THE ROLE OF E-MAIL IN INCREASING OUR CARBON FOOTPRINT

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ABSTRACT

Digital technologies are part of our daily lives, and they have a carbon footprint. This paper explores the effect of sending e-mails for business purposes, a supposedly green means of communication, in two workplaces, home and office. Quantitative data of the e-mailing activities of staff was collected and the CO_2e calculated. The survey included the perceptions of the uses of the cost in terms of CO_2e. Based on the data collected, e-mail is an integral part of modern communication within an organisation. A statistically significantly higher percentage of e-mails were sent/received in the office ($p < 0.001$) and the percentage of long e-mails with attachments/images is statistically significantly higher in the office than from home ($p = 0.0194$). The number of standard e-mails is statistically significantly higher in the office than from a cubicle within an office ($p = 0.020$). E-mail seems to be a relatively eco-oriented business and private channel, but the results of this study indicate that it results in the emission of CO_2e.

Keywords: carbon footprint; digital footprint; e-communication; e-mail; workplace

Introduction

Each industrial revolution gives rise to a different way of doing things (Beno 2019). Nowadays everything can be accessed via the Internet (Wook 2019). Different options are chosen by people with little or no consideration of the effect it has on emissions. Currently, global climate change is a topic of great interest. Humans were confined to their residences for a long time during the covid-19 pandemic.

Undoubtedly, one's place of work has undergone a massive change from a business environment to home (De Vincenzi 2022; Beno et al. 2023). This transformation, mainly due to the Covid-19 pandemic, resulted in a transition from a traditional cubicle settings to more flexible settings. In the pre-pandemic period, the use of e-mails was already increasing slowly but steadily (Felstead 2021; Beňo 2022). Hence, a large share of workforce activity globally is fully remote, hybrid or in-office. Ignoring productivity, this raises the question of which option is the most sustainable, sending e-mails from home or a cubicle in an office. Commuting is a necessary but usually disliked daily routine (Beňo 2022) and sending e-mails from home reduces the time spent travelling (Beno and Caganova 2023), leading to a reduction in transportation emissions, but an increase in use of energy at home (Cicala 2023; Shi et al. 2023) and alters ones' style of living (Oda and Kanegae 2023). While time spent travelling decreases, as expected, the overall number of trips in vehicles actually increases (de Vos et al. 2018; Zhu et al. 2018; Caldarola and Sorrell 2022). A recent study demonstrates that the "pandemic upended old routines by creating new ones such as pseudo-commuting" (Beňo 2023, p. 131). In contrast, working from a cubicle is viewed as less environmentally friendly and has its own environmental implications. Therefore, this paper explores this complex situation and its effect in two workplaces, namely working from home and an office.

A digital footprint is the data left behind after every digital service action or whenever others post information to you (actively or passively). There are many harmless everyday actions that contribute to emissions of carbon dioxide (CO_2e). These activities include the so-called "digital footprint." E-mails are still an important means of communication for both people in general and business. In 2022, there were a total of 4.26 billion e-mail users globally (Statista 2024). The greenhouse gas (GHG) emissions of the average digital user in 2019 were approximately equivalent to 356 kg CO_2 (Bordage 2019). Average e-mail traffic is equivalent to driving 10–128 miles in a small petrol-driven car (Berners-Lee 2020). As a consequence, the following question was addressed:

- What is the estimated CO_2e produced by e-communication in homes and offices?

Quantitative data were collected from staff of a particular business about their e-communication activities, and the CO_2e calculated. This survey determined the perceptions of CO_2e in the workplace.

The following section briefly explains the meaning of the digital CO_2 footprint. The third section describes the collection and analysis of the data. The results are presented in the next section, followed by a review of the findings and an outline of the meaning and relevance of the study. The last section summarises the arguments/findings of this study, discusses the implications and presents an overview of what remains to be done in the future.

