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Transformations of the tort system in the digital age: a reading of the problematic basis of compensation and the need to harmonize legislation and judicial precedent

تحولات نظام المسؤولية التقصيرية في العصر الرقمي: قراءة في إشكالية أساس التعويض وضرورة ملاءمة التشريع والاجتهاد القضائي

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Abstract:

This research addresses the problem of the relationship between law and artificial intelligence. Despite the remarkable development in intelligent systems and the lack of a unified and comprehensive definition of artificial intelligence, traditional rules of tort liability appear insufficient to accommodate the transformations brought about by the digital revolution. This is particularly evident in the difficulty of establishing a clear causal link between the risks of intelligent systems and the resulting damages, as well as the instability in applying vicarious liability in cases of improper or risky use of such systems. The study emphasizes the need to activate judicial interpretation to fill the legal gap and to develop legal texts in line with digital transformation. It also aims to determine the legal nature of intelligent systems, their possible legal personality, and their civil liability, in addition to identifying the legal basis for compensation. It concludes that modern and flexible liability rules are necessary to ensure fair and effective compensation.

key words: *Tort Liability; Artificial Intelligence; Intelligent Robots; Digital Transformation; Compensation; Insurance.*

الملخص :

يتناول هذا البحث إشكالية العلاقة بين القانون والذكاء الاصطناعي، حيث إنه بعيدًا عن التطور الهائل في مجال الأنظمة الذكية وعدم الاستقرار على مفهوم موحد وشامل له، يبرز قصور القواعد التقليدية للمسؤولية التقصيرية عن استيعاب التحولات التي أفرزتها الثورة الرقمية، ويتجلى ذلك في صعوبة إثبات علاقة السببية بين مخاطر الأنظمة الذكية والأضرار الناتجة عنها، وعدم استقرار تطبيق مسؤولية المتبوع عن عمل تابعه في حالات الاستخدام الخاطئ أو الخطير. كما يؤكد البحث على ضرورة تفعيل الاجتهاد القضائي لسد الفراغ القانوني، وتطوير النصوص القانونية بما يواكب التحول الرقمي. ويهدف إلى تحديد الطبيعة القانونية للأنظمة الذكية ومدى تمتعها بالشخصية القانونية وإمكانية مساءلتها مدنيًا، وتحديد الأساس القانوني للتعويض عن الأضرار الناشئة عنها. ويخلص إلى ضرورة استحداث قواعد حديثة ومرنة للمسؤولية التقصيرية تواكب واقع العصر الرقمي وتضمن تعويضًا عادلا وفعالا.

الكلمات المفتاحية: المسؤولية التقصيرية؛ الذكاء الاصطناعي؛ الروبوتات الذكية؛ التحول الرقمي؛ التعويض؛ التأمين.

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Introduction:

Rapid technological advancement, the information revolution, and digital transformation have deeply integrated machines, robots, and smart applications into daily life, replacing traditional human or mechanical tools. Autonomous systems now perform human functions with high efficiency, creating a "digital global village". However, this integration also brings significant risks and harms that traditional civil liability rules cannot adequately address, as establishing legal relationships and proving causal links between damage and AI systems is often difficult or impossible.

Significance of the Study:

This study is significant because digital transformation and information technology increasingly influence legal and economic domains, making intelligent systems indispensable. It emphasizes the need to assess their intelligence, autonomy, and human control, especially regarding risks from misuse. Traditional liability systems have not fully adapted, highlighting the potential need for objective liability rules even without direct human fault.

Objectives of the Study:

- To propose a non-traditional framework for addressing liability arising from artificial intelligence activities.
- To develop a new approach grounded in a deeper understanding of the nature, evolution, and pervasive influence of artificial intelligence in legal and economic life (including economic intelligence).
- To determine the nature of liability arising from risks and damages caused by intelligent systems, and to identify an appropriate compensation regime for such harms.

Research Problem:

The research problem may be formulated as follows: What is artificial intelligence and what is its impact on legal and economic life? Is there a need to develop legal systems to keep pace with digital transformation? Are existing liability rules sufficient, or should new ones be introduced to clarify responsibility among multiple actors? And is it reasonable to grant artificial intelligence legal personality given its increasing autonomy?

Methodology:

To achieve the study's objectives, the research adopts descriptive, analytical, and comparative approaches. It begins with a descriptive analysis of artificial intelligence, including its characteristics and types. This is followed by an analytical examination of its relationship with legal systems through the evaluation of existing laws and their shortcomings. Finally, a comparative approach is used to assess traditional and objective liability rules in order to determine the most suitable framework for addressing the challenges posed by artificial intelligence and digital transformation.

