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Intellectual property challenges in the 21st century: A study of digital piracy in the European Union

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Abstract

Purpose: This study addresses the challenges of intellectual property in the 21st century, focusing on digital piracy in the European Union and the impact of Artificial Intelligence (AI). It emphasizes the need to modernize the European copyright system to adapt to the digital era, highlighting the recent European AI regulation, a double-edged sword that can be used both as a tool to detect and curb digital piracy and to facilitate it.

Design/methodology/approach: The methodology employed in this research includes an analysis of existing literature on AI, digital piracy, and intellectual property, as well as empirical insights provided by a panel data model. A pluralist methodology is employed, starting from the "jurisprudence of interests," and an interdisciplinary approach is adopted that encompasses both a legal and an economic perspective.

Findings: The study of digital piracy from a legal perspective shows that the divergence of intellectual property laws among member states exacerbates the problem, and from an economic standpoint, the existence of a relationship between digital piracy and copyright norms is empirically demonstrated: systems that are more protective of copyrights have higher rates of digital piracy.

Originality/value: Due to the increasing importance of cultural and creative industries for the European economy, this research is essential. The European copyright system must be modernized to adapt to the digital age. Civil and criminal systems have failed in the fight against digital piracy, and administrative procedures threaten rights and freedoms. Other methods to combat it are proposed, such as raising awareness in society and investing in the development of new business models adapted to the digital economy. The study also investigates the role AI can play in this context.

Keywords: Copyright, Artificial intelligence, Digital piracy, European Union, Panel data

Jel Codes: K00, O34

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1. Introduction

The balance of interests upon which all intellectual property regulations have been based has been altered with the advent of the Internet. While "[e]veryone has the right freely to participate in the cultural life of the community", it is also true that "[e]veryone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author"; as indicated in Article 27 of the Universal Declaration of Human Rights. However, the continuous infringement of copyright on the Web, particularly in their property aspect, evidences a manifest imbalance between the two interests. The copyright system in the European Union (EU), which is both fragmented and unclear, is outdated and unable to meet the new challenges in protecting these rights. Furthermore, the classic instruments of criminal and civil protection has proven insufficient to halt copyright violations on the Web (*i.e.*, digital piracy), leading to the emergence of other protective mechanisms administered by the government.

The current context, marked by the quick evolution of technologies, brings with it a change in values, which is easily perceptible in the "digital natives". With the creation of P2P (peer to peer) networks for file exchanges between users, the mode of digital piracy that causes the most harm to the cultural industry, a culture of immediacy and gratuity has emerged. This has become generalized in the phenomenon of "piracy", which little by little is perceived as the normal way to access literary, artistic and scientific creations (Fouce, 2009; Ledesma, 2011). Technological development, in particular, that of the Internet, has given us the possibility of access to a large number of works and has had a special incidence on the right to reproduction, which for many users means the capacity to generate copies of said works quickly, easily and with quality identical to the original work, all without the copyright holder's control. Therefore, thanks to the Internet, new methods of exploitation have emerged, but also new ways to engage in fraud (such as the case of *Napster,* for example). Today, the phenomenon of Artificial Intelligence (AI) is poised to change the world as we know it. Some have referred to it as the fourth Industrial Revolution (Almonte, 2019; Lacruz, 2023), and one thing that is sure is that in the current context of technological development, the effectiveness of copyright systems is in danger.

In the EU, the success of the domestic market and the development of the digital single market has run into a clear obstacle: digital piracy. As will be discussed in the following section, this phenomenon refers to the unauthorized reproduction and distribution of content that is protected by copyright in digital environments. Although piracy has traditionally been associated with the desire to obtain ill-gotten gains (Martínez del Peral, 1984), nowadays it is usually differentiated from this type of piracy, referred to as commercial piracy, which consists of the illicit reproduction and subsequent commercialization of a work with the intent of earning a profit, and digital piracy, which encompasses any fraudulent act against a work protected by copyright (i.e., without the authorization of its holder) that occurs in the digital media, even when it does not necessarily entail economic benefit. Those most adversely affected are the holders of copyright, who are incapable of maintaining efficient control over their works on the Internet and therefore do not receive fair compensation for the use that is made of them. To mitigate the consequences of digital piracy and to combat it, countries are exploring alternative solutions, such as the administrative protection model developed in France, or the use of DRM systems, strategies designed specifically to fight piracy, though they come with certain drawbacks. However, it has been observed that the adoption of certain legislative measures concerning copyright directly influences a country's digital piracy rates. Moreover, AI has proven to be a double-edged sword in this context: it can serve both as a tool for detecting and stopping digital piracy and as a mechanism that facilitates it. In this regard, two reference standards are especially relevant: Directive 2019/790 (CDSM Directive) and the Artificial Intelligence Regulation (AI Act).

This research contributes to understanding the challenges of protecting intellectual property in the digital age, as well as the opportunities associated with new technologies. In the current scenario of widespread digital piracy, this article examines how AI can be used to identify and prevent it, for example, by detecting infringing content on online platforms. However, it can also be used by offenders to create more sophisticated tools for digital piracy, such developing algorithms to evade detection systems or generate falsified content. Due to the growing importance of the cultural and creative industries for the European economy, this research is of paramount importance. The European copyright system must be modernized to adapt to the digital era. In this sense, and

although it is not its primary objective, the recent European AI regulations, which are both pioneering and historic, have a direct impact on the field of intellectual property. The AI Act provides a new regulatory framework with clear requirements for the development and deployment of AI systems, ensuring that their use is secure, ethical and respectful of fundamental rights, and strengthening legal certainty, which will have significant implications for the fight against digital piracy, as will be seen in later sections.

The study investigates the extent to which the current copyright system in the European Union, and the reforms undertaken by its member states, can effectively address the adverse effects of digital piracy. If the trend in the different countries and within the EU is to increase protection for copyright, why is digital piracy still so prevalent? Answering this question means exploring the hypothesis that there exist legislative measures for copyright that are related to higher rates of digital piracy, and that countries with stricter protections for copyright tend to experience more piracy that those favoring freer access. The reasoning appears simple: the former generally represent more restrictive environments, prompting Internet users to seek access to protected content though illegal means, resorting to digital piracy. The importance and necessity of protecting intellectual property rights are not in dispute in the literature; what is debated is the scope of this protection. García and McCrary (2019) are particularly critical of the "life plus" duration standard (they advocate abandoning it), but they stress: "[w]e wish to emphasize that the critique presented in this Section is not a critique of copyright protection generally. The authors, and the literature as a whole, recognize the value of copyright's existence in incentivizing creation as a baseline matter. The critique, rather, focuses solely on copyright's duration" (García & McCrary, 2019: page 12). Their econometric study, based on the US music industry, supports the argument that the period of protection for copyright is excessive. Among other points, they argue that if information assets generate most of their revenue within the first 5 to 10 years after publication, then protection should focus on this period, after which the work should enter the public domain. The rationale is that the benefits to the copyright holder after this time are minimal compared to the social costs of limiting public access.

The objective of this work is to explore the relationship between the level of intellectual property protection in a country and its digital piracy rate. Therefore, the topic is analyzed from both a legal and economic perspective, given the influence of both fields. The methodology includes an analysis of the existing literature related to AI, digital piracy and intellectual property, along with empirical analysis using a panel data model. Section 2.1 outlines the main international treaties on copyrights, and defines "digital piracy" as it is used throughout the work. This is followed by an overview of the current state of the protection of copyright in the European Union, including relevant Directives and the rights of authors and others most affected by digital piracy. The study then examines the causes, modalities and the socioeconomic impact of this phenomenon in Section 2.2. Finally, Section 2.3 discusses the strategies adopted by EU countries to combat digital piracy and the role of AI in this context. An econometric analysis is proposed starting in Section 3 to investigate the relationship between copyright legislation and digital piracy rates. Finally, the final conclusions and limitations of the study are presented in Section 6.

Before turning to the legal discussion, it is necessary to make a terminological note: throughout the work, the terms "copyright" and "intellectual property" will be used interchangeably. In Spain, "intellectual property" refers specifically to copyright and related rights (e.g., literary, artistic, musical, photographic and audiovisual works). However, at the international level, "intellectual property" also encompasses what is known in Spain as "industrial property" (i.e., patents, trademarks, drawings and industrial models, etc.).

2. Previous Literature

2.1. International Protection of Copyright

The legal development of the copyright has always gone hand in hand with the technological advances of the time —an idea that clearly reflected in the WIPO "Internet Treaties", which aim to regulate the transition from the analog to the digital era. The cultural revolution that began in the second half of the 15th century with the creation of the printing press revealed the urgent need to protect intellectual creations. At that time, a system of privileges was adopted (granted as a "king's grace"), which aimed to protect printers and publishers —but not authors— and conveniently also served the interests of the state, especially in terms of control and censorship (Encabo, 2015). The end of the privileges regime marked the birth of copyright as we know it today. This

transformation first took place in the United Kingdom, with Queen Ann's Law of April 10, 1710 (Vega, 2002). In Spain, the Royal Order of March 22, 1763, issued by Carlos III, stipulated that privileges could only be granted to authors. France, in turn, abolished all privileges with the French Revolution, and the Law of June 19, 1793 legislatively established respect for copyright (Barrio, 2017).

