CONSIDERATIONS ON THE ENVIRONMENTAL IMPACT OF CRYPTOMINING

Technology & Human Rights

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TEDIC is a NGO founded in 2012, with the mission of defending and promoting human rights in the digital age. Among its main areas of interest are freedom of expression, privacy, access to knowledge and gender on the Internet.

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ABSTRACT

The intensive consumption of electricity generated from fossil fuels and the associated carbon emissions are the focus of global concern surrounding the environmental impact of cryptomining. Paraguay emerges in this scenario as the clean and, most importantly, cheap electricity alternative for large-scale mining due to the surplus of hydroelectric dams, shared with Brazil and Argentina. However, it is not exempt from potential environmental consequences. This paper explores the main discussions on cryptomining as an energy-intensive activity, the problem of e-waste it generates and the associated implications in Paraguay.

KEYWORDS: *cryptocurrencies, climate crisis, carbon emissions, electricity, Paraguay*

1. INTRODUCTION

The intensive consumption of electricity demanded by cryptomining and the associated carbon emissions are the focus of global discussion on the environmental impact of this activity, since it is mostly generated from fossil fuels.

Another concern is the use of hardware that has an increasingly shorter lifespan, with parts that in most cases cannot be recycled, which threatens to accelerate the increase of electronic waste in the world.

Paraguay emerges in this scenario as the clean and, most importantly, cheap electricity alternative for large-scale mining due to the surplus of hydroelectric dams, shared with Brazil and Argentina. Despite its vulnerability to the climate crisis, the discussion on the possible environmental impacts of energy-intensive cryptomining was not on the agenda during the discussion of the bill that seeks to regulate this activity.

This paper explores the main discussions on cryptomining as an energy-intensive activity, the problem of the e-waste it generates and the associated implications in Paraguay.

2. INTENSIVE ELECTRICITY CONSUMPTION AGGRAVATING THE CLIMATE CRISIS

The main concern regarding large-scale cryptocurrency mining is its high energy consumption. As of October 2022, the Cambridge University Bitcoin Electricity Consumption Index (CBECI) estimates that the electricity use of the Bitcoin network - the main cryptocurrency - is around 101.4 terawatt hours per year. If it were a country, it would be ranked 34th out of 40 countries with the highest electricity consumption, almost matching Argentina.

This energy-intensive consumption comes from the consensus algorithm used to mine cryptocurrencies, which is proof of work (PoW). It is designed to demand more and more computing power as more entities attempt to validate transactions on the blockchain to obtain cryptoassets, a process that demands a lot of computer time and, therefore, electricity.

In an analysis of Bitcoin Electricity Consumption Index data, Neumueller (2022) found that the network mostly uses electricity generated from fossil fuels (62.4%), primarily coal, and just over a third is from renewable sources (37.6%). Burning fossil fuels to generate energy emits carbon dioxide (CO_2), the main greenhouse gas that is responsible for global warming.

A report by the White House Office of Science and Technology Policy (OSTP) estimated that carbon emissions from cryptoasset mining in 2022 range from 110 to 170 million metric tons globally, representing between 0.2% and 0.3% of global emissions. Like the Bitcoin electricity consumption rate, the OSPT clarifies that these estimates are uncertain due to the complexity of assessing cryptoasset emissions.

Cryptocurrency adds another challenge to the compliance of the Paris Agreement[1], which aims to limit the global temperature increase to well below 2 °C, if possible by 1.5 °C compared to pre-industrial levels; for which emissions must be reduced. The latest report of the Intergovernmental Panel on Climate Change (IPCC, 2022) warns that anthropogenic climate change is a threat to human welfare. It states that simultaneous extreme heat waves, droughts and floods are already affecting millions of people, exposing them to situations of food and water scarcity, especially in Africa, Asia, Central and South America.

In the context of the climate crisis, Mora et al. (2018) suggests that the decarbonization of electricity could help reduce Bitcoin's carbon footprint. Also, the Cambridge Electricity Consumption Index points to hydropower as the "best-case scenario" for reducing emissions, should mining only use that source, and as the "worst-case scenario" if it relied exclusively on coal-generated electricity.