Section I:

Civil Liability Arising from the Unlawful Use of Artificial Intelligence Systems

The technological advancements witnessed by most countries have led to the emergence of artificial intelligence, which has, in turn, resulted in the replacement of human beings by robots in activities traditionally performed by humans. This transformation has given rise to a number of legal and ethical challenges. Among the most significant of these is the destabilization of the traditional framework of civil liability established under general legal rules, which has become a subject of considerable doctrinal and legal debate due to its inability to accommodate such developments within many legal systems.

A) Artificial Intelligence – A Theoretical and Conceptual Framework:

Despite the relatively recent emergence of the concept of artificial intelligence dating back to 1956 and its continuous expansion and development, there is still no universally agreed-upon or precise definition of this concept. This is primarily due to the lack of consensus regarding the nature and definition of human intelligence itself, as well as the diversity of perspectives through which artificial intelligence may be understood and characterized[1].

1 - The Concept of Artificial Intelligence:

Intelligence is generally defined as the ability to perceive, understand, and learn, while "artificial" refers to something created by humans rather than occurring naturally. Accordingly, artificial intelligence[2] can be understood as intelligence simulated by machines or computer systems. Despite differences in defining intelligence, there is broad agreement since the 1950s that artificial intelligence is a scientific and technological field focused on developing methods and techniques to create machines capable of simulating human intelligence, with various definitions based on technical and disciplinary perspectives. Among the most prominent are the following:

- **John McCarthy's definition**: Artificial intelligence is the science and engineering of creating intelligent machines, especially computer programs, capable of simulating human cognitive processes such as learning, problem-solving, and decision-making[3]. It includes technologies like machine learning, natural language processing, neural networks, and deep learning, which enable machines to perform tasks that typically require human intelligence and to improve their performance through data and interaction with human language[4].

- **Andreas Kaplan's definition**: Artificial intelligence refers to "the ability of a system to correctly interpret external data, learn from such data, and use that knowledge to achieve specific goals and tasks through flexible adaptation"[5].

- **The French National Consultative Ethics Committee definition**: Artificial intelligence is "a set of computer programs designed to perform tasks typically carried out by humans, often more efficiently, involving advanced cognitive processes such as

perceptual learning, memory organization, and critical reasoning, with a degree of autonomy"[6].

- **The European Group on Artificial Intelligence definition**: Artificial intelligence is "a collection of systems designed by humans that operate to achieve complex objectives in the physical or digital world by perceiving their environment, interpreting data through artificial cognition, reasoning based on this knowledge, and determining the best actions to reach predefined goals"[7].

Some experts define artificial intelligence as "a branch of computer science concerned with understanding and applying technologies that simulate human intelligence"[8]. It enables machines to perform tasks within the scope of human intelligence, including learning, logical reasoning, self-correction, and self-programming[9]. Thus, it is a field within computer science focused on developing systems capable of processes analogous to human thinking, such as inference, learning, and self-correction[10].

Artificial intelligence has become a major domain within computer science focused on designing technologies and systems that enable machines to perform tasks requiring human cognition. Its goal is to create models capable of learning, adapting, retrieving information, and making autonomous decisions. AI also transforms human interaction with the environment by automating complex tasks[11]. increasingly rivaling human intelligence and impacting sectors such as economic, commercial, educational, technological, medical, and administrative fields.

2 - Characteristics and Advantages of Artificial Intelligence:[12]

Artificial intelligence is distinguished by features and advantages that make it an effective tool across many domains. Intelligent systems and applications have become integral to daily life, including scientific, academic, administrative, legal, economic, technological, and security fields. Among these characteristics are the following:

1- A key feature of artificial intelligence is its ability to learn, gain experience, and make autonomous decisions without direct human supervision, allowing it to enhance performance, increase productivity, and respond quickly and flexibly to changing conditions[13].

2- Artificial intelligence uses knowledge representation, employing structured formats to capture facts, relationships, and rules in a knowledge base, providing the information needed to solve specific problems[14].

3- The ability to handle incomplete information, by generating appropriate solutions even when the available data is uncertain or incomplete[15].

4- The capacity to learn from past experiences, acquire knowledge, and establish rules governing its use, as well as the ability to apply such knowledge effectively.

5- Adaptability, allowing AI systems to adjust to different circumstances and modify their behavior accordingly[16].