Piracy emerged alongside the creation of copyright. New printing techniques made it possible to produce large quantities of copies and facilitated the distribution of works, thereby also empowering "pirates". Piracy refers to the creation and distribution of unauthorized copies of protected materials (Panethiere, 2005). The two exclusive rights most affected are the right of reproduction and the right of distribution (these two, along with the right of public communication and the right of transformation, constitute the proprietary content of copyright, as distinct from moral rights). With the advent of the Internet, often dubbed the "new printing press", a shift occurred in how protected content is copied and shared. This is what we now call "digital piracy", since the violation of copyright takes place through digital means. The definition of digital piracy used in this work, which I consider the most appropriate, is provided by Ledesma (2011): "se entiende por piratería digital cualquier acto que se realiza en la Red, por el cual se lleva a cabo una explotación de derechos de propiedad intelectual sin contar con la pertinente autorización del titular de los mismos, con el fin de eludir el cumplimiento de la ley en beneficio propio" (translated as: "digital piracy is understood as any act that is carried out on the Web, through which intellectual property rights are exploited without the pertinent authorization of their holder, in order to circumvent the law for one's own benefit" (page 25). None of the international legal instruments protecting copyright discussed below explicitly refers to the term "digital piracy", despite its widespread use. Nor do they include a definition of "piracy" in their provisions. Only the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) includes the concept of "pirated copyright goods", along with the obligation to sanction them for infringing copyright (Art. 61 TRIPS).

Bilateral treaties for the protection of literary works, which began in the 1840s, represent an early attempt at harmonizing legislation. These agreements already contained the principles of national treatment and most-favored-nation status, which would later be incorporated into the legislative development of International Law. To harmonize the treatment of copyright across different jurisdictions, the Berne Convention for the Protection of Literary and Artistic Works was adopted in 1886. Its predecessor was the 1878 Paris International Literary Convention, convened by the French Société des Gens des Lettres, which led to the creation of the Association Littéraire et Artistique Internationale, under the presidency of Victor Hugo. Hugo's advocacy was instrumental in the adoption of the Berne Convention. A firm defender of the public domain, his concept of the "domaine public payant" failed to convince the drafters of the Berne Convention, who ultimately rejected it in favor of perpetual copyright terms or their limitation to the author's lifetime plus a few years, which was finally included in the convention. The Convention established a Union for the protection of copyright over literary and artistic works, as stated in the first article. Today, 181 countries are signatories.

The Convention includes three key principles, all set out in Article 5: the principle of national treatment (the works originating in one contracting state are protected in other contracting states to the same extent as local works); the principle of automatic protection (the protection of copyright does not require any formalities, such as registration or the deposit of copies); and the principle of independence of protection (a work is protected in the participating states regardless of whether it is protected in the country of origin). Article 2 defines the subject matter of protection (the literary and artistic works) as "every productions in the literary, scientific and artistic domain, whatever may be the mode or form of its expression". Article 6 bis requires member states to recognize the authors' moral rights, including the right of paternity and integrity. Article 7 sets the minimum term of protection at the lifetime of the author, plus fifty years p.m.a. (*post mortem auctoris*). For the purposes of the material that constitutes the subject matter of this study, what should be highlighted is the definition of the right to reproduction that is set out in Article 9 and the regulation of the right of public communication established in Articles 11 and 11 bis. From these provisions, the exclusive nature of copyright has become a basic principle in the area of intellectual property, as can be deduced from the wording of Article 9 itself.

Another key instrument is the Agreement on Trade-Related Aspects of Intellectual Property Right (TRIPS or TRIPS Agreement), which is Annex 1C of the Marrakesh Agreement establishing the World Trade Organization, signed in 1994. TRIPS incorporates many existing international obligations that pertain to intellectual property,

particularly with regards to the limits to copyright, outlining intellectual property standards in a multilateral trade system. In 1995, the WIPO and the WTO signed an agreement to facilitate the application of the TRIPS Agreement.

Article 9 of the TRIPS Agreement mandates that WTO members adhere to Articles 1 to 21 of the Berne Convention, including the principles of national treatment, automatic protection and independence of protection—even if they are not signatories of Berne. However, Article 9.1 exempts the members that are not signatories of Berne from complying with Article 6 bis of said Convention, i.e., the provisions on moral rights. The disregard for these by the United States prevented their accession to the Berne Union until 1989. It should be mentioned that the main point of divergence between countries following the European continental tradition (the authors' rights system) and the Anglo-Saxon legal systems (United Kingdom, the Commonwealth and the United States; the copyright system) lies in the moral right of the author: it is stressed by the former and disregarded by the latter. TRIPS also imposes the "most-favored-nation treatment" requirement and establishes the protection for computer programs as literary works under the Berne Convention.

As already mentioned, TRIPS does not define "digital piracy", but it does refer to piracy in Note 14 of Article 51: "'pirated copyright goods' shall mean any goods which are copies made without the consent of the right holder or a person duly authorized by the right holder in the country of production and which are made directly or indirectly from an article where the making of that copy would have constituted an infringement of a copyright or a related right under the law of the country of importation". Article 61 obliges states to penalize piracy, albeit limited to commercial piracy, since this activity has traditionally been linked to the idea of profit. However, the term "digital piracy" is currently used to designate broader realities. National regulations have gradually expanded the concept of "piracy" to include those unauthorized reproductions which, while not for commercial purposes and therefore not for profit, are made in large quantities, representing large-scale infringements.

In 1970, the United International Bureaux for the Protection of Intellectual Property, better known by its French acronym BIRPI (*Bureaux Internationaux Réunis pour la Protection de la Propriété Intellectuelle*), is replaced by the World Intellectual Property Organization (WIPO). Like its predecessor, the WIPO is responsible for administering the Paris Convention for the Protection of Industrial Property of 1883 and the Berne Convention of the Protection of Literary and Artistic Works of 1886. In 1974, WIPO became one of the first specialized agencies of the United Nations. The WIPO defines intellectual property as "creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce" (World Intellectual Property Organization [WIPO], n.d.). Its objective is to develop a balanced international intellectual property system that compensates creativity, stimulates innovation and contributes to economic development, while at the same time safeguarding the public interest. One hundred ninety-three states form part of the organization.

On December 20, 1996 two key treaties were adopted that meant an adaptation of international regulations on copyright and related rights in association with the new digital age: the WIPO Copyright Treaty (WCT) and the WIPO Performances and Phonograms Treaty (WPPT), known collectively as the "Internet Treaties". Both treaties sought to promote a secure legal framework that ensures adequate and effective protection of intellectual property rights on the Internet. However, even though they were presented as Internet "anti-piracy" treaties, neither explicitly mentions "digital piracy", nor do they prescribe any penalty whatsoever for cyber piracy, leaving enforcement up to national legislation. The preamble of the WCT expressly indicates that it is adopted in light of the need to respond to the new economic, social, cultural and technological developments arising from advances in the digital and telecommunications fields. The treaty requires countries to establish a framework of basic rights that allows creators to exercise control and/or receive compensation for the different ways in which their creations are used and enjoyed, ensuring adequate and effective protection for the holders of these rights when their works are disseminated through the new technologies. It clarifies that the traditional right of reproduction continues to apply to the digital environment, and with regard to the storage of material in digital format on an electronic medium, and emphasizes the need to maintain a fair balance of interests between the holders of copyright and consumers of protected content. It grants countries great flexibility in setting exceptions or limitations to rights in the digital environment, for example, for uses considered to be in the public interest, as well as for non-profit educational and research purposes.

In a press release on December 14, 2009 (PR/2009/626), WIPO celebrated the EU's ratification of the Internet Treaties, reaffirming Europe's undeniable role in protecting creators and cultural industries, and promoting the information society and by which it became a full contracting party. With a focus now on EU Law, we must begin by noting that intellectual property is enshrined as a fundamental right in Article 17 of the Charter of Fundamental Rights of the European Union (CFREU). However, unlike in certain areas of industrial property (such as the community trademark and industrial design, regulated respectively by Regulation (EU) 2017/1001 and Regulation (EC) No. 6/2002), the field of intellectual property has not yet seen the creation of unitary rights through regulations. In this regard, Encabo (2015) notes that the evolution of the technical phenomena affects the entire international community and the concern for protecting authors and those acquiring intellectual property rights is shared by all countries. Nevertheless, each state has followed its own legislative path. The principle of territoriality guides the system regulating copyright.

This fragmentation in the regulation of copyright within the European Union—where, instead of a sole title on the European level, there exists a set of national rights—complicates the fight against digital piracy. Moreover, the challenges stemming from the principle of territoriality also hinder the achievement of a single digital market. There is broad consensus that harmonizing the regulations of the member states concerning copyright and related rights contributes to the realization of the objectives of the internal market. For this reason, the fundamental right to intellectual property protection serves as one of the guiding principles behind market harmonization policy (Espín, 2014; Serrano, 2008). At the same time, there is also near unanimous agreement on the necessity of reforming the current legal framework—an effort that began with the Directive on Copyright in the Digital Single Market (CDSM Directive) and the debates surrounding it.

