduces dark data and positions organizations in a stronger position to maintain sustainable knowledge processes and, thus, decrease their digital carbon footprint.

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Net-zero,
Decarbonization,
Digital decarbonization,
Sustainability,
Knowledge use,
Dark data,
Information technology,
Digital strategy,
Digital carbon Footprint,
Digitalization,
Artificial intelligence

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