6- The ability to support administrative decision-making by providing information based on analytical processing rather than merely executing predefined algorithms[17].

7- The use of intelligent reasoning to solve problems despite incomplete information[18].

8- The capacity for creative thinking, enabling AI systems to generate innovative ideas and solutions, execute tasks with high speed and accuracy, and interact with their environment through sensors and detection systems[19].

9- The ability to process large volumes of data, allowing artificial intelligence to analyze and manage big data efficiently[20].

10- Learnability is a core feature of artificial intelligence, enabling systems to learn from past experiences, improve performance by addressing previous errors, and generalize knowledge while ignoring irrelevant information[21].

11- Advanced knowledge representation[22], as AI programs unlike traditional statistical programs employ structured methods for representing information, including facts, relationships, and rules that collectively form a knowledge base used to address specific problems.

12- Reasoning capability is the ability of AI to infer possible solutions to a problem using available data and prior knowledge, particularly when traditional methods fail, by storing solutions and applying logical inference rules and strategies [23].

13- The adoption of a heuristic or exploratory approach [24], allows AI systems to tackle problems without a well-defined solution method, using flexible strategies that can be adjusted if initial attempts fail, unlike traditional programs that seek precise and fixed solutions.

14- The ability to operate under incomplete information [25], allows AI systems to generate viable solutions even when some data is missing, producing conclusions that, while potentially less precise, remain valid.

B) The Debate on Recognizing Legal Personality for Intelligent Systems and Machines:

Legal personality is the capacity to acquire rights and assume obligations, recognized for both natural and legal persons. For natural persons, it is tied to actual or presumed life, while for legal persons, it depends on the nature of their activities and the governing legal frameworks. Contemporary legal scholarship and civil legislation remain uncertain about granting legal personality to intelligent machines, robots, and smart systems. Given AI's significant autonomy and its ability to simulate or surpass human intelligence, sometimes exceeding the control humans have over animals, this issue has sparked a major doctrinal and judicial debate between proponents and opponents, which will be explored below.

1- The Approach Supporting the Recognition of Legal Personality for Artificial Intelligence and Intelligent Machines:

Proponents of recognizing legal personality for intelligent robots base their argument on the need to keep up with rapid technological and informational developments and to establish suitable legal rules to govern them[26].

Some contemporary legal doctrine and jurisprudence view intelligent systems and devices as a distinct category that goes beyond traditional machines but does not reach

human status. Legal personality is not limited to humans; it is granted based on the capacity to acquire rights and assume obligations, making it a form of legal recognition rather than a mere fiction[27].

This view is supported by practical and functional considerations, especially the increasing independence of artificial intelligence from human personality. It aligns with the historical development of legal thought, which treats legal personality as an abstract, specialized concept limited to the legal domain[28].

From this perspective, current civil law rules are insufficient for addressing the evolving role of intelligent robots. Granting them legal personality serves a functional purpose, namely enabling their accountability for actions that cause harm to others[29], requiring liability to be attributed to them in a personal capacity[30].

Moreover, the digital and industrial revolutions, along with growing societal reliance on advanced technological systems, have created a new legal reality requiring adaptation. Intelligent systems have gained autonomy with the ability to think, acquire knowledge, evaluate situations, understand relationships, and generate original ideas, capabilities that may eventually approximate or replicate human cognition.[31].

This raises important questions about who is responsible for compensating damages and whether artificial intelligence systems can be granted legal capacity to bear responsibility for material and moral harm. These considerations point to the need for a special functional legal personality tailored to the tasks assigned to them.

This issue is especially pressing because many legal systems, particularly in the Arab world, have failed to keep pace with rapid developments in artificial intelligence and digital technologies, and to classify them adequately within existing liability frameworks[32]. This highlights the need to reform the legal system to incorporate artificial intelligence and grant it legal personality, similar to legal persons, while considering scientific and economic factors[33].

Assuming that artificial intelligence systems increasingly display human-like characteristics, it may be appropriate to recognize them similarly before the law. Granting them legal capacity to acquire rights and bear obligations has moved beyond science fiction and is entering legal discourse, warranting serious examination, including its scope and conditions[34]. Proponents of this approach rely on the following arguments:

- The concept of “person” is not limited to natural persons. Legal personality is already granted to non-human legal entities, showing that it is an abstract notion. Thus, “person” and “human” should not be conflated[35]. Some scholars argue that legal personality goes beyond will and consciousness to include social value[36].