In the second half of 2014, following the renewal of its members, the European Commission announced the creation of a digital single market as one of its priority objectives. In its May 2015 communication *A Strategy for Europe's Digital Single Market* (COM(2015) 192 final), the Commission acknowledged the need to modernize intellectual property rights regulations in line with new technologies, and to harmonize the regime by overcoming the territorial nature of these rights. This led to a wave of legislative proposals and communications culminating in the adoption of the CDSM Directive on April 17, 2019. Its legislative process was highly contentious: the Commission presented the proposal for a directive in 2016; the Parliament subsequently rejected it and negotiations stalled. The final text was only approved after the introduction of several amendments. The most debated provisions were Articles 11 and 13 of the Proposal, which eventually became Articles 15 and 17 in the Directive. Never before had the passage of a European regulation generated as much interest as the 2019 Directive on Copyright in the Digital Single Market—interest later echoed in 2024 with the Artificial Intelligence Regulation. This is understandable given the importance of copyright to the European economy and labor market, as well as the fact that, when discussing copyright, we are fundamentally addressing culture. From this, we can deduce the significance of its protection and the fight against piracy in safeguarding creative and innovative activity, which in turn contributes to the economic and cultural development of European society.

Although the objectives of the CDSM Directive do not explicitly include combating piracy, it introduces a series of measures that strongly protect copyright. These have generated—and continue to generate—considerable debate and controversy, not only within European institutions and the European Parliament, but also among European citizens at large. The transposition of this directive has been uneven across member states, often delayed, leading to sanctions in several cases, including Spain and Portugal.

The EU has consistently regulated intellectual property rights with the express purpose of ensuring a high level of protection, having approved fourteen directives to date. The Directive most relevant to the topic of this paper is Directive 2001/29 (the Infosoc Directive), which defines two exploitation rights that are typically infringed in all forms of digital piracy—namely, the rights of reproduction and public communication (Articles 2 and 3, respectively). It also regulates the limit for private copying and protects the technological measures used for right management. The importance of intellectual property protection for the proper functioning of the internal market is underscored in the first recital, while Recital 8 addresses the concern that the internal market's success could be compromised by disparities in the level of protection found in the member states. Recital 9 identifies piracy as a disruptive factor in the internal market by enabling the instant and global distribution of pirated products. Also relevant are Directive 2004/48, which establishes the procedures that member states must

regulate to ensure the enforcement of intellectual property rights, and Directive 2000/31, which, although not directly addressing intellectual property, plays a complementary role to the Infosoc Directive by regulating the liability of intermediary service providers.

Regarding the right of reproduction, the Infosoc Directive defines it as broadly as possible to cover all acts of reproduction. However, Recital 33 notes the legislator's option to consider temporary reproductions as exceptions to the author's exclusive rights, provided the requirements of Article 5.1 are met (Serrano, 2008). As for public communication, considerable controversy has surrounded the definition of "public", as evidenced by the extensive and contentious case law of the CJEU. The *Svensson case*, which addressed hyperlinking, marked a turning point in interpreting public communication and content availability. The Vcast Limited case further established a clear jurisprudential line.

Article 5.2.b) of the Infosoc Directive presents the exception for private copying as one of the optional limitations that the member states may incorporate into their legislation. Internet users who access protected content though various forms of digital privacy often invoke this exception. However, for it to apply—arguably the most economically relevant exception—several conditions must be met. These include that the copy must not be for collective use (placing the work on a web server makes it accessible to an indeterminate number of people), and that the source of the copy must be lawful (i.e., access must not breach licensing terms; making a work publicly available without the rights holder's authorization does not qualify as legal access). File sharing through P2P networks is explicitly excluded from the scope of the private copy exception. Directive 2019/790 introduces four mandatory exceptions for member states, one of which concerns text and data mining—an essential element for the development of AI technologies. This directive aims to balance the protection of copyright with the need for broader access to data to support innovation and technological advancement. establishing a more robust and adaptable framework that defends creators' rights while promoting innovation and competitiveness in the digital market.

The current technological frontier is AI, which has emerged prominently in our society. In the context of this paper, AI has already had a direct impact on intellectual property by challenging traditional concepts such as authorship. Regulation 2024/1689 of June 13, on harmonized AI rules, defines an "AI system" in Article 3.1) and Lacruz (2022) compiles a range of doctrinal definitions. This technology enables the creation of music, paintings and stories—activities historically considered uniquely human. The ongoing debate about whether a machine can be considered an author and whether AI-generated content should receive protection (Saiz, 2019; Lacruz, 2021; Pazmiño, 2023; Calles, 2024) highlights the urgent need to revisit the principles set out in classic instruments. The impact of AI on intellectual property has led to new lines of research and protection mechanisms. One notable example is blockchain technology, which makes it possible to record the provenance of digital assets (Garbers, Haag & Gruber, 2022). It can be used to create immutable and traceable records of artistic and intellectual works, thereby guaranteeing authorship and reducing the risk of unauthorized copying (Almonte, 2019; Lacruz, 2023). Certain aspects of Regulation 2024/1689 will be analyzed in Section 2.3.

2.2. Digital Piracy

As a general rule, there are no official statistics on the impact of digital piracy. Most available data come from reports published by the affected industries, i.e., the private sector, which inevitably tends to overstate the magnitude of its effects. However, there is no doubt that digital piracy results in significant loss of income for authors, artists and the cultural industry as a whole, including the music, audiovisual, publishing and software (including video games) sectors. According to the European Union Intellectual Property Office (EUIPO), losses are estimated at approximately 16 billion euros (Press release, January 16, 2024). In 2018, the report from the Observatory of Piracy and Digital Content Consumption Habits continued to identify the music sector as the most affected. Although recorded music revenues had been plummeting since 2001, if the value of lost profits due to piracy were factored in, 2018 revenues would approach the market value from 2001. The report also noted that illegal consumption of digital press content surpassed legal consumption.

While the rate of digital piracy across EU countries remains high, the trend shows a decrease in the volume of illicit content accessed. Spain reflects this trend: since 2015, there has been a cumulative 12% decline. The most common forms of digital piracy include P2P networks, direct downloads, streaming, and linking to protected

content. Among these, the sharing of protected files via P2P networks remains the most widespread and damaging for the cultural industry, dating back to the launch of Napster in 1999.

In addition, digital piracy also harms consumers. They are affected in those cases where the pirated works are defective or incomplete. This is to say that the quality of these goods can be inferior. Moreover, accessing illegal content online exposes Internet users to privacy and data security risks. The public interest is also damaged: if there is a profit motive on the part of the offenders, then the marketing of pirated goods involves tax fraud. Piracy can be understood to harm society as a whole, but there is no shortage of voices that defend the benefits that it can mean for certain markets. In the music industry, for example, it has been said that digital piracy performs an advertising function, since it allows music to reach more citizens free of charge, allowing artists to gain exposure. This can lead to the purchase of complementary goods. Others have also argued that the free distribution of content protected by copyright familiarizes the public with artists or their work and this opens the door to other forms of business, such as merchandising (Villarroel, 2010). While these opinions on the positive effects of digital piracy are noted, there is a lack of empirical evidence to support them.

The unprecedented expansion of the Internet makes digital piracy easier than ever and thus can be considered its main cause. The cost of reproducing and distributing the protected content digitally is virtually zero. Additionally, greater bandwidth availability has facilitated faster sharing speeds. Yet the problem is more complex than it would seem at first glance. There are many factor that influence a country's digital piracy rate—some of which are included as regressors in this study's econometric models. They include:

1. High prices: many consumers turn to piracy because they perceive the legitimate content as too expensive. According to a 2017 EUIPO survey, 71% of Europeans said they would consider stopping piracy if contents were more affordable. A vicious circle has been created: piracy limits industry revenues, which in turn leads to higher prices for legal content to offset losses—thereby fueling further piracy.
2. Education and awareness: many consumers see piracy as harmless, believing that it does no real harm. Some even consider it a normal way to access cultural content. The lack of legal consequences reinforces this perception. The lack of education and awareness of the adverse effects of piracy and the confusion between legal and illegal platforms also contribute to this problem. The EUIPO report of March 2017 found that 24% of Europeans who accessed protected content questioned the legality of the source—up from 19% in 2013.
3. Outdated business models: a lack of business models adapted to the digital era and limited legal content offerings on the Internet push users toward piracy. Market segmentations, geo-blocking and insufficient availability delay or prevent access to cultural goods, leading consumers to turn to illegal channels. New technologies have enabled novel forms of creation and consumption, and therefore they have also revealed the need to adapt business models to the "digital economy". For example, legal streaming services such as Spotify (popular across the EU in the music industry), Deezer (also in the music industry, but especially in France) and Netflix (for audiovisual content) illustrate successful transitions to legal online content distribution.
4. Macroeconomic variables: according to development theories, countries with a lower per capita GNP tend to have higher digital piracy rates.
5. Copyright legislation: in the legal environments that strongly protect intellectual property, users often encounter greater barriers to accessing protected content. Legislative measures are occasionally introduced that reduce the circulation of works online. One such example is the secondary liability of Internet Service Providers (ISPs). When rights holders can demand that a platform (e.g., YouTube) remove potentially infringing content, users may lose access to that content and seek it through illegal means—like P2P networks or torrent platforms. At the same time, the introduction of exceptions to copyright, which usually favors consumers, can reduce the incentives to resort to piracy.

2.3. Strategies to Combat Digital Piracy: Artificial Intelligence (AI)

To find solutions that help establish a legally secure digital environment, several EU countries have proposed specific legislative models. Traditional anti-piracy measures rely on civil and criminal protection, but with the HADOPI I law, France introduced an administrative protection system for intellectual property on the Internet. Many countries adopted similar approaches, including Belgium, Denmark, Spain, Finland, the United Kingdom and Sweden in Europe, and Australia and Japan beyond it. Despite criticism, the French model is noteworthy for its educational component. It created a public authority responsible for promoting legal content online, protecting works from infringement and controlling the illegal use of said works. The penalty administrative procedure was carried out in three steps: first, Internet users were informed of the potential penalties and were made aware of legal alternatives and the cultural harm caused by piracy. Then a formal warning was issued via certified letter. Finally, if the behavior continued, users could face the suspension of Internet service. However, this sanction was declared unconstitutional because Internet access is considered part of the right to freedom of expression and communication, meaning only a judge could restrict it. This led to the adoption of a revised version, HADOPI II. Several econometric studies have evaluated the effectiveness of the HADOPI law, with mixed results.