Footprint of digital CO_2

According to Sharma and Dash (2022), there are CO_2 emissions associated with various human and natural activities. Digitisation "designates the analogue information conversion into digital information" (Beno and Saxunova

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2018). The use of Internet results in a high percentage of CO_2e emitted (Sharma and Dash 2022). "The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product" (Wiedmann and Minx 2007, p. 4). Grinstein et al. (2018, p. 1) typify "carbon numeracy as one's ability to approximate a correct value of one's carbon footprint without resorting to an explicit calculation." Digital footprint simply means all data left behind when going online (passive or active (Lutz and Hoffmann 2017) or all direct and indirect emissions (Wiedmann and Minx 2007). The digital carbon footprint, simply stated, is the effect on the environment associated with digital online activities, measured as the sum of all greenhouse gas emissions. In 2022, Austria's total greenhouse gas (GHG) emission (other than land use, land use change and forestry – LULUCF) amounted to 72.8 Mt CO_2 equivalents (CO_2e) (UB 2024, p. 9). The average person in Austria emitted 6.9 t CO_2 in 2022 (Ritchie and Roser 2024) compared with German's 12 t (Gröger 2020). According to Gröger (2020), the estimated CO_2e of digital activities totals 850 kg CO_2e per year. Based on LocaliQ data (Marino 2023), a lot can happen in a minute in today's hyper-connected Internet era, e.g. 231 million e-mails can be sent; in a day, 6 billion are sent and received. Daily e-mail traffic (of both business and public) exceeded 362 billion in 2024 (Radicati 2023). In 2019, the global digital CO_2 was equal to that of a country two to five times the size of France (Bordage 2019). Digital communications accounts for 2% to 4% of greenhouse gas emissions (EC 2024).

Wissner-Gross report that it takes on average about 20 milligrams of CO_2 per second to visit a website (Simpson 2009). An Apple iPhone13 produces 64 kg of carbon emissions (Apple 2021). Streaming 35 hours of video a month is equivalent to 2.68 metric tons of CO_2 (Marks et al. 2020). Berners-Lee (2020, p. 16) provides the average carbon footprints of different e-mails as follows:

- 0.03 g CO_2e for spam e-mail picked up by a filter;
- 0.2 g CO_2e for short e-mail sent/received on a phone;
- 0.3 g CO_2e for short e-mail sent/received on a laptop;
- 17 g CO_2e for long e-mail that takes 10 minutes to write and 3 minutes to read, sent/received on a laptop;
- 26 g CO_2e for an e-mail that takes 10 minutes to write and is sent to 100 people, of whom one reads it and the other 99 glances at it for 3 seconds and decide to ignore it.

The average business e-mails account for 131 kg of CO_2e per year, 22% of which is spam-related (McAfee 2009). If every person in the UK sent one e-mail less per day it would save 16.433 t of CO_2 per year (OVO 2019).

Materials and Methods

In this paper, evaluative (McDonough and McDonough 1997) and instrumental (Stake 1995) research methods were utilised. For purposes of evaluation, the data were divided into two parts: dependent (received per day, sent per day, standard e-mails, long e-mails with attachments/images, desktop/mobile) and independent variables (business and public). Data was collected for six months from September 2023 to February 2024 using both variables.

In order to satisfy this requirement, a quantitative study was conducted. The methodology used was that cited by Beno et al. (2022) and consisted of an ad hoc questionnaire in a real workplace environment in an Austrian company (in the region of Lower Austria) with workers at home (n = 10) and in the office (n = 10). The author has business contacts with organisation selected and the agreement to participate was given during an interview with the manager. This organisation was chosen as its staff either worked from home or office. A consent form between the researcher and research participants was agreed, which stipulated their roles and responsibilities towards one another throughout the entire research process.