- Principles of justice require that an actor be accountable for the consequences of its actions. Given the high autonomy of artificial intelligence systems, it is fair that they bear legal responsibility as the true source of harm[37]. Holding a human liable for actions beyond their control would be unjust.

- Recognizing digital legal personality for artificial intelligence systems does not infringe on human rights, as the rights granted would be limited to what is necessary for performing their functions and protecting those who interact with them[38], without extending to the full rights enjoyed by humans.

- Practical and scientific realities necessitate granting legal personality to artificial intelligence systems[39], not for their own protection, but to protect society against their unlawful use.

2- The Approach Opposing the Recognition of Legal Personality for Artificial Intelligence and Intelligent Machines:

Another segment of legal doctrine and jurisprudence opposes granting legal personality to artificial intelligence systems, machines, and robots. They argue that AI only simulates human intelligence, making it a fundamentally virtual entity that cannot be equated with legal persons.

This position reflects the novelty of artificial intelligence systems in relation to traditional civil law, liability rules, and compensation framework[40]. While legal personality aims to identify the entity responsible for damages[41], existing laws are ill-equipped to classify and regulate such intelligent entities. This challenge is further complicated by ongoing doctrinal disagreement[42].

From a practical standpoint, granting legal personality to artificial intelligence faces significant legal and conceptual challenges. Opponents argue that AI lacks true independence from human control, remains subject to human direction(), and should therefore continue to be classified legally as "things"[43].

Current intelligent technologies, such as robots, have not yet achieved intelligence comparable to or exceeding human intelligence, especially in fully autonomous decision-making. Therefore, they cannot be granted legal personality, either in terms of holding rights or exercising capacity to act[44].

Additionally, granting legal personality to such systems is seen as unnecessary and impractical, conflicting with the fundamental philosophy of law and based on a mistaken attempt to remove intelligent robots from the category of objects[45].

Attributing legal personality to intelligent systems could assign them civil liability for their actions while absolving designers, manufacturers, owners, and operators of responsibility. This approach relies on scientifically questionable assumptions about their autonomy and may serve the interests of companies designing and programming these systems[46], Opponents of recognizing legal personality for artificial intelligence systems base their position on the following arguments[47]:

- The absence of genuine will and complete autonomy in artificial intelligence systems.

- The lack of necessity or practical utility in establishing an independent legal personality for such systems.

- The risk of allowing producers, operators, programmers, or users to evade liability.

- The difficulty of conceptualizing rights and obligations attributable to artificial intelligence.

- The challenge of establishing a clear causal link between damage caused by artificial intelligence and the fault attributed to it, given the difficulty of imputing such fault to a machine or system.

Section Two: Legal Foundations of Tort Liability Arising from the Use of Artificial Intelligence Systems

Rapid industrial and technological developments in the age of artificial intelligence have enabled control over machines such as robots, drones, autonomous vehicles, and smart weapons. While AI offers many benefits and convenience, it also poses risks, particularly when operating beyond human control. In such cases, compensating victims becomes necessary, but legally identifying the person responsible for damages caused by an intelligent system or machine remains a fundamental challenge.

A) The Relationship Between Tort Liability and Artificial Intelligence:

Tort liability from digital transactions is increasingly important for legislators, judges, and jurists due to the complex scientific and practical issues it raises. It is essential to assess whether established civil law tort liability rules can address digital transactions. This includes tort liability for personal acts of intelligent systems, as outlined in Article 124 of the Algerian Civil Code[48], as well as liability for the acts of others and of things.

1- Tort Liability for Defective Products:

The European legislator, through Directive No. 85-374[49] issued on 25/07/1985, introduced producer liability for defective products. The French legislator incorporated this strict liability into its Civil Code of 19/05/1998[50], holding producers responsible for harm caused by defects due to insufficient safety, regardless of fault or contractual relationship with the injured party[51].

The main feature of this liability is its objective nature: fault is irrelevant. The injured party only needs to prove the existence of a defect, meaning the product fails to meet safety standards. Article 1 of the European Directive confirms: "The producer shall be liable[52] for damage caused by defects in his products".

However, it is debated whether it is fair to hold producers, manufacturers, or designers liable for intelligent systems with advanced autonomous software, given their autonomy and intelligence. Some French jurists argue that this liability can apply to smart machines[53], as it aligns with modern digital and industrial technology. It also requires reconsidering exemptions; if the defect was absent at the time of marketing or use, the producer is exempt from liability[54].