In Sweden, the IPRED law also took effect in 2009. It focused on enabling rights holders to obtain the personal identification data of infringers. The efficacy of the law was put to the test in 2010 when the administrators of the portal known as The Pirate Bay, the world's largest BiTorrent tracker, were sentenced to one year in prison and a fine of €2.7 million in damages. In Spain, the so-called "Sinde Law" (Law 2/2011, of March 4, on the Sustainable Economy) was heavily influenced by the French model. It allowed administrative authorities—rather than judges— to investigate and order the closure of websites hosting unauthorized intellectual property content. In the 2011 and 2014 reforms, judges were still required to intervene, but with very limited powers. The last reform in 2019 eliminated judicial oversight altogether in certain cases. This has raised concerns regarding fundamental rights, particularly freedom of expression and information, since Articles 20.2 and 20.5 of the Spanish Constitution stipulate that content cannot be censored in advance, and that only a judge can order the seizure of publications.

As for non-legislative measures, Digital Rights Management (DRM) systems constitute another strategy to prevent unauthorized copying and reduce the overall piracy rate. DRM (also referred to as Technological Protection Measures [TPMs] or Electronic Copyright Management systems [ECMs]) includes technical tools used by publishers and copyright holders to control how digital content is used by consumers. These systems can permit certain uses—like sharing to multiple devices—while restricting others, such as editing, copying or printing. In the music market, however, it remains unclear whether DRMs are truly effective. For this reason, Apple removed DRM from its iTunes store in 2009. The use of DRM systems is also controversial in other respects. First, the technological protection of copyright does not respect the private copying exception. Second, it may conflict with fundamental user rights, particularly those related to information access and privacy. An illustrative case occurred in 2009, when Amazon remotely accessed customers' Kindle devices to delete two e-books—*Animal Farm* and *1984* by George Orwell—and then refunded the customers because the company did not hold the rights to those works.

Technological innovations have dramatically changed how cultural goods are consumed. When legal digital offerings are lacking, consumers are more likely to turn to illegal alternatives, this is, any form of digital piracy. Therefore, creating and promoting new business models on the Web that respect intellectual property rights is a key factor in reducing digital piracy, as will be seen in the following sections. Music and movie streaming platforms (such as Netflix, Spotify and Deezer, among others) and direct download sales programs (such as iTunes for music and Steam and Origin for video games) are examples of business models that have known how to adapt to the changes brought about by the development of the Internet. Additionally, alternatives to proprietary intellectual property, such as free software in the case of computer programs, also represents an opportunity to eliminate the economic incentive for piracy. This is also true of open licenses, such as Creative Commons and public domain licenses. Educational campaigns are also essential. UNESCO recommends educational strategies on the negative effect of digital piracy that target young people, who are the most frequent users of pirated content. (In digital piracy, age is a very important factor.)

Finally, the potential of Artificial Intelligence (AI) should be mentioned, as a tool to fight against digital piracy. As of today, the only thing that is certain is that it plays a dual role: AI may be used both to fight against digital piracy and to facilitate it. On the one hand, AI technologies can develop advanced algorithms capable of detecting and eliminating infringing content on online platforms, thus strengthening the ability of copyright holders to protect their intellectual property. On the other hand, violators can also use AI to develop more sophisticated methods to evade protection systems or to create falsified content (e.g., deepfakes). The latter example, like the content used to train generative AI systems, poses new challenges for the protection of copyright. For instance, Meta recently announced that it will use content published by Facebook and Instagram users to train its AI systems. This news has generated a great deal of criticism, not only because it represents an invasion of privacy, but also for the use of any post shared by users while it is protected by copyright. Meta has already been subject to one lawsuit related to this issue. In July 2023, American comedian and author Sarah Silverman joined a class action lawsuit (still pending) against OpenAI (the creator of ChatGPT) and Meta (LLaMA), accusing them of violating copyright (Whitaker, 2024). Once the datasets used in training were made public, it was revealed that some were derived from illegal repositories such as The Pile, which includes material from shadow libraries distributing books without the authorization of the copyright holders.

In response to such concerns, the EU has made a historic move by approving the AI Act in June 2024, the world's first regulation on Artificial Intelligence. The AI Act, as it is known, defines an AI system and classifies risks, making it possible to focus the debate by clarifying certain controversial aspects. In general terms, intellectual property plays a fundamental role when talking about AI, given that the tools these technologies use are supplied with large amounts of data, much of which are protected by copyright. While the Regulation does not explicitly mention digital piracy, Recital 110 warns that AI could pose systemic risks, such as the dissemination of illicit or false content. It imposes several obligations on developers and providers of AI models to protect copyright, including obtaining authorization from the holders of copyright to use their works for text and data mining (Recital 105). For increased transparency, it requires summaries to be published of the protected data used for training (Recital 107 and Article 53.1.d)). Furthermore, certain guidelines must be adopted in order to comply with EU legislation regarding copyright and other related rights (Articles 25.5 and 53.1.c)). The AI Office will oversee compliance with these obligations (Recital 108 and Articles 50.7 and 56.2).

The challenges in terms of intellectual property posed by AI in general and generative AI in particular cannot yet be met by the current legal systems (Muñoz, 2024). Key concerns regarding the mass use and exponential growth of generative AI tools are the use of protected content in the training of these AIs (such as the case of Sarah Silverman). The use of protected works in the training of generative AI models without obtaining authorization from the rights holders constitutes a case of piracy and acknowledging this is not only important from a legal perspective, but also from an economic one (Ordelín, 2023). AI can also result in the creation of AI-generated forgeries, with the subsequent difficulty to attribute responsibility for the violation of copyright (Anguiano, 2023). For example, DALL-E is an AI system capable of producing images by imitating the style of many artists (Iglesias, 2022), and The Next Rembrandt project created a software that could understand Rembrandt and recreate a painting as if it had been produced by the artist himself (Saiz, 2019). In the new format of digitalization of works such as tokens, although blockchain technology makes it possible to fight against digital piracy while providing legal security, as indicated above, it can also be used to promote the creation and marketing of these "forgeries". It is possible for a Non-Fungible Token (NFT) that identifies a digitalized work of art to not be created by the legitimate author (Lacruz, 2023). Blockchain technology makes it possible to unequivocally identify a work, but the token holder is the individual who creates it, not the author of the tokenized work. This makes fraudulent use possible as someone could market a tokenized work without being the author.

AI, therefore, has a direct impact on digital piracy. At the same time, AI also represents an opportunity to fight it. Some see the tokenization of works of art as the remedy for the proliferation of copying that is facilitated by the Internet (Lacruz, 2023). It is also being used to develop tools for identifying false content: in May 2024, the press reported an alert warning of falsified works sold on eBay, which were identified thanks to an AI system designed by the Art Recognition company (García, 2024). Another convincing example of AI use to fight against piracy is YouTube's Content ID, a pattern recognition algorithm that allows copyright holders to identify protected

content that has been uploaded without their authorization. From the perspective of the rights holders, it is important to recognize that the use of their works to train generative AI systems constitutes an act of piracy, since it paves the way for participation in the economic benefit obtained from the development of business models that use these AI systems (Ordelín, 2023). Meanwhile, authors may face increasing burdens: as Culliton (2024) notes, creators already spend significant time monitoring for piracy and requesting content takedowns. The fact that generative AI is trained with protected works that are used to create other works is a concern, since it would mean that authors would have to be constantly vigilant for violations of their copyright. If we reflect on what has been presented so far, we see a three-level structure: first would be the legal protection (copyright laws); next would be the technological protection that could be used to protect these rights; and finally, we see legal safeguards for these technologies. On a national level, Spain has recently created the Spanish Artificial Intelligence Oversight Agency (AESIA), which is in the process of appointing its first director. This public body will oversee the responsible development and use of AI, providing training, guidance and regulation for both public and private institutions. Finally, in addition to the legislative and technological measures mentioned, public policy must address the root cause of digital piracy. Examples of effective strategies include awareness campaigns to educate users about the legal and economic risks of illegal access to protected content. These should emphasize that negative consequences not only affect the copyright holders and society in general, but also the users themselves, since their privacy, security and personal data protection can be severely affected. Likewise, it is essential to improve the legal offering of protected content, ensuring affordable prices and an efficient distribution in order to eliminate the incentives of pirate platforms. (In this sense, the elimination of geo-blocking on certain streaming platforms could prove useful.) Furthermore, governments could promote the consumption of legal software and cultural content through tax breaks or subsidies. Investment in these three aspects would represent a good strategy against digital piracy, and they would also maintain the balance of affected interests: that of the copyright holders and that of the users.

3. Data

A review of the previous literature confirms that the digital piracy rate (DPR) of a country is influenced by a variety of factors. The following sections aim to identify and explain these factors and to empirically demonstrate their effects. In particular, the intent is to show that the countries with stronger legal protection for copyright present higher rates of digital piracy than those countries that favor free access, and that the presence of business models adapted to the digital economy reduces it.