3. PARAGUAY: THE IMPACT OF CLIMATE CHANGE ON CLEAN ENERGY PRODUCTION

The decarbonization of electricity is presented as a way to reduce emissions from cryptocurrency mining. From this perspective, Paraguay emerges as a clean, large and cheap energy opportunity for cryptocurrency companies, especially Bitcoin.

The country's energy matrix has a strong component of renewable origin. According to the Vice Ministry of Mines and Energy (VMME), in 2021 its supply was made up of biomass (39%), hydropower (35%) and imported oil derivatives (26%). However, the final consumption of hydroelectricity was only 18% in the same year and 41% for oil derivatives. The electricity that Paraguay does not use (surplus) is exported to Brazil and Argentina, partners in the Itaipú and Yacyretá hydroelectric dams, correspondingly.

In addition to the clean energy availability, it is also cheap. A representative case is the boom in large-scale cryptomining in Villarrica, Guairá department, driven by the low tariffs of Compañía de Luz y Fuerza SA (CLYFSA). There, mining farms owned by local entrepreneurs coexist, such as Emmanuel Friedman, an ex-Parlasurian, as well as operations of the Canadian Bitfarms. CLYFSA, which purchases power from the National Electricity Administration (ANDE), won a court injunction to keep its prices when ANDE increased tariffs in 2017. Blair (2022) reports that the company offers cryptominers a rate starting at $16 per megawatt-hour, while the rate for most ANDE industrial customers increased 20% or more that year.

Cantero (2022) places 2017 as the start of large-scale mining in the country with the entry of foreign capital, a process accelerated after China declared all cryptocurrency transactions illegal in September 2021. In response to the new demand, senators Fernando Silva Facetti, Antonio Apuril and Juan Bartolomé Ramírez presented a bill that year to regulate cryptoasset mining.

The regulation proposal comes at a crucial moment: in 2023, the revision of Annex C of the treaty that gave rise to the Itaipu hydroelectric power plant is scheduled to take place, an opportunity for Paraguay to negotiate with Brazil the terms and conditions for the sale of electricity[2]. According to VMME data, in 2021 the energy ceded to the neighboring country represented 80% of the surplus.

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1 Paris Agreement. 2015. ONU https://unfccc.int/es/acerca-de-las-ndc/el-acuerdo-de-paris

2 Researchers Guillermo Achucarro and Liz García address this issue at length in *"Energy and Cryptocurrency in Paraguay: Energy-intensive use of cryptocurrency mining in the scenarios of the Review of Annex C of the Itaipu Treaty in Paraguay."*

Supporters of the regulation proposal argue that Paraguay must take advantage of the electricity currently ceded to Brazil, such as businessman Fernando Arriola, from the Paraguayan Chamber of Fintech. He argues that cryptomining "is the only industry in the country that can use surplus energy". He says that the law is necessary to give legal security to Paraguayan small and medium-sized enterprises (MSMEs) in the field, numbering around 20 in the chamber by itself (F. Arriola, personal communication, October 21, 2022).

ANDE rejects the proposal. In one of its reports to the legislature, it questioned the lack of guarantees to discontinue supply contracts to the miners once the energy surplus is over, considering that it will even have to bring forward public investments to meet the high demand for this activity.

In its assessment of the energy sector, the Columbia Center on Sustainable Investment (CCSI) et al. (2021) notes that ANDE projects that peak electricity consumption will exceed peak supply in 2036; while the Instituto de Profesionales del Sector Eléctrico del Paraguay (IPPSE) estimates that the deficit will be brought forward towards 2030. These estimates do not include cryptomining.

According to the former Vice-Minister of Mines and Energy, engineer Mercedes Canese, this energy deficit could be accelerated with green hydrogen and cryptomining. She does not rule out the possibility of even importing electricity (M. Canese, personal communication, September 30, 2022).

The consequences of climate change, meanwhile, affect power generation in hydroelectric plants on the Paraná River, such as Itaipú and Yacyretá. According to the VMME (2022), last year primary production to generate electricity fell by 11.2% due to the low water level of this river, which recorded its worst drought in almost 80 years. This type of extreme weather event, as well as heat waves, floods and forest fires, are becoming more frequent and intense in Paraguay.

