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CONTEMPORARY LEGAL APPROACHES FOR TECHNOLOGICAL DEVELOPMENT

ABORDAGENS JURÍDICAS CONTEMPORÂNEAS PARA O DESENVOLVIMENTO TECNOLÓGICO

ENFOQUES JURÍDICOS CONTEMPORÁNEO PARA EL DESARROLLO TECNOLÓGICO

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ABSTRACT

Technological development simultaneously drives economic advancement and generates challenges that often exceed the regulatory capacity of existing legal systems. Grounded in critical theoretical perspectives, the paper rejects the notion of neutral technological progress and emphasizes the role of power structures and institutional choices in shaping technological trajectories and their social consequences. Drawing on an interdisciplinary theoretical framework that integrates the political economy of technological progress, legal theory, and methodological approaches to legal research, this study aims to understand key events of the Digital Revolution, the role of integrating different methodological approaches, and to contribute to a more flexible, responsive, and technologically compatible legal approach aligned with the dynamics of contemporary technological development.

Keywords: Scientific Research. Emerging Technologies. Law.

RESUMO

O desenvolvimento tecnológico impulsiona simultaneamente o avanço econômico e gera desafios que frequentemente excedem a capacidade regulatória dos sistemas jurídicos existentes. Fundamentado em perspectivas teóricas críticas, o artigo rejeita a noção de progresso tecnológico neutro e enfatiza o papel das estruturas de poder e das escolhas institucionais na configuração das trajetórias tecnológicas e de suas consequências sociais. Com base em um arcabouço teórico interdisciplinar que integra a economia política do progresso tecnológico, a teoria jurídica e abordagens metodológicas da pesquisa jurídica, este estudo busca compreender eventos-chave da Revolução Digital, o papel da integração de diferentes abordagens metodológicas e contribuir para uma abordagem jurídica mais

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flexível, responsiva e tecnologicamente compatível, alinhada às dinâmicas do desenvolvimento tecnológico contemporâneo.

Palavras-chave: Pesquisa Científica. Tecnologias Emergentes. Direito.

RESUMEN
El desarrollo tecnológico impulsa simultáneamente el avance económico y genera desafíos que a menudo superan la capacidad regulatoria de los sistemas jurídicos existentes. Basado en perspectivas teóricas críticas, el artículo rechaza la noción de progreso tecnológico neutral y enfatiza el papel de las estructuras de poder y las decisiones institucionales en la configuración de las trayectorias tecnológicas y sus consecuencias sociales. A partir de un marco teórico interdisciplinario que integra la economía política del progreso tecnológico, la teoría jurídica y enfoques metodológicos de la investigación jurídica, este estudio busca comprender los eventos clave de la Revolución Digital, el papel de la integración de diferentes enfoques metodológicos y contribuir a un enfoque jurídico más flexible, receptivo y tecnológicamente compatible, alineado con las dinámicas del desarrollo tecnológico contemporáneo.

Palabras clave: Investigación Científica. Tecnologías Emergentes. Derecho.

1 INTRODUCTION

Technological development has both the power to propel humanity toward its economic peak and the capacity to generate problems that the law is incapable of managing. In the constantly evolving landscape of technological advancement, the transformative potential of emerging technologies (…) is reshaping the foundations of industries and societies (Holland, 2020).

In this sense, an analysis of the perception of the impact of the technological revolution on society, and of how the definitions of Law change as one overlaps the other, becomes essential, since “technological changes are a constant throughout history as are influential people deciding their directions” (Acemoglu and Johnson, 2024, p. 184).

> The study of law and information technology comes with an inherent contradiction in that while technology embraces notions such as internationalization and globalization, the law, for the most part, is to a certain extent still confined to national borders (Greenstein, 2022).

Thus, it is necessary to understand the role of different methodological approaches in research concerning Law in the face of advanced technological development and its implications, because at present “the current legal frameworks that regulate emerging technologies reflect a constantly changing landscape, seeking to deal with the rapid evolution of innovations,” attempting to adapt existing legislation to new problems, yet without offering the necessary adaptability and flexibility (Lescrauwaet et al., 2022).

Contemporary scientific literature recognizes that technological development constitutes a structural phenomenon of social, economic, and institutional transformation, whose effects go beyond the technical sphere and directly impact the field of Law. Studies focused on emerging technologies indicate that innovations such as artificial intelligence, blockchain, and biotechnology are reshaping the foundations of industries and societies, altering productive patterns, social relations, and forms of governance (Holland, 2020).

