INSIGHTS INTO REGIONAL DEVELOPMENT
ISSN 2669-0195 (online) http://jssidoi.org/IRD/
2022 Volume 4 Number 4 (December)
http://doi.org/10.9770/IRD.2022.4.4(1)

Publisher
http://jssidoi.org/esc/home

SOME IMPACTS OF GLOBAL WARMING ON CRITICAL INFRASTRUCTURE PROTECTION - HEAT WAVES AND THE EUROPEAN FINANCIAL SECTOR

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Received 17 August 2022; accepted 17 October 2022; published 30 December 2022

Abstract. Global warming is one of the hottest topics today, impacting every aspect of our life on Earth. Surprisingly, the effects of climate change on critical infrastructure protection have not been studied extensively. This paper i) examines three challenges raised by heatwaves: managing environmental risks; failure of partners and supply chains caused by extreme weather; operation during heatwaves, and ii) gives an overview of the responses of the European financial sector. By contributing to the growing research area of global warming, this study provides an opportunity to understand some of the climate risks better and offers some insights into the climate strategy of the European banking industry. Research data is drawn from two primary sources. Relevant literature was explored, and current supervisory recommendations were examined along with the results of the European financial sector's first climate risk stress test.

Keywords: European Central Bank; banking industry; critical infrastructure protection; heat waves; global warming

Reference to this paper should be made as follows: Somogyi, T., Nagy, R. 2022. Some impacts of global warming on critical infrastructure protection - heat waves and the European financial sector. *Insights into Regional Development*, 4(4), 11-20. https://doi.org/10.9770/IRD.2022.4.4(1)

JEL Classifications: Q54, M15, N24

1. Introduction

According to the widely accepted theory, the increasing amount of the so-called greenhouse gases in the atmosphere causes an increase in the global temperature by the adsorption of the heat that tries to leave the Earth after being heated by the Sun (Lechter, 2021). No doubt, the Earth is warming up in an accelerating way: in the last decades, it has been hotter than at any other time in the last millennium (McGuire, 2014). Among the effects of this global warming are rising sea levels, more frequent floods, severe storms, tornadoes and hurricanes, droughts and heatwaves (Fletcher, Smith, 2020).

The so-called heatwave is one of the most relevant extreme weather events due to its effects on health, society, agriculture and the environment. As the World Meteorological Organisation stated, 2015-2021 were the warmest years, with exceptional heatwaves in North America and Europe (World Meteorological Organization, 2022). For example, Greek data confirms the increasing trend in the frequency and length of heat waves between 1960 and

ISSN 2669-0195 (online) http://jssidoi.org/jesi/
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http://doi.org/10.9770/IRD.2022.4.4(1)

2019 (Founda et al., 2022). The latest report of the United Nations' Intergovernmental Panel on Climate Change (IPCC) forecasts that warming in Europe will continue to rise faster than the global mean (Intergovernmental Panel on Climate Change, 2022). Although hot weather jeopardizes all the regions of Europe, the Mediterranean is much more threatened (Molina, Sánchez, Gutiérrez, 2020). For the 2021–2050 period, heatwave amplitudes are expected to increase by 0.5–2 °C on average (and the maximum can reach 50 °C or more) in the warmest parts of the Mediterranean and southern Europe (Zittis et al., 2021). July 2022 was one of the three warmest Julys on record, and numerous July records for maximum temperature were broken in Western Europe, reported by the EU's Copernicus Climate Change Service (Copernicus Climate Change Service, 2022).

According to the World Health Organization, skin eruptions, heat fatigue, heat cramps, heat syncope, heat exhaustion, and heat stroke are classic heat-related illnesses (World Health Organization, 2004). The 2021 report of the Lancet Countdown on health and climate change has established a link between increased temperature and mortality (Romanello et al., 2021). It has been found that heat waves increase the number of deaths (Ye et al., 2012). Furthermore, it has been demonstrated in Spain that the vulnerability of the urban population to heatwaves is bigger than the vulnerability of the non-urban population (López-Bueno et al., 2021), which underpins that death is more likely to occur in high-income countries (Amirkhani et al., 2022), e.g., in the member states of the European Union.