In this sense, Canese recalls that, although hydroelectric energy is obtained from renewable sources, it has limits: "We are talking about a very large consumption of electricity in a country that is not prepared for climate change".

Although the use of hydroelectricity contributes to reducing emissions from cryptomining, the use of hydroelectricity adds pressure on Paraguay's resources, which are already overexploited in the current agro-export economic model. This goes against the grain of efficient energy use in the process of energy transition, precisely at a time when countries need to save energy.

Cantero (2022) describes large-scale cryptomining as "digital extractivism", similar to the post-war enclave economy at the end of the 19th century, because it involves the extraction of electricity to produce cryptoassets for the global market, low labor employment and low tax contribution.

4. MINING DEVICES MAY INCREASE THE GENERATION OF E-WASTE

While energy-intensive consumption and the associated pollution focus attention on the environmental impact of cryptomining, the generation of electronic waste is also an issue. Miners have to constantly replace their devices with newer, more powerful ones for profitable mining. De Vries and Stoll (2021) estimated that Bitcoin mining alone produced 30.7 metric kilotonnes of e-waste per year, which is equivalent to the annual e-waste generation of the Netherlands. They projected that this could reach 64.4 metric kilotonnes in the medium term.

The authors found that the lifespan of Bitcoin miners is limited to 1.29 years, which could aggravate the growth of e-waste worldwide. They explain that this phenomenon is driven by the disposal of ASICs (Application-Specific Integrated Circuit), which are the machines for mining Bitcoin. They serve only for mining, so they are often discarded.

They mention that 53.6 million metric tons (Mt) of e-waste was generated in 2019 alone, of which barely 17.4% was collected and recycled properly. The amount of e-waste is expected to double by 2050 and this projection does not include the effect that Bitcoin mining could have.

Electronic waste represents a growing threat to the environment and public health. Its impact ranges from toxic chemicals and heavy metals leaching into soils to air and water pollution from improper recycling. Lead and mercury are the most common toxic elements in this type of waste.

The Global E-waste Monitor (2020) mentions a series of harmful health effects associated with informal e-waste recycling, such as problems in childbirth, neurodevelopmental disorders, DNA damage, cardiovascular and respiratory problems, skin diseases and cancer.

According to data from the Observatory, Paraguay generated 51,000 tons of electronic waste in 2019, an increase of 16 percent over 2016[3]. This is equivalent to each resident generating seven kilograms of this waste, which, officially, was neither collected nor recycled. While Abbate et al. (2018) projected that Asunción and Central alone will generate 80,762 tons of e-waste by 2025. These estimates do not consider cryptomining waste.

The Paraguayan Blockchain Association questioned in a note to representatives that this is not contemplated in the bill that regulates cryptomining. Luis Benítez, secretary of the Association, says that the generation of e-waste is accentuated in the industry because equipment is being changed faster and faster and most of the parts are not reusable (L. Benítez, personal communication, September 29, 2022).

Benitez puts the focus on large miners using ASIC equipment, which are computers designed for computation. Other devices are GPUs, which are video controller cards used for computation and graphics.

3 According to the Global E-Waste Monitor 2017, Paraguay generated 44000 tons of e-waste in 2016; equivalent to 6.4 kg per capita.

“With GPUs, eventually if you don’t have a lot of wear and tear, you can reuse them, for example, in artificial intelligence. But ASICs, which are the majority mostly in Bitcoin installations, are basically used until they burn out. Once they burn out, they have to be thrown away and replaced with new equipment,” he explains. According to Blair (2022), it is estimated that there were more than 30,000 ASICs in Villarrica alone at the beginning of this year.

Benítez believes that the eventual approval of the cryptocurrency law will allow the massive entry of companies operating on a large scale. “E-waste is going to be a problem in the short term with this equipment,” he warns. He believes the Ministry of Environment should be involved in the process, beyond requiring an environmental license.

“In many cases, this equipment uses lithium, even lead. It depends a lot on the configuration of the installation not to use lead battery, for instance. We don’t have a place to deal with that,” he points out.