In this context, critical theoretical scholarship rejects the notion of automatic or neutral technological progress, emphasizing that technical transformations are historically conditioned and guided by human and institutional decisions. As argued by Acemoglu and Johnson (2024), technological changes have always coexisted with choices made by powerful actors responsible for defining their trajectories and distributing their benefits and risks. This approach highlights the centrality of power structures in shaping the social impacts of technology.

In the legal field, the literature points out that existing regulatory frameworks face difficulties in keeping pace with the speed and complexity of technological innovations.

Recent research indicates that prevailing regulatory models largely operate through incremental adaptations of preexisting legislation, resulting in partial and often insufficient responses to unprecedented problems (Lescrauwaet et al., 2022). This scenario reveals a mismatch between technological dynamics and the adaptive capacity of Law.

According to Karl Polanyi (2021), Law is a historical-cultural reality resulting from the integration of society, culture, and economics, making it impossible to understand it adequately through a one-dimensional approach. In this sense, the choice of descriptive, analytical, or critical approaches conditions the interpretation of technological phenomena and influences the formulation of legal solutions. Thus, the literature emphasizes the need to examine Law as situated knowledge, historically constructed, and sensitive to social and technical transformations.

Therefore, the theoretical framework of this study is grounded in the convergence of literature on technological revolution, the political economy of progress, and legal research methodology, providing the conceptual foundations necessary to support the hypothesis that current legal models lack sufficient flexibility and adaptability to address emerging technologies.

The data analysis was conducted based on a theoretical framework that articulates Law, technological revolution, and research, aiming to examine Law in light of technological innovations, with the objectives of historically and succinctly describing technological development, understanding the role of different methodological approaches in research concerning Law in the face of the digital revolution, and proposing practical solutions for a more flexible and adaptable approach to the topic.

2 THEORETICAL FRAMEWORK

Polanyi (2021) affirms that unemployed workers are a sign of economic malfunction. Hence, the spread of AI, pervading all sectors, from various types of work to personal life, raises a debate about its use and its social, economic, and legal implications.

Within this context, Acemoglu and Johnson (2024) affirm that AI seems set on a path that may aggravate the world's inequality. Thus, the discussion of whether its course can be changed or redirected towards a more beneficial trajectory, based on equality, empowerment of the people, and both flexible and adaptable norms.

Within this framework, Sunstein (2018) acknowledges the necessity of applying the Cost-Benefit Analysis in the setting of policy making, and understanding the context in which it may be applied. Regarding AI, it needs to be limited without restraining progress, in a way that does not benefit some to the detriment of others.

3 RESULTS AND DISCUSSION

Brief historical examination of key events of the Digital Revolution between 2000 and 2020 and its implications

Technological development, the economy, law, and society are intrinsically connected; although they are usually analyzed separately, in practice, it is hardly possible to separate them. “Technology is the way that collective human knowledge is used to improve nutrition, comfort, and health” (Acemoglu; Johnson, 2022, p.14), thought to be beneficial to society, although often creating a rift between those who have access and those who cannot.

> The world Wide Web, developed by Tim Berners-Lee in 1989, was particularly transformative. It introduced the context of hypertext, which allowed users to navigate between different pages and resources through links, making the Internet more user-friendly and accessible to non-technical users. The Web’s introduction led to a dramatic increase in the Internet users, as it became easier for people to find and share information online (Hicks, 2024, p.22).

In this context, with the further development of the internet, from telephone wiring to wireless, alongside mobile communication, it rapidly evolved into the systems now used. Bergström *et al* (2024) affirmed that it “was built on the transition from circuit-switched to packet-switched data communication networks – a transition that spread across telecommunication domains and dissolved the borders between data and telecommunication”.

Furthermore, with the advent of Social Media, the relationship of people with each other and the Internet changed, as well as the definitions of privacy, image exposition, and fame, once content creation is as rewarded as the arts, economically and concerning public attention. Dhingra and Mudgal (2019) affirm that “as more and more people are becoming dependent on social media for different purposes, in the future also there is likelihood of emergence of even more sophisticated forms of social media which will cover the masses across the world”.

According to Mo and Ouyang (2025, p.512), “GenAI refers to a class of machine learning models typically trained using self-supervised learning and capable of producing outputs that closely resemble human-generated content”. Meaning that it generates a response based on a prompt, using the Internet as a database, and informally providing answers, resembling human behaviour, with no input of critical thought. It is fed on both the information online and shared by the user.