We begin by referencing Terra (2016), who proposes an Ordinary Least Squares model with data from 2013, carried out on a population sample of 108 countries belonging to the WIPO, including, however, a series of modifications in the analysis proposed here: an additional variable ("IPchargesperinhab") replaces the one used by Terra (2016) in order to replicate, with EU data, the model estimated by the 2013 Ordinary Least Squares (OLS) model proposed by this author; a model with panel data is proposed (as well as two OLS models, one for 2013 and another for 2017), dispensing with some variables in order to find the best estimate of the DPR. The population sample is also different: since this work uses as its starting point the latest reform in the area of copyright undertaken by the European Union and its objective is the study of digital piracy in those countries that make up this organization, the sample is composed of the 27 EU member countries, to which 9 more are added (the United Kingdom in both 2023 and 2017 was a full member of the EU; Norway; Albania; Montenegro; United States; Canada; China; Japan; and Colombia), for the dual purpose of obtaining accurate estimates (for proper estimation, $n > 30$; Stock and Watson, 2012) for the two OLS models and to increase cross-sectional variability. Data from these countries are used with reference to the years 2013 and 2017. The data used for the econometric analysis proposed in this work come from different sources (described in the lines below), and the Gretl econometric software was used to process them.

3.1. Variables

The dependent variable or variable of interest is the digital piracy rate (DPR), the data for which are taken from the BSA Global Software Survey report (2014, 2018). This report focuses on the piracy of computer programs, but data on this type of copyright violations constitutes a very good approximation of the overall level of digital piracy in the country. This is because the violations of copyright for all types of digital assets (software, movies,

music, books, video games, etc.) are related in the sense that the determining factors are the same. For this reason the piracy rates for computer software can be extrapolated to the other figures and constitute a very good approximation of the general level of digital piracy in a country (Terra, 2016). It has already been pointed out that studies on digital piracy tend to overestimate its effects, since the companies in charge of producing them are the ones affected. In this aspect, the BSA is an organization of pro-copyright companies (Apple, Adobe, Oracle, Intel, Microsoft, etc.), and so it is likely that the report contains an overestimation of the national digital piracy rates. In order to determine the DPR, the BSA uses a methodology that combines user surveys, analyses of market trends and economic estimates (pp. 11-16 of the 2014 edition and pp. 17-19 of the 2018 edition):

1. Global survey of software users: in the 2014 edition, 22,000 users were surveyed, while in the 2018 edition the sample increase to 22,500 users, making it possible to see the acquisition and installation patterns for software in both domestic and professional environments.
2. Calculation of the unlicensed software installation rate: the DPR is calculated based on a series of formulas that estimate the proportion of software installed without a license in relation to the total amount of software installed in a certain market, and thus the following data constitute the basis for the fundamental equation for the rate:
   a) General DPR formula:

$$\text{Unlicensed Rate} = \text{Unlicensed Software Units} / \text{Total Software Units Installed} \quad (1)$$

   b) Determination of the total amount of software installed:

$$\text{Total Software Units Installed} = \#\text{ PCs Getting Software x Software Units per PC} \quad (2)$$

   c) Determination of legitimate software:

$$\text{Legitimate Software Units} = \text{Software Market Value} / \text{Average Software Unit Price} \quad (3)$$

   d) Determination of unlicensed software:

$$\text{Unlicensed Software Units} = \text{Total Software Units Installed} - \text{Legitimate Software Units} \quad (4)$$

3. Calculation of the commercial value of the unlicensed software: the economic value of the losses attributable to the use of unlicensed software is calculated by means of the following formula:

$$\text{Commercial Value} = \#\text{ Unlicensed Software Units x Average Software Unit Price} \quad (5)$$

4. Software included and excluded from the measurement: the BSA analysis covers software installed on computers (desktop computers, laptops and ultra-laptops), including operating systems, databases, security packages, business applications and consumer applications, such as games or personal finance packages. The availability of (legitimate) free and open code software is considered, and cloud computing services are also included, such as SaaS an PaaS, as well as software sold as part of legalization programs. Excluded are software loaded on tablets or smartphones, and free download utilities, such as screensavers.
5. The effect or impact of exchange rates: the fluctuations in exchange rates can affect the estimation of the commercial value of unlicensed software. In the 2014 edition, the BSA exemplifies this impact by showing how a depreciation of the local currency against the U.S. dollar can alter the valuation of economic losses attributable to the use of unlicensed software in a specific country.

With regard to the independent variables, the eleven variables that are presented below are the factors that can affect a country's DPR. The "aggregate" variable represents the level of protection of the copyright in a country. This is taken from Terra (2016), who constructs said variable from the calculation of series of legislative measures on copyright (the legislative measures considered are those listed below and shown in Table 2). A process is carried out to quantify the legislative measures on copyright, as they are variables of a qualitative

nature, and a weighted means is subsequently calculated to obtain the variable to be used in the regressions, i.e., the "aggregate" variable. This assumes a value between 0 and 1, indicating that a country is more inclined towards free access (i.e., adopts more pro-consumer rules, so to speak) if it has a value close to 0 and, conversely, that legislation is more protective of authors and other copyright holders if the result is closer to 1.

The coding process and weighting criteria followed here correspond to those used by Terra (2016: page 117), having checked the national laws of the states collected in the sample (n = 36) in the WIPO database (WIPO Lex) to update the values of the selected measures, where appropriate. The legislative measures used in the construction of this aggregate variable, which are listed below, are of one of two types: 7 are binary, and in the coding process they are simply given a value of 0 if the measure does not exist in a country and 1 if it is present, and 7 are categorical, and are given a discrete value from 0 to 3 in order to reflect different levels of protection (a negative sign is indicated if they are considered more restrictive measures and positive sign if they are more pro-consumer).

1. The sweat of the brow doctrine is applied if the author obtains protection for the mere effort or diligence in the creation of a work, such a database, without requiring a certain level of creativity ("sweatbrow", binary, -).
2. Consideration of the software as a literary work ("softlitwork", binary, -).
3. Provisions on work for hire ("workforhire", binary, -).
4. Existence of methods for solving problems on collective works and orphan works ("collorphanworks", binary, +).
5. Scope of performance rights, if they include digital technologies, especially relevant in a world dominated by streaming and cloud services ("performdisplay", discrete, -).
6. Secondary liability of the Internet Service Providers (ISP) and secure ports, if there are provisions regarding their liability and mechanisms that limit it ("secliabilityisp", discrete, -).
7. Scope of moral rights ("moralrights", discrete, -).
8. Existence of provisions on mandatory licenses ("compulsorylicenses", binary, +).
9. Regulation and scope of the collective management agencies ("collectingagencies", discrete, -).
10. Possibility of private copying and the existence of a digital tax or compensation for private copying ("privatecopying", discrete, +).
11. Concepts similar to the fair use or fair dealing doctrines ("fairuse", discrete, +).
12. First sale or expiration of rights doctrine ("firstsale", binary, +).
13. Remedies for the infringement of authors' right, including civil, criminal and administrative consequences ("remedies", discrete, -).
14. Legal provision of copyleft models ("copyleft", binary, +).

The ten remaining variables are related to socioeconomic and demographic characteristics of the countries that might also affect their digital piracy rate. The following sources have been used to compile the data: World Bank, Eurostat, Federal Reserve Economic Data (Fred) and World Economic Forum. For the "businessmodel" variable, which indicates the presence of business models adapted to the digital economy, the Spotify, iTunes and Netflix websites are visited to verify the availability of these service in the different countries (these three are used since they are the ones used by Terra in his research and because they are the ones that best exemplify the transition to the Information Society economy). In Table 1 below is a list of variables as well as the justification for their relevance in the study:

DPR	Digital piracy rate as a %
aggregate	Representative variable for the level of protection of copyright in each country. To calculate it, see the formula used by Terra (2016): the weighted mean of all the legislative measures that are used ("sweatbrow", "softlitwork", "workforhire", "collorphanworks", "performdisplay", "secliabilityisp", "moralrights", "compulsorylicenses", "collectingagencies", "privatecopying", "fairuse", "firstsale", "remedies", "copyleft"), converting the results into absolute and logarithmically standardized values. A value closer to 1 means that, generally speaking, the copyright law is more favorable to the rights of authors, while figures close to 0 imply that the regulations are more favorable for the consumers in that country. [This variable represents the hypothesis of the study: measures more protective of copyright increase the DPR.]
gdppercap	Per capita GDP in U.S. dollars. [According to development theories, the richer a country is in terms of per capita GDP, the lower its DPR is, because the population as a whole can afford to legally access protected content without having to resort to free pirated products.]
gini	Gini index (estimate by the World Bank). [Greater inequality in the distribution of income can increase the DPR, since populations with fewer resources may turn to piracy.]
unemployment	Unemployment rate, as a % of the total workforce (according to estimates by the ILO). [A higher unemployment rate could increase the DPR, since unemployed persons might turn to piracy.]
internetusers	Internet users for every 100 people. [The more Internet users there are, the greater the probability of digital piracy, since access to illegal content is facilitated online.]
businessmodels	Presence of business models adapted to the digital economy (Spotify, iTunes and Netflix). [The availability of legal content online, easily accessible for the public, reduces the DPR by offering an attractive legal alternative that is more secure than piracy.]
expendinvdev	Expenditure in investment and development as a % of the GDP. [The larger the expenditure is in a country's investment and development, the lower its DPR should be, by incentivizing innovative legal alternatives.]
pop65	Population 65 years of age or older, as % of the total population. [The larger the proportion of elderly persons is in a country, the lower its DPR will be, since this population group tends to use digital services less and it is the younger public that most tends to engage in digital piracy.]
pirateparty	Presence of the Pirate Party in the country. [The presence of the Pirate Party in a country could increase its DPR, since it advocates for more relaxed policies with regard to copyright.]
observance	Level of observance of copyright, measured through the component of protection of intellectual property ("intellectual property protection") from the World Competitiveness Index by the World Economic Forum. [The higher the level is of the observance of copyright in a country, the lower its DPR should be.]
IPchargesperinhab	Payments for the authorized use of products protected by intellectual property rights per inhabitant, in U.S. dollars. [The higher this figure is, the lower its DPR should be, as it is understood that consumers pay for the authorized use of protected content instead of resorting to piracy.]