For his part, Fernando Arriola from the Paraguayan Chamber of Fintech assures that electronic waste derived from cryptomining will not be a problem for three or four years because “most of the technology that is arriving in Paraguay is new”. Also that there is a secondary sector that is dedicated to recycling computer equipment with which they work.

Regarding the study that found that the useful life of mining equipment is limited to a little more than one year, he says that it does not match the commercial and industrial reality of the mining process where “the minimum return on investment on a mining machine is three years”. He adds that he has machines in his data centers that are more than five years old.

5. THERE IS NO SPECIFIC REGULATION FOR E-WASTE IN THE COUNTRY

Paraguay does not have a specific law on electronic waste, as do most Latin American countries, but it does have regulations applicable to these types of waste:

- Law 42/90 banning the import, storage and use of products classified as hazardous industrial waste or toxic waste and its regulatory decree 19969/97.

- Law 567/95 ratifies the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. This international treaty was specifically designed to prevent the transfer of hazardous waste from developed countries to others.

- Law 3956/09 on Integrated Solid Waste Management and its regulatory decree 7391/2017. The decree includes in its classification "technological waste from the computer industries, manufacturers electronic products or motor vehicles and others that when their useful life elapses and that, due to their characteristics, require specific management" (Chapter V, subsection f). Also hazardous wastes provided for in the Basel Convention.

- Law 5882/2017 on the integral management of batteries and batteries for domestic use, pending the environmental management plan that should operationalize the law.

- The National Plan for the Integrated Management of Hazardous Waste of Paraguay (PNGIRPP) of 2020. It highlights the great lack of knowledge about e-waste management in the country, which ends up in landfills mixed with other waste.

In 2018, researchers from the Catholic University of Our Lady of the Assumption (UCA) presented to the Ministry of Environment and Sustainable Development (MADES) a proposal for a regulation for the "Integrated management of waste electrical and electronic equipment (WEEE) generated in the country". It proposed that users could deposit their electronic waste free of charge, for example, at the same place where they purchased the computer they were going to dispose of. At the same time, this company had to deliver the wastes to authorized operators for their treatment or final disposal, with the aim of promoting recycling.

The concern about the environmental impact of electronic waste is not recent. In 2011, the ICTs Master Plan of the former SENATIC – which is now the Ministry of Information and Communication Technologies (MITIC) - considered it necessary for Paraguay to have recycling centers that would provide adequate treatment for this type of waste. He considered centers for the refurbishment of second-hand computers to be destined for low-income sectors of the population.

6. THE QUEST FOR WAYS TO COUNTERACT THE ENVIRONMENTAL IMPACT OF CRYPTOMINING

As mentioned, the most widespread approach to reduce pollution from cryptomining aims to decarbonize electricity. But there are also proposals to decrease its energy consumption.

The U.S. White House Office of Science and Technology Policy (OSTP) published a survey in September 2022 on the climate implications of cryptomining in the U.S. Their recommendations aim to provide technical assistance to states, communities and miners to develop capabilities to minimize emissions, noise or the impact on water. They also propose updating mining equipment standards and promoting research to improve the environmental sustainability of cryptoassets.

The OSTP report mentions that the Proof of Stake (PoS) consensus mechanism appears to be an alternative to Proof of Work (PoW), decreasing the amount of computers needed to maintain the blockchain. PoS was estimated to consume 0.28 billion kilowatt-hours in 2021, less than 0.001% of global electricity use.

Ethereum, the platform for the second most popular cryptocurrency (ether) after Bitcoin, announced in September this year its migration from proof-of-work to proof-of-stake, with expected annual energy savings equivalent to the energy consumption of Chile (BBC, 2022).

Luis Benítez of the Blockchain Association believes that, although this system is in place with ether and other cryptocurrencies, it does not yet have a “massive test as it already has with Bitcoin”, which has been operating since 2009 with proof-of-work (L. Benítez, personal communication, September 29, 2022).

In the case of Bitcoin, Mora et al. (2018) also proposed introducing ad hoc modifications to the overall system that could result in an immediate reduction in electricity consumption, such as adding more transactions per block and decreasing the difficulty or time needed to solve the proof-of-work.