Within this framework, Artificial Intelligence (AI) development comes as a watershed moment, redefining all previous concepts. The use of AI extends to all aspects of

contemporary life; Machine Learning was taken to another level; some specialists define it as machines or algorithms capable of demonstrating “intelligent behaviour” or “advanced capabilities”, although there is not yet a consensus regarding that matter (Acemoglu; Johnson, 2024, p. 403).

Yet, according to Castán (2024), the issue concerning the lack of a concept of AI “may be explained both by the absence of a widely accepted technical definition of AI and by the lack of specific regulation in force, which has led to an absence of applicable legal definitions”. Despite the legal problem, this issue has not prevented its use in different fields, whether for various job applications, for entertainment, or for criminal practices, based on the ease with which the tools can be used.

Understanding the role of different methodological approaches in research concerning Law in the context of the Digital Revolution

The Academy has one of the most important roles as it has the capacity to explain phenomena and foresee possible scenarios concerning them, as well as influence society towards more beneficial paths.

> There has been a complete paradigm shift in regard to the production, management and use of data, of knowledge and of information, which are key elements which have always defined and continue to define human relationships, economic structure and the fabric of modern society and science itself (Maiorana, 2025).

In this regard, it is necessary to discuss the methodological approach concerning the crescent development of digital technologies and its implications. The rise of a technology is not inherently beneficial to society as a whole; history proves that milestone moments devoid of human rights and law support often turn into a pretext for exploration, gap areas that previous law has to be adapted into, and economic advantage for an elite group, and not to all. Growth for a few can hardly be considered propitious (Acemoglu; Johnson, 2024).

Hence, the importance of understanding different methodologies regarding research lies in the desired outcome. It is crucial to integrate different fields of knowledge, such as economics, law, and sociology, with the analysis of the new technologies' impact, such as AI, to avoid the misuse of it for the lack of an adequate legal framework, since it “could disrupt the already fragile balance of the world order. This disruption could arise from state competition in AI technology and the application of AI in the military domain, which exists in a “gray zone” of international law and is not regulated” (Kykeyeva; Kurmangali; Aktai, 2024, p.5).

> Academia plays a central role in the cultivation and exercise of this type of social power because universities build the perspectives, interests, and skills of millions of talented young people who will work in the technology sector. In addition, top academics often work with leading tech firms and also directly influence public opinion. We would therefore benefit from a more independent academia (Acemoglu; Johnson, 2024, p.428)

Within this scope, it is paramount to consider the integration of various fields when it comes to the approach used in research concerning the impacts of digital technologies and their repercussions in Law, observing the necessity of norms without risking overregulation, aiming to secure the responsible use instead of restraining advancement. In this case, tools are not the issue, but the way and the purposes for which they are used (Baldassarre *et al*, 2023).

Accordingly, the economic approach is based on the analysis of how different sectors perform in the face of AI (Mo; Ouyang, 2025), presenting both increases in productivity and risks, giving more freedom to employees, and alternative ways of both collecting and processing data. As for social sciences, Baldasserre *et al* (2023, p.363) affirm that “These studies are needed to address potential vulnerabilities and ensure the development of these technologies considers the diverse social contexts and realities in which they are deployed”.

> In informatics, sociology, philosophy, and politics, the develop-ment of generative models will continue to ignite in-depth discus-sions on various subjects. These discussions include topics such asregulation, risk mitigation, liability, transparency, and accountabil-ity, as well as the effects on socialization patterns and the trajectoryof technological development itself (Baldassarre *et al*, 2023).

Within this context, it is important to note that “despite the wide agreement that the latest advances in AI will have disruptive repercussions on the labour market, there is very little evidence for actual integration of AI in the labour market” (Tolan *et al*, 2021). As it is too soon to discern the trends, considering historical trends, the impact of AI on the labour market may be negative, with some undesirable consequences, but the course is yet not set.

3.1 REVOLUTION OF LAW REGARDING TECHNOLOGICAL DEVELOPMENT

Historically, Law is conceived to attend to the necessities of its time, hardly made to prevent or foresee possibilities. It is the product of a need for defense. After the horrors of the Second World War, human rights were catapulted into another dimension, generating new foundations for a world based on equality, raising the question of whether international peace is a product of welfare for the world's citizens or vice versa (Williams, 2025).