Besides affecting our health and life, heatwaves also significantly affect physical security and fire safety: they create better conditions for fire in which opportunities may be seized. Fire can be used to cause damage to infrastructure and through it to an entire society, as it was experienced in 1991 when the Iraqi army set fire to the petroleum infrastructure in Kuwait (Moger, 2021). Moreover, arson has become a method of extremism, thus a weapon of terrorists threatening critical infrastructure and engaging security forces (Besenyő, 2017).

Thus, global warming and heat waves significantly affect our European society. The central questions of this study ask what heatwaves raise the challenges. How can we manage environmental risks and failures of partners and supply chains? How can the smooth operation of critical infrastructures be maintained during heat waves? A qualitative case study approach is used to answer these questions. This paper first examines how the European financial sector approaches the issue of global warming in general based on publicly available sector-specific data. It will then give an overview of the main challenges caused by heat waves. In the end, it attempts to identify areas for further research.

2. Critical infrastructure, financial sector

The financial sector also offers a wide array of services and products to individuals and corporations. Beyond dispute, any significant disruption of these services would have economic, social and perhaps political effects. A state's economic status is an essential condition of military and political security (Dumitru, Ferarau, 2018), hence the possible political effect. Taking into consideration the networks of parent companies and subsidiary companies in the European banking industry, these economic and political effects can easily cross the borders and impinge on other states as well. Therefore, financial services play an essential role in the economy's growth and well-being of people and are also vital for the states. This follows that banking industry services shall be considered essential (Nagy, Somogyi, 2021). Hence the importance of the infrastructure of the European financial system.

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3. Global warming and the European financial sector

Having understood the existential threat posed by climate change, the European Union has adopted the regulation 2021/1119 of the European Parliament and of the Council of 30 June 2021, establishing the framework for achieving climate neutrality. According to Article 10, "the Commission shall engage with sectors of the economy within the Union that choose to prepare indicative voluntary roadmaps towards achieving the climate-neutrality objective" (Regulation (EU) 2021/1119). Within the European financial sector, the European Central Bank (ECB) and the national central banks are the sector-specific authorities, and one of their tasks is to promote the smooth operation of payment systems1. In line with their legal and moral obligations, addressing global warming is a priority for the ECB and the national central banks. It has been confirmed that one of the critical factors of the secure and efficient activity of the European financial sector is supporting the sector members in their efforts to identify risks and reduce their impact on climate change (Sidak et al., 2020). In July 2021, an action plan was presented by ECB to include climate change considerations in its monetary policy strategy (European Central Bank, 2021).

One observer has already drawn attention to the paradox of securing critical infrastructure owned and operated by the private sector in a centralized way. The importance of involving economic and market actors in maintaining public security has been emphasized (Besenyő, Fehér, 2020). Nevertheless, sector-specific authorities are responsible for fostering the sector members' efforts to ensure the availability of essential services.

4. Heatwaves and critical infrastructure protection

The frequency and the length of heat waves are projected to increase, hence the importance of preparedness for extremely high temperatures. Three main areas affected by global warming will be discussed: managing climate change risks, outsourcing and supply chain failure caused by extreme temperatures, and daily operation during heatwaves. The final section summarises the main findings.

4.1 Enhanced risk management framework

In July 2022, further steps were taken by ECB. Besides reducing climate-related financial risks in Euro system credit operations, risk management practices have been enhanced with climate change-related risks (European Central Bank, 2022a). As a banking supervisor, ECB ensures that banks have an appropriate approach to identifying, assessing and managing climate-related risks. Believing that one of the main challenges for banks is addressing risks stemming from climate change, climate change-related risks have been defined as critical vulnerabilities and have become one of the supervisory priorities for 2022-2024 (European Central Bank, 2022b). In the first half of 2022, the first climate-related stress test was conducted in Europe (European Central Bank, 2022c) to assess the financial sector's preparedness for global warming hazards. The stress test focuses on risk management (European Central Bank, 2022d).