Table 1. Definitions of variables

3.2. Correlations matrix

The previous variables are used to construct the database for this project. The main descriptive statistics are detailed in Table 2. The correlations matrix in Table 3 shows that the different variables do not exhibit any excessively liner correlation among them, with values below 0.7 and above -0.7, with a few exceptions. It is interesting to note the sign of the correlation for each of the legislative measures on copyright with the digital piracy rate. As expected, measures such as the exception for private copying ("privatecopying") or the legal copyleft provisions ("copyleft") reduce it. On the contrary, the measures correlated with the highest rates of digital piracy are the sweat of the brow doctrine and the secondary liability of Internet service providers ("secliabilityisp"). The former are considered more favorable for consumers, while the latter are more protective of authors. The correlation matrix also shows that legislation that is more favorable to copyright is positively

correlated with the DPR (the correlation between the variables "aggregate" and "DPR" is positive and reasonably strong, 0.6794).

Variable	Mean	Standard Deviation	Minimum	Maximum
DPR	39.167	16.815	16.000	78.000
sweatbrow	0.055556	0.23067	0.0000	1.0000
softlitwork	0.97222	0.16549	0.0000	1.0000
workfohire	0.16667	0.37529	0.0000	1.0000
collorphanworks	0.41667	0.49647	0.0000	1.0000
performdisplay	2.8056	0.46387	1.0000	3.0000
secliabilityisp	1.5556	0.60255	1.0000	3.0000
moralrights	2.7222	0.65482	1.0000	3.0000
compulsorylicenses	0.94444	0.23067	0.0000	1.0000
collectingagencies	2.6389	0.63480	1.0000	3.0000
privatecopying	2.6389	0.67773	0.0000	3.0000
fairuse	2.4722	0.73105	0.0000	3.0000
firstsale	0.97222	0.16549	0.0000	1.0000
remedies	2.8611	0.48369	1.0000	3.0000
copyleft	0.13889	0.34826	0.0000	1.0000
aggregate	0.41583	0.21486	0.0000	0.70000
gdppercap	32975	23504.8	4532.9	1.1070e+005
gini	32.422	5.1264	24.900	53.500
unemployment	9.1482	5.1814	2.8000	27.300
internetusers	77.393	13.156	45.800	97.800
businessmodels	2.3889	0.97223	0.0000	3.0000
expendinvdev	1.6003	0.95788	0.15000	3.5500
pop65	17.239	3.6734	6.1600	27.109
pirateparty	0.87500	0.33304	0.0000	1.0000
observance	4.7854	0.98121	2.9000	6.5000
IPchargesperinhab	815.90	2576.2	0.0000	15738.2

Table 2. Descriptive statistics

workforhire	collorphan	performdispla	secliabilityisp	moralrights	compulsorylicense	collectingag	privatecopying	fairuse	firstsale	
-0.433	-0.577	-0.2468	0.4078	-0.0239	-0.3389	-0.3585	-0.6336	-0.6309	-0.3729	DPR
-0.1085	-0.205	-0.6874	-0.0225	-0.4559	-0.4706	-0.4382	-0.7708	-0.6589	-0.6969	sweatbrow
0.0756	0.1429	0.2956	-0.1256	0.4477	-0.041	0.4395	0.6628	0.5756	1	softlitwork
1	0.378	-0.2966	-0.1661	-0.6113	0.1085	0.2562	0.1292	0.2225	0.0756	workforhire
	1	-0.1325	-0.2197	-0.0722	0.205	0.4841	0.286	0.2264	0.1429	collorphanworks
		1	0.0896	0.6543	0.4241	0.1408	0.4903	0.3576	0.2956	performdisplay
			1	0.1824	0.0225	0.0164	-0.1916	-0.0924	-0.1256	secliabilityisp
				1	0.0829	0.0941	0.4055	0.1602	0.4477	moralrights
					1	0.2458	0.4104	0.3248	-0.041	compulsorylicenses
						1	0.4783	0.494	0.4395	collectingagencies
							1	0.5765	0.6628	privatecopying
								1	0.5756	fairuse
									1	firstsale

gdppercap	gini	unemployment	internetusers	businessmodels	expendinvdev	pop65	pirateparty	observance	IPchargesperinha	
-0.7691	0.2383	0.533	-0.8433	-0.6984	-0.7194	-0.3638	-0.3659	-0.8481	-0.2358	DPR
-0.2801	-0.1129	0.3421	-0.2303	-0.6001	-0.3367	-0.287	-0.275	-0.2358	-0.2358	sweatbrow
0.1849	0.0401	-0.2887	0.1726	0.4182	0.2115	0.1587	-0.0639	0.2013	0.0534	softlitwork
0.2939	0.1731	-0.2687	0.3203	0.2059	0.342	0.1081	0.0563	0.4488	0.2607	workforhire
0.4481	0.0963	-0.4594	0.4574	0.3015	0.6901	0.0415	-0.1065	0.6343	-0.1568	collorphanworks
0.1582	-0.3021	-0.1389	0.1039	0.295	0.2603	0.4468	0.4786	0.1595	0.1187	performdisplay
-0.413	0.4026	0.428	-0.3997	-0.1336	-0.3326	-0.0081	0.0702	-0.3401	-0.2657	secliabilityisp
-0.1112	-0.1483	-0.0846	-0.0761	0.1278	0.0688	0.3265	0.0969	-0.1217	-0.3138	moralrights
0.2381	0.0183	-0.1529	0.0985	0.2861	0.3141	0.1079	0.275	0.2951	0.0759	compulsorylicenses
0.1086	0.0129	-0.1036	0.1224	0.322	0.4481	0.0903	0.1832	0.2698	-0.1734	collectingagencies
0.387	-0.0674	-0.4015	0.3753	0.5795	0.4004	0.2673	0.2964	0.4429	0.1393	privatecopying
0.5037	-0.1801	-0.3377	0.4389	0.5505	0.3906	0.1714	0.188	0.5161	0.2135	fairuse
0.1849	0.0401	-0.2887	0.1726	0.4182	0.2115	0.1587	-0.0639	0.2013	0.0534	firstsale
0.3294	0.0675	-0.3306	0.3044	0.5657	0.3755	0.2294	0.2404	0.4313	0.091	remedies
0.4677	-0.3878	-0.2176	0.5127	0.2542	0.4465	0.1461	0.1518	0.4223	-0.0204	copyleft
-0.6856	0.208	0.4528	-0.6611	-0.4371	-0.5604	-0.0332	-0.0271	-0.6728	-0.1357	aggregate
1	-0.2326	-0.3579	0.7492	0.5044	0.5178	0.1169	0.2928	0.7816	0.5067	gdppercap
	1	0.1386	-0.3865	0.0811	-0.3149	-0.3452	-0.3662	-0.2156	-0.0408	gini
		1	-0.4453	-0.3848	-0.4419	-0.1154	0.0555	-0.5297	-0.1014	unemployment
			1	0.5986	0.5958	0.3501	0.3555	0.5986	0.5958	internetusers
				1	0.3119	0.3082	0.3262	0.8256	0.236	businessmodels
					1	0.4418	0.2951	0.5789	0.1831	expendinvdev
						1	0.512	0.7067	-0.042	pop65
							1	0.3023	-0.2221	pirateparty
								1	0.3323	observance
									1	IPchargesperinhab

Table 3. Correlations matrix

4. Econometric methodology

The aim of this work is to identify the relationship between laws concerning copyright and the digital piracy rate in EU countries. Therefore, our main interest in the econometric analysis lies in estimating the effect of the "aggregate" variable on the "DPR", to verify whether the hypothesis is upheld that those countries that are most protective of copyright show higher digital piracy rates. Likewise, it is interesting to estimate the incidence that the new business models have on the digital piracy rate, to verify the opinion stated in Section 2.3, according to which the presence in a country of business models adapted to the digital economy reduces digital piracy. Both economic and demographic variables are included to reduce the bias of omitted variables. In response to this objective, the proposed econometric analysis consists of the following: first, an OLS model is estimated for the year 2013 and is compared to the results obtained by Terra (2016); next, the same process is carried out for an estimation with 2017 data; and finally, a model is estimated with panel data for the reference period.