Despite attempts to apply general product liability rules to damages caused by smart robots, this approach has faced criticism. Some French jurists argue that intelligent robots cannot easily be classified as products[55], making it difficult to adapt liability accordingly. Intelligent machines combine software, data, and external structures, interact

with their environment, and make independent decisions, placing them in a gray area beyond ordinary machines but below human capabilities[56].

Another group of jurists observes that AI applications and smart machines, though inherently dangerous, do not necessarily have design or manufacturing defects[57]. In other words, they may exceed required safety standards, yet their operation can still cause harm to others.

Thus, we can conclude that the legal system[58] bases this liability not on fault but on damage, imposing liability by law when harm results from a defect in the marketed product.

2- Tort Liability for the Acts of Others (Liability of a Principal for Acts of a Dependent):

The concept of tort liability for acts committed by others due to dependency, or for damages caused by factories, machines, and non-intelligent robots, dates back to the Industrial Revolution. Civil legislation established rules holding principals liable for the acts of dependents within the scope of their tasks. Over time, technology gradually replaced human dependents with machines and robots equipped with smart software simulating human behavior, relieving humans from tasks previously performed by workers or dependents.

AI was subsequently integrated into machines, enabling them to perform both mental and physical tasks previously done by humans, creating a genuine legal challenge to the rules of obligation theory[59]. Its rapid spread has led to a smart life dominated by generations of AI[60], paving the way for a future where the world lives in a "smart village."

Article 1242 of the French Civil Code, amended by Decree No. 131 of 2016[61], corresponding to Article 178 of the Egyptian Civil Code[62], states that a person is liable not only for damages from their own acts but also for damage caused by those under their responsibility or by things in their custody[63]. Since AI is not considered a legal person by some, certain jurists propose applying liability for the acts of others, as with helper robots. However, determining supervisory authority at the time of damage can be challenging.

French jurisprudence has sometimes applied rules of liability for the acts of others to AI, similar to holding a custodian responsible for neglecting inanimate objects in high-risk areas such as factories or mines. André Nadeau notes that custodianship can be transferred to a person entrusted by the owner to use or safeguard the object, who has the right to manage, supervise, and prevent damage[64]. Jean Pineau and Monique Ouellette affirm that custody can be transferred, and the owner is not necessarily the custodian; a borrower or lessee may serve as the custodian"[65].

French law distinguishes between legal custody and actual custody. Since the 1941 Franck case[66], jurisprudence has followed the theory of actual custody, where the custodian is the person with effective control over the object, including supervision, management, and direction[67]. n Egypt, jurists agree that actual custody determines liability for damage caused by things[68]. Thus, establishing custodian liability requires exercising authority over use, direction, and control.

Autonomous AI-based robots challenge traditional custodian liability, as their independence conflicts with the custodian's control[69], representing concealment rather than transfer of custody. French law distinguishes between "custody of composition" and "custody of use"[70], especially for complex objects like AI robots. The manufacturer holds custody of composition, having more knowledge of product functionality, while the consumer holds custody of use[71].

This distinction creates practical difficulties for injured parties in determining whether damage is due to an object's components or its use before filing a claim[72]. undermining the main benefit of liability for things: relieving the victim from investigating the cause. Generally, a custodian avoids liability only if damage results from a third-party event beyond their control, such as force majeure, which must be external, unforeseeable, unavoidable, and unavoidable in its consequences. Other third-party causes, like the fault of the injured or others, can also affect custodian liability[73].

A custodian may avoid liability for AI-induced damage if it results from a design defect or unforeseen events like lightning[74]. However, AI's independence, including its ability to learn, self-correct, and make autonomous decisions without owner commands, makes it difficult to control and often beyond custodian supervision. Therefore, the custodian may not be liable for damage caused by acts beyond their control.

Assigning custodian liability for AI damage would require bearing all errors from every stage of AI design, which is unrealistic. AI software is intangible, making it difficult to identify a responsible custodian[75].

Therefore, the current notion of custodian cannot apply to AI software. Applying custody to AI requires a precise modification of the concept. Modern legal situations created by smart technology call for moving from fault-based liability to a risk-based approach, allowing liability and compensation even when causal links between designer or manufacturer fault and victim harm are hard to prove[76].