As generally accepted, risk management is the formal process utilized to quantify, qualify, and mitigate specific concerns an organization may discover or define (Broder et al., 2020). Without incorporating climate risks into the risk management framework, risks cannot be adequately identified, assessed and mitigated. Preparedness with appropriate mitigating actions and continuity plans depends on identifying and assessing risks. Hence the importance of enhancing risk management by adding climate risks to the existing risk portfolio, which has been found to reduce disaster risks by enabling the decision-makers to consider different types of extreme events (Urlainis et al., 2022).

1 see Article 2 and Article 3 of Protocol No 4 on the statute of the European system of central banks and the European central bank https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:12016E/PRO/04

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A Guide on climate-related and environmental risks2 has been issued by ECB in order to support financial institutions in their business strategy and risk management framework implementation (European Central Bank, 2020). According to this guide, the management must consider climate-related and environmental risks when developing the institution's overall business strategy. Moreover, institutions are suggested to consider the impact of climate-related and environmental events on their business continuity. Climate-related and environmental risks in the financial sector have come to be used for two categories: physical and transition risks. The former comprises risks from extreme weather events, such as heatwaves. The latter refers to possible financial loss that can result from the process of adjustment towards a lower-carbon and more sustainable economy. Therefore, physical risks caused by global warming are expected to be incorporated into the risk management framework of European banks.

4.2 Resiliency to the failure of partners and supply chains

Another area of critical infrastructure protection where considerable attention is needed is outsourcing and supply chains. The effects mentioned above of global warming affect everyone, including the partners. Although the banking industry is not a productive sector built on critical materials, the risks related to supply chains are worth mentioning. Extreme temperatures can make the supply chain fail by either causing failure in production or making transportation difficult. Hence the importance of proper supply change management. As suggested, multiple approaches are required to overcome a supply crisis (King, 2021), which depends on the particular sector and critical material. However, coopetition within the sectors can be suggested (Strauss, 2020), especially when it is coordinated by, e.g., the sector-specific authority. Addressing common barriers together and planning long-term crisis responses have been recommended to increase supply chains' resilience, especially after the coronavirus pandemic (Gebhardt et al., 2022).

The European Banking Authority has issued a guideline[3] Regarding to outsourced ICT services (European Banking Authority, 2019a). According to this guideline, the contracts between members of the European financial sector and service providers have to include operational and security incident handling, thus raising the level of preparedness for service disruptions. Moreover, business continuity plans are made in the financial sector. According to the latest *guideline on outsourcing arrangements* issued by the European Banking Authority, banks maintain and periodically test appropriate business continuity plans for outsourced critical functions (European Banking Authority, 2019b). Considering that heatwaves can result in failures at the service providers, business continuity plans have been suggested for the outsourced services.

Moreover, risk assessment has to be performed regularly to assess the impact of the failure or inadequate services. The type of such risk assessment framework in the financial sector depends on the financial institution: the more significant the institution, the more sophisticated the risk assessment. It should be noted that evaluating cascading effects and interdependence between systems and services has been suggested as a methodology to focus on understanding the vulnerability of infrastructures to the impact of natural hazards (Krausmann et al., 2019).

2 Guides are not binding for the institutions but rather serve as a basis for supervisory dialogue

3 According to the Article 16 of EU Regulation No 1093/2010 authorities and financial institutions make every effort to comply with the EBA guidelines.

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4.3 Daily operation and heatwaves

Facilities, mainly where essential services are being operated, should be prepared for the operation during heatwaves. Regarding extreme hot periods, two key factors can be mentioned: they can be predicted, and power outages are likely to occur (Watson et al., 2022). Early warning systems can help prepare, mainly if emerging technologies are used (Argyroudis et al., 2022) in data collection, procession and communication. However, avoiding the so-called alert fatigue caused by false alerts (Roberts et al., 2022) is essential since it may lead to indifference toward alerts. This information shows that global warming raises challenges. The significant difficulties faced by office areas (e.g., headquarters) and data centres will be discussed in this section.