A quantitative data collection was appropriate for this study because it allows a vast volume of data to be obtained from respondents. This was done using a search folder for incoming and outgoing e-mails for each participant and creation of a VBA code in Outlook. In addition, the organisation's own record of the total number of e-mails received/sent per day in a month was used. The respondents only noted the number of attachment/image e-mails in an Excel sheet on a daily basis. E-mails opened/sent using mobile phones were recorded and noted in an Excel sheet by the respondents. Finally, the data were analysed using Excel, statistical tools and SPSS, and a correlation analysis. In addition, Berners-Lee's (2020) and Fighiera's (2024) average CO_2e data was used to determine the @CO_2e. For this purpose, the following formula was used:

$$\mathbf{@CO_2e = a@ \times GWP \times sCO_2e}$$

where:

@CO_2e = e-mail carbon footprint

a@ = average number of types of e-mail (standard/long e-mails with attachments/images)

GWP (global warming potential) = **1** (Eurostat 2023)

sCO_2e = standard values of carbon footprint generated by different types of e-mail (the values were as follows: standard e-mail 0.4 g CO_2e, and long e-mail with attachments/images 50 g CO_2e (CWJOBS, n.d.))

Results

Carbon literacy is "an awareness of the carbon costs and impacts of everyday activities and the ability and motivation to reduce emissions on an individual, community and organisational basis" (CLP 2020, p. 2). As reported in the literature, receiving/sending e-mails results in a wide range of values of CO_2e. In order to protect the world, every step taken to reduce the production of CO2 is important. What about e-mails? It is important to know the amount of CO_2e generated using e-mails in business?

First, just like any digital channel, e-mailing relies on energy. Normally, e-mail is viewed as relatively eco-oriented. But, as there are enormous numbers of e-mail users, billions of e-mails are sent every day, all of which produce CO_2. The @CO_2e depends on various factors, e.g. weight, attachments, images, videos, recipient residence and storage. Generally, e-mails are not counted and used in mass as a tool in business and home environments to communicate in order improve mutual cooperation and relationships.

Based on the data collected in this study, e-mail is an integral part of modern communication in and within an organisation. On average, each day the in-house workforce received 35 and sent 118 e-mails via computers and received 10 and sent 45 e-mails via smartphones. At home, each day the workforce received 56 and sent 164 e-mails using computers and received 10 and sent 45 e-mails using smartphones. In terms of size: on average, the in-house employees received/sent 56 standard and 97 long e-mails with attachments/images each day. Those working from home received/sent 104 standard and 116 long e-mails with attachments/images each day.

In the cubicle in the office, the average number of e-mails (sent/received) is 153, consisting of 56 (36.6%) standard and 97 (63.4%) long e-mails with attachments/images. For business, the average daily number of e-mails (sent/received) is 220, consisting of 104 (47.3%) standard and 116 (52.7%) long e-mails with attachments/images. In order to determine whether there is a difference between the percentage of e-mails received/sent, the difference between the percentages was tested. The software only provides the p-value for these tests. There was a statistically significantly higher percentage of e-mails sent/received in the office than in the cubicle ($p < 0.001$), but the percentage of long e-mails with attachments/images for the cubicle is statistically significantly higher than for the office ($p = 0.0194$). The percentage of standard e-mails is statistically significantly higher for the office than the cubicle ($p = 0.020$).

As mentioned above, billions of e-mails are sent on a daily basis, all of which produce CO_2e. As shown in Table 1 (see figures in bold), e-mails from home emit more emissions than those from the office.

The average e-mail traffic recorded for the office and home emits more CO_2e per day than commuting by diesel car 27 km a day, as shown in Table 2 (see figure in bold).

E-mails sent/received in the office emit more CO_2e per year than heating/cooling, as demonstrated in Table 3 (see figures in bold).

Discussion

According to Huang and Shyu (2009), e-mailing is valuable for cultivating relationships. Comparable to the data recorded in this study (in terms of the average num-

Table 1 CO_2e.

Average /Day		Standard in kg	Long with attachment /image in kg	Average /Year	Long with attachment /image in kg	Standard in kg	Total in t
	Office	0.022	4.85		4.748	1028.2	**1.03**
	Home	0.041	5.80		8.819	1229.6	**1.24**

Table 2 Daily CO_2e of different modes of transport (Based on UNFCCC 2021; Statistics Austria 2024).