4.1. OLS 2013 and OLS 2017 Models

The OLS model for 2013 is proposed to compare it to the results obtained by Terra (2016). This author uses a sample of 108 countries belonging to WIPO, while the present work considerably reduces the sample size. The intent is to verify whether the results are maintained for a sample of n = 36 observations (the 27 countries in the EU and nine additional countries: the United Kingdom, Norway, Albania, Montenegro, the United States,

Canada, China, Japan and Colombia). Next, an OLS model is presented for 2017 to examine how the results vary, as a generalized decrease in the DPR is observed for all countries. The estimated models are two multiple linear regression models according to this formula (Equation 1):

$$DPR_i = \beta_0 + \beta_1 aggregate_i + \beta_2 gdppercap_i + \beta_3 gini_i + \beta_4 unemployment_i + \beta_5 internetusers_i + \beta_6 businessmodels_i + \beta_7 expendinvdes_i + \beta_8 pop65_i + \beta_9 pirateparty_i + \beta_{10} observance_i + \beta_{11} IPchargesperinhab_i + u_i \quad i = 1, \ldots, 36 \tag{1}$$

where i = number that identifies each country, u_i = error term and the variables are those defined in Table 2, according to the OLS assumptions. For both models, a White test (White, 1980) is performed to test for homoscedasticity or, expressed another way, to detect problems with heteroscedasticity. The null hypothesis in this comparison is that homoscedasticity exists and the alternative hypothesis is that heteroscedasticity exists:

$$H_0: \sigma_i^2 = \sigma^2, \ i \qquad H_1: \sigma_i^2 \neq \sigma^2 \tag{2}$$

To analyze the multicollinearity among the regressors, the Variance Inflation Factor (VIF) indicator is used. It is defined as:

$$VIF_j = \frac{1}{1-R_j^2} \tag{3}$$

Where R^2_j is the coefficient of determination of the j-th regressor over the remainder. The minimum value is 1 and value greater than 10 may indicate a problem of multicollinearity (Belsley, Kuh, & Welsch, 1980).

4.2. Panel Data Model. Hausman Test.

After a thorough collection of data for the countries and years mentioned above, a panel was formed. This gives us a total of 72 observations, n = 72. For future research, an important limitation should be noted here: although the time period is four years, there is no data available in between, so for the econometric software used, Gretl, the step will be one period. Panel data models provide a greater capacity for estimation when the variables show little variation over time, but great cross-sectional variability. The same units are followed over time, so by studying changes in the dependent variable, it is possible to eliminate the omitted variable bias that occurs in multiple regression caused by not including in the regression certain variables for which data is not available, those that differ between individuals, but are constant over time. These cases of omitted variables would give inconsistent OLS estimates with cross-sections (Stock & Watson, 2012). This is the main advantage of regressions with panel data. We want to estimate the effect of copyright regulations and business models on the rate of digital piracy, controlling for the variables of GDP per capita and research and development expenditure. The estimated econometric model will be as follows (Equation 4):

$$y_{it} = \beta_0 + \beta_k x_{kit} + \delta_0 d17_t + a_i + u_{it} \quad i = 1, \ldots, 36; \ t = 2013, 2017 \tag{4}$$

where i = number identifying each country (individual entity that is being observed), u_i= error term and the variable a_i capturing unobserved factors that affect y_{it} and that remain constant over time. The regressor y_{it} refers to the digital piracy rate of the i-th country in the year t, while x_{it} denotes the k-th regressor of the i-th country in the year t. The variable *d17* is the time dummy (the same for all individuals), a binary variable that takes on a value of zero when t = 2013 and a value of one when t = 2017. The previous model can also be represented in this manner (Equation 5):

$$y_{it} = \beta_0 + \beta_k x_{kit} + \delta_0 d2017_t + v_{it} \tag{5}$$

where $v_{it} = a_i + u_{it}$ represents the composite error term, which has a fixed and a time-varying component. When choosing the estimation method, several things must be taken into consideration. As indicated, the variable a_i represents the unobserved and invariable heterogeneity, thus the OLS estimation will be biased and inconsistent unless X_{it} is correlated with v_{it}. Otherwise, what is referred to as heterogeneity bias will occur. In order to estimate the individual heterogeneity model indicated in Equation 1, a random effects regression will be used which, using the Generalized Least Squares (GLS) method, yields asymptotically efficient estimators. However, a model is first estimated using pooled OLS to compare the results. The Breusch-Pagan test will rule out this model. It is interesting to study the effect of a variable that varies minimally over the period of reference, the "aggregate" variable, in order to analyze the effect of legislative measures on copyright in the DPR of the countries.

The fixed effects (or intra-group) estimator cannot be used because, as with the first differences estimator, explanatory variables that are constant over time disappear (if T=2, both estimators are equal, but for more than two periods, the intra-group estimator is usually more efficient than the first differences estimator, although both are consistent). This is another advantage of random effects models: they allow the estimation of the contribution of variables that do not change over time. The fixed effects estimator allows estimation of a model under less restrictive assumptions, but is less efficient than the random effects estimator (Kanwar & Evenson, 2003; Taylor, 1980). While both are consistent, using random effects provides greater efficiency (less standard error). For this reason, we chose to estimate a random effects model (an option that is also supported by the Hausman test). In addition to the model in Equation 4, a basic assumption should be added: that the unobserved heterogeneity (a_i) is uncorrelated with the independent variables, which is what is tested in Hausman. If the null hypothesis is not rejected (H_0: the assumptions of the random effects model are correct), then the random effects estimator will be more efficient than the fixed effects estimator, even if both are consistent. The contrast statistic measures the difference of both estimators; if it were statistically significant, the null hypothesis would be rejected, since there is evidence against the random effects model.

5. Econometric results

5.1. OLS Models

The results of the models estimated by OLS are shown in Table 4.

After estimating the equation using *Gretl*, a White test of heteroscedasticity is conducted, which fails to detect this (p-values of 0.454858 in 2013 and 0.296243 and 0.930960 in 2017), and thus it is not necessary to estimate the covariance matrix of the coefficients by means of the White robust estimator (White, 1980) in any of the cases, since these results suggest that the estimates are efficient. The first column in Table 4 contains the explanatory variables, followed by the F contrast of joint significance (the null hypothesis of which is that all the coefficients of the slopes are zero; this is rejected in all three cases, because the p-value is very small, from which the joint significance of the model and the contribution of at least one variable in the explanation of the DPR is derived), the adjusted R^2 (the adjusted R^2 is shown and not the R^2, because of the advantages of the former, which among others include that it does not necessarily increase when a new regressor is added (Stock and Watson; 2012)), the Schwarz criterion, the p-value of the White test and the maximum variance inflation factor (VIF). In models (1) and (2), this value is quite high (9.145 and 6.815, respectively), however, if it is less than 10, it will not have a significant influence on the efficiency and stability of the parameters (Belsley, Kuh, & Welsch, 1980), but a certain multi-collinearity would exist. In the model (3) the VIF value decreases to 2,062, suggesting a reduction in the multicollinearity and greater robustness in the estimation of the coefficients. The sample size (n = 36) is indicated at the end of the Table. Even though this sample size is adequate to carry out the proposed econometric analysis, since it is relatively small, it could have an influence on the statistical robustness of the results, since a small sample size increases the sensitivity of the model to possible atypical values or specific variations within the sample.

With regard to the OLS model with 2013 data, the results obtained by Terra (2016) in his work were not replicated with regard to the "aggregate" variable coefficient, the effect of which is especially interesting to measure. Here, the results obtained indicate that it is not significant, and it also shows the opposite sign to that which is expected. The same thing occurs with the control variable "observance". The rest of the variables, with

the exception of "unemployment", "gini" and "pop65" were also significant in his analysis. In the model proposed by Terra (2016), the variable "unemployment" presented the opposite sign to that expected and was not significant; however, in the model proposed here, the correct sign is obtained and it is significant at 5%. The Gini index, on the other hand, presents the same sign as in Terra's work (2016), which is negative, while it would be expected to be positive. The differences with regard to Terra's estimate (2016) could be due in part to the sample size, since his results were for 108 countries, while here they are for 36.

Dependent variable:	2013 (1) DPR	2017 (2) DPR	2017 (3) DPR
const	122.711*** (16.7244)	85.8658*** (18.7765)	70.4791*** (4.64099)
aggregate	-3.52206 (10.0899)	0.723327 (5.85051)	10.0023* (5.46658)
gdppercap	-0.000109301 (0.000116671)	-0.00014516* (7.52505e-05)	-0.000259756*** (3.55784e-05)
gini	-0.706466** (0.325939)	0.225825* (0.266046)	
unemployment	0.632236** (0.281737)	0.510479 (0.336436)	
internetusers	-0.760551*** (0.21128)	-0.319606 (0.178983)	
businessmodels	-3.00041** (2.01184)	-6.00979*** (2.13582)	-6.75839*** (1.15978)
expendinvdev	-5.19677 (2.33931)	-5.25897** (2.01121)	-6.73998*** (0.998767)
pobl65	-0.0897829 (0.570976)	0.164871 (0.467182)	
pirateparty	-9.859 (7.00483)	1.60547 (3.91427)	
observance	4.81224 (3.40557)	-1.88626 (2.43247)	
IPchargesperinhab	-0.000707117 (0.000818284)	5.56445e-06 (0.00024127)	
F (joint signif. coeffs.) (p-value)	19.62946 (2.36e-08)	49.05057 (1.01e-13)	86.45671 (2.34e-16)
Adjusted R2	0.868602	0.892086	0.863210
Schwarz criterion	236.6712	252.5516	245.2166
White test (p-value)	0.454858	0.296243	0.930960
Max.VIF	9.145	6.815	2.062
n	36	36	36

Notes: standard deviation in parentheses. *significant at 10%, **significant at 5% and ***significant at 1%.