4.3.1 Office areas

Health problems caused by heat are an increasing risk for indoor and outdoor workers, as has been found (Xiang et al., 2014). Besides affecting health, heatwave significantly affects productivity (Flourish et al., 2018). Since temperature is a crucial factor, air conditioning has been confirmed to reduce the impact of heat waves (Wang et al., 2016). However, a link between heat waves and electrical demand has been established (Agel et al., 2021). These results confirm that facilities should be prepared by appropriately being equipped with air conditioning systems and supplied with electricity. Undoubtedly, maintaining an appropriate temperature to reduce accidents and occupational health problems in the workplace is an obligation in the EU (see Council Directive 89/391/EEC). Considering the importance of the cooling ability, especially in critical infrastructures, passive and active cooling solutions can be suggested (Attia et al., 2021) that are robust and able to work under extreme temperatures.

Besides staying in cool places, drinking water is essential during heat waves (Kovats, Kristie, 2006). Providing enough drinkable cool water in office areas is undoubtedly an important task. Therefore it should be emphasized that becoming resilient to the failure of water dispensers is a must.

Creating a suitable environment for working is probably unaffordable for many people. Thus, being in the office instead of home-working is likely during heat waves. Moreover, it is almost certain that the energy demand of the office areas will be higher during heat waves. Planning for extreme heat in cities is poorly understood (Keith et al., 2019). However, cooperation between operators of essential services can be suggested: based on sector or locality, the possibility of a standard preparation should be investigated. It should be determined if it is possible to have one building where vital employees of companies providing essential services can work during heatwaves. This would mean that only one building should be equipped with complete air conditioning and an uninterruptible power system and supplied with enough cool drinkable water instead of many buildings in the same area.

One of the financial sector's specialities is that branches are operating countrywide beside the headquarters. However, there are larger branches with more services, e.g., in county towns. These branches can be considered critical branches with more advanced business continuity solutions. Keeping only the key branches open during extremely hot periods may simplify the preparation, save energy, and prevent heat illness.

4.3.2 Data Centres

Banks offer more and more digitalized services as Information and Communication Technology spreads. Therefore, the smooth operation of data centres is becoming increasingly important. Data centres are vulnerable to extreme temperatures and power outages. Thus, the sector-specific authority specifies the protection of data centres against natural hazards in the European financial sector. According to the Guidelines on ICT and security

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risk management4, physical security measures should be applied to protect the data centres from environmental hazards. Moreover, the applied measures should be commensurate with the importance of the buildings and the criticality of the operations or ICT systems in these buildings (European Banking Authority, 2019a). It is worth an overview of the main challenges heatwaves raised and the possible risk-mitigating actions within and outside the financial sector.

It is almost certain that the energy-efficient free cooling methods (Zhang et al., 2014) will fail at places hit by heatwave since the external air is not cool enough. Thus, appropriate cooling methods and air conditioning systems should be applied. However, a study has found inefficient air conditioning in more than half of the data centres in Europe (Ni, Bai, 2017). A method has already been proposed to enhance thermal awareness and identify the ineffective cooling system in a data centre to avoid hardware failure and wasting energy (Grishina et al., 2022). Nevertheless, developing air conditioning systems raises the problem of increased energy demand. Since air conditioning systems need energy, increased electricity demand is highly probable. Therefore, preparing for the increased energy demand during heatwaves is essential. It should be examined whether or not operators of essential services can cooperate in fulfilling the increased power demand of their data centres during heatwaves which are predicted to be more frequent. Cutting back the emission of greenhouse gases is a shared responsibility. Therefore, the solutions of switching to efficient cooling and renewable or clean energy in data centres should be explored by facilitating cooperation between sectors, including the financial sector.