7. ENVIRONMENTAL IMPACT ABSENT FROM BILL TO REGULATE CRYPTOASSET MINING

The Congress sanctioned on July 14, 2022 the bill 6962 that regulates cryptoassets mining in Paraguay. This law aims to "regulate the activities of mining, commercialization, intermediation, exchange, transfer, custody and administration of cryptoassets" and recognizes cryptoasset mining as an industrial activity.

ANDE rejected categorizing cryptocurrency mining as an industry -which has a preferential tariff- because it does not generate added value. In a report, it warned about its energy-intensive nature and "little or no employment of labor"[4].

The Ministry of Industry and Commerce (MIC) also rejected granting it the industrial tariff because of its nature "similar to an extractive activity" which, in addition to having a low impact on economic and social factors, could jeopardize ANDE's financial sustainability in the short and medium term.

On the other hand, supporters of the bill, such as businessman Fernando Arriola, of the Paraguayan Chamber of Fintech, defend the argument of using the surplus electricity from the Itaipú hydroelectric plant in the country instead of ceding it to Brazil, Paraguay's partner in the dam (F. Arriola, personal communication, October 21, 2022).

In general, the debate of the law in public opinion revolved around the use of energy, as occurs globally, but not its environmental implications. This was observed by the Paraguayan Blockchain Association, which sent a note to members of Congress questioning the fact that the regulation does not contemplate environmental compensation for energy-intensive cryptocurrency mining.

The Ministry of Environment and Sustainable Development (MADES) did not participate in this process, despite the fact that the environmental license it grants - after evaluating the environmental impact of a venture - is a prerequisite for obtaining authorizations from other public bodies, such as municipalities. In response to a request for information on cryptomining projects, MADES reported that, from 2020 to October 2022, six companies applied for environmental licenses and only three obtained them. In general, the projects are presented under the umbrella of "data center".

When asked about the environmental impact of cryptomining in Paraguay, the national director of Climate Change, Ulises Lovera, replied that his directorate has not yet entered "into issues related to cryptomining" (U. Lovera, personal communication, October 10, 2022).

The Executive Branch objected to the cryptoassets mining bill and returned it to the Legislative. At the time of writing this article, the Senate rejected the veto at the end of October 2022 and it is still pending consideration in Congress.

4 Following the approval of the law in Congress, in October 2022 the ANDE established a dollar rate for cryptomining within what it calls the "Special Intensive Consumption Group": https://www.ande.gov.py/interna.php?id=10455#.Y4TFTX3MIaF

7.1. El Salvador's Bitcoin Law

In June 2021, El Salvador became the first country to establish Bitcoin as legal tender. In addition to the so-called "Bitcoin Law", President Nayib Bukele announced that El Salvador would be the first to generate electricity from geothermal energy to mine this cryptocurrency, as well as the purchase of 300 ASIC machines to enable a farm. This amount, compared to the Villarrica cryptocurrency mining reported by Blair (2022), does not even reach 10% of local entrepreneur Emmanuel Friedmann's miners.

Like Paraguay, El Salvador's energy matrix has a strong renewable energy component, in this case hydroelectric and geothermal. The difference is that our country still has surpluses to export. Salvadoran economist Meraris López, researcher and professor at the Universidad Centroamericana José Simeón Cañas, explains that El Salvador imports about 20% of the electricity it uses (M. López, personal communication, October 5, 2022).

"By adding mining, the demand increases and having already an unsatisfied demand, there is obviously a deepening of inequalities, also in a country highly vulnerable to extreme events," he points out. As in Paraguay, Salvadoran hydroelectric energy production is susceptible to the climate crisis.

CONCLUSION

In Paraguay, the main concern about cryptocurrency mining is its enormous electricity consumption. This was evident during the process of discussion of the bill that seeks to regulate the mining of cryptoassets.

As most of the country's electricity comes from renewable sources, carbon pollution associated with the use of energy from fossil fuels is not a concern.

But the environmental implications of energy-intensive cryptomining are not limited to emissions. The impacts of climate change have already affected the generation of hydroelectricity in the last year due to the drought that affected the Paraná River. Added to this is the disposal of mining devices, which could accelerate the generation of electronic waste in the medium term, with the environmental and health risks that this implies.