Similarly, with the Industrial Revolution, the extensive labor journey, low payments, overpopulation in urban centers, and inhumane conditions of living mobilized the population to discuss salaries and better work conditions. Although industrialization and capitalism have led to better economic outcomes, it also generated an unemployment problem and, consequently, a growth of external social assistance. Socially, the present population did not follow the establishment of a new era (Polanyi, 2021).

> AI appears set on a trajectory that will multiply inequalities, not just in industrialized countries but everywhere around the world. Fueled by massive data collection by tech companies and authoritarian governments, it is stifling democracy and strengthening autocracy (Acemoglu and Johnson, 2024, p. 46).

In this context, observing the changes brought about by generative AI and its implications raises questions about its use and regulation. Shetty *et al* (2025) affirm that “in relation to AI, the regulatory landscape is in a state of constant change and domestically implemented by different governing bodies. These include frameworks based on risk, specific bans, and classification systems”.

Thus, it is possible to understand that a new setting may cause imbalance, but specificity and flexibility are key to regulating its use successfully without impeding progress, and “enhanced international cooperation is necessary to address cross-border AI challenges and harmonize regulatory standards” (Abu-Saqer *et al*, 2024) as well. The current law structure proves insufficient to meet the contemporary demands.

According to Shetty *et al* (2025), “the growing field of AI moderation poses a crucial requirement for assessing the congruence between theoretical frameworks and scholarly forecasts with actual regulatory actions”, which is necessary since the indiscriminate use of AI-based tools results in numerous issues, such as the use of image for criminal purposes, as occurred in 2025, with the arrest of twenty-five people involved in AI generated child pornography (Burgess, 2025).

Hence, using Cost-Benefit Analysis to evaluate the law's applicability and the effects of its outspreads. Sunstein (2018) affirms that “even when it is hard to specify the costs and benefits of a regulation, we might be able to come up with ranges, which can give us enough information to decide if that regulation is worth pursuing”; aiming for the best outcome towards a more balanced and adaptable legal setting regarding digital technologies and generative AI.

> The European Commission's proposal for an AI Act was not the first to attempt to introduce or suggest a legal definition of AI, but it has been the most relevant

and debated regulatory initiative for the regulation of AI since it was published in April 2021, being the first initiative trying to comprehensively regulate the development and use of AI systems at a supranational level (Castán, 2022).

Within this scope, it is possible to notice that there is a need for an adaptable text, as Gstrein, Haleem, and Andrej (2024) affirm about the AI Act, “this rather general definition will need more interpretation going forward, yet contains a lot of flexibility which might have ultimately been the deciding factor for the legislators”. Since it is impossible to predict all that AI can accomplish and the forms it may take in the future, a malleable approach would be better.

The main challenge for regulation is posed by the fact that AI is not a product that once put on themarket does not further evolve during itslifecycle. Moreover, machine learning technologies learn from data, which means that known and unknown challenges in how these systems act are introduced, posing new risk profiles (Cole, 2024).

4 CONCLUSION

Technological development emerges as a structurally transformative force that simultaneously expands economic possibilities and exposes the limitations of existing legal frameworks. As demonstrated throughout this study, emerging technologies not only reshape productive systems and social relations but also challenge the conceptual and operational foundations of Law, revealing a persistent gap between the speed of innovation and the adaptive capacity of legal regulation.

The analysis highlights that this mismatch is not merely technical but deeply rooted in the historical nature of Law. While technological systems tend toward globalization and rapid evolution, legal systems remain largely bounded by national structures and incremental reform logics. As a result, prevailing regulatory approaches based primarily on the adaptation of preexisting norms prove insufficient to address novel and complex technological phenomena.

Moreover, the study reinforces the importance of rejecting deterministic views of technological progress. By recognizing that technological trajectories are shaped by political, economic, and institutional choices, it becomes evident that Law must not only respond to innovation but also actively participate in shaping its direction and distributional consequences. This perspective underscores the centrality of power structures and methodological choices in both the interpretation of technological change and the formulation of legal responses.

In this context, the adoption of diversified methodological approaches proves essential. Descriptive, analytical, and critical frameworks each contribute distinct insights, and their integration enables a more comprehensive understanding of the relationship between Law and technological transformation. Such an approach supports the conception of Law as historically situated, context-sensitive, and inherently interdisciplinary.

Ultimately, addressing the challenges posed by emerging technologies requires more than incremental regulatory adjustments. It demands a reconfiguration of legal thinking itself, one that prioritizes flexibility, adaptability, and methodological plurality. Only through this shift can legal systems move beyond reactive models and develop regulatory frameworks capable of effectively engaging with the complexities of the digital age.

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