Mode	Factor	Average km	kg CO_2e/day	kg CO_2e/ year	Total in t
Bus	0.103	27	2.78	590.26	0.59
Diesel car	0.168		**4.55**	964.15	0.96
Metro	0.027		0.74	157.41	0.16
Railway	0.036		1.00	211.44	0.21

Table 3 Yearly CO_2e that was emitted heating the office (Based on UNFCCC 2021).

	Consumption kWh/hour	Working hours per day (141.33)	Factor 0.13	kg CO_2e	Total in t
Heating (2 months)	0.15	21.199	2.755	5.51	**0.01**
Cooling (3 months)	3.65	515.845	67.061	201.18	**0.20**
Heating (7 months)	5.15	727.849	94.620	662.34	**0.66**

ber of e-mails sent/received), e-mail promotes business and strengthens relationships in a variety of ways. This is similar to the situation in Australia, where at least 121 e-mails are sent/received every day (Jenkin 2014).

Generally, the sending of e-mails is not synchronized (Mick and Middlebrook 2015; Palupi 2022). But based on the data collected, the percentage of standard e-mails sent from the office is significantly higher than from the where at least 121 e-mails are sent/received every day (Jenkin 2014).

Generally, the sending of e-mails is notcubicle ($p = 0.020$). This means that e-mails sent/received in the office are synchronous because workers are expected to respond to an e-mail right away.

This study reports that e-mails emit CO_2e. Bordage (2019) highlights the carbon footprint has increased due to modern digital technology. Furthermore, consuming one euro of digital technology in 2018 induced direct and indirect energy consumption 37% higher than in 2010 (Theshiftproject 2019). In both work environments, CO_2e is higher than when commuting 27 km by a diesel car or even when heating/cooling an e-office. Digital technology can indirectly reduce CO_2e (Shen et al. 2023), but recent research indicates that nearly 72% of UK citizens are unfamiliar with the CO_2e associated with their inbox (OVO 2019). When determining the CO_2e of e-mails, size must be considered. For a long e-mail with an attachment/image, more electricity is needed, therefore the e-mail emits a greater weight of CO_2e (4.85 kg and 5.8 kg of CO_2e daily in the office and home respectively). As explained by Fighiera (2024), it is more impressive when the whole volume of CO_2 emitted by e-mails exchanged daily in the world is considered. As stated by Beňo (2021), despite the numerous benefits of digital technology, there is a need to emphasize its effect on the environment as reported in this study.

Conclusions

What appears to be a green activity, such as sending and receiving e-mails, can result in the emission of CO_2e. It is likely the online world will continue to expand. For this reason, it is necessary to have a better understanding of the digital contribution to global change due to e-mail CO_2e. This study collected the data necessary for answering the following research questions:

- What is the estimated CO_2e emission from e-communications sent from home and offices?

E-communication is an essential aspect of daily life, but it also affects the environment. Based on the data collected, sending e-mails is seen as eco-oriented, but it results in the emission of CO_2e. The volumes of 1.03 t for those sent from home and 1.24 t for those sent from offices per year are not very large, but if considered globally it is much greater. The weight of the emissions resulting from the use of e-mails is significant: 4.85 kg and 5.8 kg of CO_2e produced daily for home and office use, respectively. Although significant it is much less than from other sources of pollution. One should start by limiting the size of e-mails clean-up your mailbox. All in all, the effect of e-mails is smaller and greener than other sources, but this does not mean it should not be reduced.

This topic is complex and solutions to reduce CO_2e need collaboration between different stakeholders. A decrease of @CO_2e may be achieved by encouraging the workforce to use eco-friendly practices.

A limitation of this research is that a retrospective measure of e-communication was used for estimating the @CO_2e in only one department of one company in Lower Austria. Thus, it was not possible to test it. Further, it would be difficult to repeat this study due to various factors, e.g. the type of industry, the availability of data on home and office use of e-mails. Thirdly, the analysis was constrained by the data and limited time available.

Qualitative study needs to be part of future studies. In addition, it should include the hidden cost of spam e-mails, which could be significant as the spam folders of many computers contain very large numbers of e-mails.

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