The possible consequences on the environment were not taken into account in the bill. The participation of the Ministry of the Environment with respect to cryptomining today is reduced to granting licenses for companies to operate.

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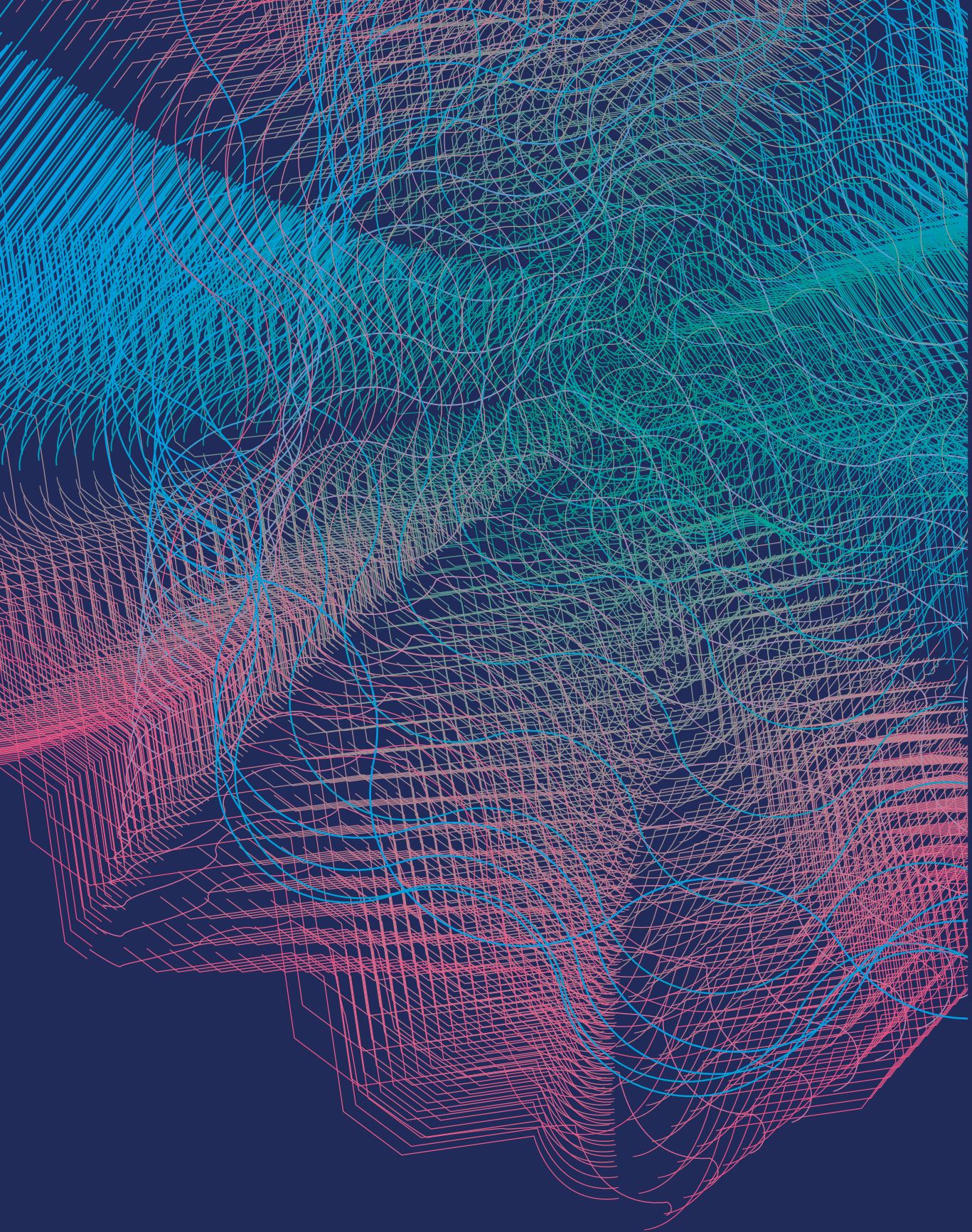

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