Besides improving the cooling systems and being prepared for the increased energy demand, other risk-mitigating actions can be suggested. Optimizing the operation of not non-stop services and re-scheduling the operational tasks may save energy in data centres. It has been calculated that approximately 8-19% of the energy could be saved using the application signatures method (Salinas-Hilburg et al., 2022) when optimizing the scheduled running of tasks.

Furthermore, it has been demonstrated that the location of the data centres affects the energy spent on cooling. Due to the lower temperature in Northern Europe, less energy is needed for cooling the buildings (Avgerinou et al., 2017). Cooling is one of the crucial factors behind the emergence of the data centre industry in Nordic countries (Saunavaara et al., 2022). This information suggests several courses of action for the operators of essential services.

1. Northern Europe should be considered when either building new data centres or buying data centre services. The location of data centres supporting essential services should be considered very important, besides the redundancy and internationally recognized certificates on operation continuity of the course.
2. A data centre in Northern Europe seems to be an advantage for the operators of essential services. Reallocating virtual machines from a data centre to a Northern one before summer or the warmer periods may decrease energy consumption (Arshad et al., 2022) and mitigate the risk of significant disruptions caused by power outages.

One possible implication of these findings is that protecting data centres from global warming is the biggest concern within critical infrastructure protection. As pointed out, the most critical issues are cooling and providing the necessary energy. The following section summarises the key findings by discussing the three main areas affected by global warming (managing climate change risks, outsourcing and supply chain failure caused by extreme temperatures; daily operation during heatwaves).

4 According to the Article 16 of EU Regulation No 1093/2010 authorities and financial institutions make every effort to comply with the EBA guidelines.

5. Discussion & Conclusions

Global warming and heat waves significantly affect our European society by jeopardizing our health and infrastructure. Therefore, there is an urgent need to address the effects of global warming on critical infrastructure protection. Our research set out to assess the effect of heatwaves on critical infrastructure protection and provide an overview of the responses of the European banking industry. This study cannot encompass all the action plans and climate change-related strategies; the focus has been put on the risks related to the infrastructure rather than the financial risks.

The following conclusions can be drawn after examining the challenges raised by global warming and heat waves.

1. Assessing the sector's climate risk preparedness with the first climate risk stress test in Europe, ECB has found that banks do not yet sufficiently incorporate climate risks into their risk management. Preparing for the unique challenges raised by global warming is essential. Therefore operators of essential services are urged to enhance their risk management framework with climate risks.
2. The stress above test results showed the need for sector-wide cooperation to sharpen the focus on climate risks and create the best practice in the financial sector.
3. The strategy should be developed to manage possible supply chain failure or the outage/degradation of outsourced services due to extreme weather events. Sector-wide cooperation should be considered, or if it makes sense, cooperation based on locality rather than sector. Such cooperation could be fostered by an appropriate risk reduction programme driven by the EU.
4. Cutting back the emission of greenhouse gases is a shared responsibility. Therefore, the solutions of switching to efficient cooling and renewable or clean energy in data centres and office areas should be explored. Partnership with the academic world may enhance the development of efficient and green energy technologies.
5. Addressing the increasing vulnerability of data centres providing essential ICT services is fundamental. It has been shown that cooling data centres in Northern Europe need less energy than in areas hit by heatwaves. European operators of essential services may cooperate in moving some critical infrastructure elements to the North.
6. As heatwaves affect everyone, a comprehensive test could be organized for operators of essential services involving third-party service providers and relevant authorities.

The most prominent finding to emerge from this study is that climate risks must be addressed, and strategies must be developed to help our European society deal with the inevitable effects of global warming. No doubt, sectors providing essential services are also responsible for saving our planet.

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Author Contributions: Conceptualization: *Nagy, Somogyi*; methodology: *Nagy, Somogyi*; data analysis: *Somogyi*, writing—original draft preparation: *Somogyi*, writing; review and editing: *Nagy*; visualization: *Nagy, Somogyi*. All authors have read and agreed to the published version of the manuscript.

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