Table 4. OLS 2013 and OLS 2017; DPR determinants

The third and fourth columns show the results for the year 2017, which corresponds to models (2) and (3). The change is from a general model to a more specific one, eliminating the variables that have the opposite sign and those that are not significant; the "gini" variable was eliminated, as its effect on the DPR is unclear. Model (3) shows that the "aggregate" variable is positive and significant at 10%, which suggests that the legislative measures that are more protective of copyright increase the digital piracy rate. One possible interpretation of this finding is that in countries with stricter regulations, where access to protected content is very difficult, the opposite effect actually occurs, encouraging consumers to use illegal means of access to works protected by copyright. On the other hand, business models adapted to the digital economy have a strongly negative influence

of the DPR (the "businessmodel" variable is significant at 1%). This result backs the hypothesis that the existence of new models for accessing protected content, such as Spotify for music or Netflix for audiovisual works, offer legal alternatives (always with the consent of the authors of the works, as well as a contract with their consumers) that are affordable and more secure than the pirated options. As a result, consumers find it less attractive to resort to illegal means and the DPR decreases. These conclusions provide evidence backing the hypothesis presented in this work. Variables referring to the GDP per capita and the expenditure on investment and development are also significant at 1% and show a negative sign. This indicates that the richest countries have lower digital piracy rates and the larger the investment is in R&D, the lower the DPR will be.

Following the criterion used by Schwarz to select the most appropriate model to estimate the DPR, model 3 is the preferred model, as it minimizes the Schwarz criterion. The adjusted R^2 is higher in model 2, but it is not a completely reliable measure due to the limitations this estimator has (Stock & Watson, 2012: pages 166-167). Therefore, model 3, in the fourth column, is the best specification and the best way to estimate the DPR of a country, and thus this will be the "base model", which will also be estimated using the panel data.

5.2. Random Effects Model

Table 5 shows the results of the estimation by the panel data. The independent variables are shown in the first column, followed by the selected statistics and the sample size. Here we have 72 observations, referring to the countries in the sample for both time periods.

Dependent variable:	Combined OLS (4) DPR	Random effects (GLS) (5) DPR
const	71.4241*** (4.59218)	43.1623*** (6.37324)
aggregate	5.4111 (5.53727)	28.8322*** (8.93827)
gdppercap	-0.000233749*** (5.14108e-05)	-0.000168379*** (6.38389e-05)
businessmodels	-6.56361*** (1.04152)	-1.40582* (0.816825)
expendinvdev	-6.90423*** (1.04938)	-3.57554*** (1.27482)
d17	-0.141803 (1.71977)	-2.70463*** (0.713948)
F (regressor set contrast) (p-value)	72.86036 (1.60e-25)	114.597 (4.36894e-023)
Schwarz criterion	500.4035	541.6153
Breusch-Pagan contrast (p-value)		16.129 (5.91707e-005)
n	72	72

Notes: standard deviation in parentheses. *significant at 10% and ***significant at 1%.

Table 5. Panel data models

The second column shows the results of the model estimated by combined OLS. It is observed that the coefficient for the "aggregate" variable, while presenting the correct sign, is not significant. This may be because the estimation is biased (unobserved heterogeneity bias). For this reason, it is estimated according to random effects. Using the GLS method, asymptotically efficient estimators are obtained. In addition, the Breusch-Pagan contrast leads us to reject the null hypothesis that this is a combined OLS model.

The results of model (5), estimate by random effects, reinforce the conclusion reached in model (3). Especially noteworthy is the strong, significant effect presented by the "aggregate" variable in this model. This indicates that, indeed, legislative measures that are more protective of copyright increase the rate of digital piracy. The

other effect that was particularly interesting to measure was that of the business models adapted to the digital era. It can be said that the presence of new legal alternatives adapted to the digital economy considerably reduce the DPR. The "businessmodel" variable is the only one whose coefficient is not statistically significant at 1%, rather at 10%. The GDP per capita also has a significant negative effect on the DPR, so this analysis corroborates what development the theories predict (Karaganis, 2011; Burke, 1996), showing empirically that the richer a country is in terms of GDP per capita (*i.e.*, the greater its level of economic development), the lower its digital piracy rate will be. Likewise, it is observed that the expenditure on investment and development is also inversely related to the DRP. Finally, the variable "d17", the time dummy, captures the mean difference in the DPR between 2017 and the base year (2013), holding everything else constant. It is also significant and negative, which indicates that, on average, the DPR decreased by 2.7 percentage points.

6. Conclusions

From the study of digital piracy and the copyright protection system in the EU from a legal perspective, it is concluded that the traditional legislative model in the area of copyright, guided by the principle of territoriality, has become obsolete. The problem of digital piracy, which is complex because it is continually changing as the technologies evolve, is complicated by fragmentation within the EU itself, where the member states do not deal with this matter in the same way. This highlights the need to adapt the legal framework of copyright to the digital era in a harmonized fashion. A trend exists in national legislation to reinforce the protection of intellectual property rights, but these efforts are not being compensated with a noticeable reduction in digital piracy. The challenge is to find an efficient regulation of copyright that protects the creations, adequately compensating this activity and incentivizing the creation process, which leads to greater cultural and economic development of the country. However, this protection must not be so strong that it restricts access to online cultural content or incites Internet users to resort to illegal means to access them.

From an economic perspective, it has been empirically shown that there is a relationship between digital piracy and copyright regulations: those countries with the highest digital piracy rates are those which are more restrictive in terms of copyright, in other words, with greater protection for intellectual property. The most positive results in terms of reducing the digital piracy rate come from adapting the business models to the "information economy". From an economic perspective, achieving a digital piracy rate equal to zero is neither possible nor desirable. Even if it were possible, it would not be recommendable due to the irrecoverable loss of efficiency that would occur.

However, it is necessary to indicate certain limitations to this study and research challenges. With regards to the former, and with an eye on future research, it is necessary to take into account the limitation related to the small sample size, as more precise estimates would have been achieved with a larger sample. This fact, together with the composition of the sample, which consisted of countries in the EU and a few additional countries, restricts the capacity to extrapolate the findings to other contexts or regions with different legal, cultural or socioeconomic characteristics. Likewise, the effect of the Gini Index on the DRP is unclear, because the sign of the variable changes between models. For this reason, it would be beneficial to study this in further research to clarify its relationship with digital piracy. On the other hand, the lack of official data on digital piracy could limit the accuracy of the analysis, knowing that the estimates on digital piracy are usually calculated by those companies that are directly affected. We must be aware that the influence of this bias cannot be completely eliminated and that its implications must be considered when evaluating the results. Furthermore, the latest available edition of the BSA Global Software Survey is from 2018. After this date, there are two different acts that could potentially affect the DPR, namely the CDSM Directive and the AI ACT, the influence of which is worth studying in future works.

With regard to research challenges, it should be said that the relationship between digital piracy and copyright has not been studied to any great extent, with the focus of most works being on the relationship between digital piracy and sales. Copyright pose great difficulties for research, since as there is no mandatory register, it is difficult to obtain accurate data on the number of these works that are created and protected, not to mention the fact that nowadays, content is continuously created on the Internet. In spite of this, this work has attempted to determine the relationship that exists between digital piracy and copyright to better understand why the attempts

made by countries to reduce their digital piracy rate are not providing the expected results. The following joint conclusion can be drawn from both the proposed legal and econometric analyses: the tendency to increase intellectual property protection does not contribute to improving the situation; quite the contrary, the proposed models demonstrate the existence of a direct, positive relationship between the strengthening of copyright and the increase in digital piracy.

The civil and criminal systems have failed in the fight against digital piracy and administrative procedures pose a threat to rights and liberties. For this reason, the economic and legislative policy recommendations that are proposed target investment in the development of new business models adapted to the digital economy, offering users legal alternatives, and the education of the younger generations, who have been born into an economy of copying or "everything is free". An important conclusion that can be drawn from the legal discussion and which is supported by the econometric results is precisely that the presence of business models adapted to the digital economy, in other words, those adapted to the needs of the Information Society, reduces the rate of digital piracy. The reasoning, while not shared by many, is simple: models like Spotify and Netflix represent legal sources of access to protected content under the same conditions that are sought when resorting to piracy. Namely, they offer fast, convenient and affordable alternatives for their users. If to this we add that these legal models pose no security problems or risks of any kind for consumers, there is no incentive to resort to digital piracy. Any legal framework that is developed must ensure the balance of rights that seeks to ensure respect for copyright as well as promoting user access to cultural assets.

Furthermore, the incidence of AI in the world of intellectual property remains a subject of concern, as it is transforming the panorama of digital piracy and the protection of intellectual property. The risks posed by AI in general and by generative AI in particular in this sense must be correctly identified and analyzed, having merely been mentioned in this article. AI can affect the digital piracy rate, but it remains to be seen what its role will be in reducing or increasing the DPR. Its ambivalent nature has already been noted, but it must also be kept in mind that these technologies may result in errors, such as the deletion of legitimate content, which directly affects fundamental rights. In this sense, with regard to the implementation of AI in the protection of copyright, it is recommended to investigate the use of systems that combine the algorithmic monitoring with human review to minimize errors and ensure balance. AI could be used by authorities and companies to identify and fight against digital piracy by identifying and automatically eliminating illegal content, monitoring networks and performing the real-time tracking of copyright violations. Fields such as machine learning could significantly improve the detection of violations and optimize resources destined to protect content. However, it also poses new challenges in terms of ethics, privacy and legality that must be analyzed. The recent regulation of AI in the EU represents an important step in this direction.

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