This is known in modern civil jurisprudence as strict liability, requiring only a causal link between damage and the source activity, regardless of fault, even if the activity itself was lawful[77]. This has led modern jurists to two approaches:

1- Smart Agent Theory: Some jurists argue that agency rules can apply to AI-induced damage, with the smart robot acting as an agent for the principal, implicitly authorized through operational use[78]. If the robot causes damage due to a manufacturing defect, strict liability applies to the manufacturer, who may avoid liability by proving a third-party cause(), while AI system producers remain liable[79].

Natural persons have tangible existence, and legal persons are intangible entities recognized by law[80]. AI or smart robots cannot be considered agents, as human-based agency rules do not apply between manufacturer or operator and the robot. Since Arab and Western laws do not grant independent legal personality to robots, they cannot enter agency agreements. Therefore, a smart robot lacks the legal will to conclude an agency contract, making it impossible[81].

2- Human Proxy Theory: Due to technological advances in AI and difficulties in applying traditional tort rules, the European legislator, via the Civil Law for Robots of February 2017[82]. This theory recognizes robot autonomy, learning, and decision-making, treating robots as evolving mechanized entities with rudimentary human logic[83]. The person responsible for creating the robot acts as a proxy, not a custodian or guardian, to ensure liability for the robot's actions, since the robot itself cannot be held liable[84].

Some jurists liken this theory to insurance for AI against unspecified future victims, but it differs as insurance benefits the damage causer and requires a licensed company[85]. the proxy cannot be personally bound without a prior agreement with the victim[86]. European law does not grant robots full legal capacity, only a special legal status. The human proxy differs from legal representation, as the proxy acts by law, assuming responsibility for robot-caused damage and ensuring victim compensation[87].

B) Legal and Judicial Foundations of Compensation for Damages Arising from the Use of Artificial Intelligence Systems:

Compensation for damages caused by artificial intelligence follows the establishment of civil liability. Victims are entitled to compensation, but legal doctrine and jurisprudence differ on its basis, reflecting varying views on the nature and foundation of liability. This will be discussed in the following two subsections:

1- Judicial Compensation:

Judicial compensation is awarded by the courts to the injured party and is subject to judicial discretion. The principle is full compensation, meaning the amount should match the damage suffered. Various methods exist for calculating compensation, but the judge is guided by general principles from jurisprudence and doctrine. Damage is assessed at the time of judgment to ensure the fairest balance between harm and compensation[88].

The law grants individuals the right to seek judicial protection of their rights. A person harmed by artificial intelligence systems can bring a claim for compensation before the courts. Electronic liability is established through a judicial ruling by the competent authority, especially in cases involving harmful or improper use of digital systems and smart devices. Once the court verifies the elements of electronic civil liability, it awards compensation[89], in accordance with Article 124 of the Algerian Civil Code[90].

The method of compensation is determined by the judge based on the circumstances. It may be paid in installments or as a lump sum, with monetary compensation being the general rule. The injured party may request restitution in kind when possible, or the court may grant other forms of relief related to the unlawful act, in accordance with Article 132 of the Algerian Civil Code[91].

The traditional method of compensation may be inadequate for modern situations, especially damages caused by AI-powered robots, due to their complexity and the difficulty of assessing risks. This has led legislators in various jurisdictions to explore

new systems to ensure effective victim protection and enable adequate compensation without excessive burden or cost.

Judicial compensation generally takes two forms[92]:

- Restitution in kind, which seeks to eliminate the damage itself and restore the situation to its previous state;

- Compensation by equivalent, whereby the injured party is awarded compensation to redress and mitigate the harm suffered.

Compensation may be monetary or non-monetary and can cover material damages caused by AI-based robots, such as defects in operation due to the producer, changes in material or immaterial components, or inadequate maintenance, all of which can be financially assessed.

However, greater difficulty arises in relation to moral (non-material) damages[93], as such harm is not easily quantifiable in monetary terms. Despite arguments denying the possibility of compensating such damages, both legal doctrine and jurisprudence have recognized their compensability. Measures aimed at alleviating or mitigating such harm can be translated into monetary terms, and courts should, as a general rule, award financial compensation, as there is no legal impediment to compensating moral damages[94].

Although various methods exist for calculating compensation, none are binding on the judge, who retains discretion in selecting the appropriate method, provided that the general principles governing compensation, established in doctrine and jurisprudence, are respected[95].

2- Automatic Compensation:

Some legal systems have moved toward establishing alternative compensation mechanisms that serve as substitutes for judicial solutions, which may require considerable time, effort, and cost. Among these alternatives are insurance schemes and compensation funds[96].

Insurance pools risks to guarantee compensation when the insured event occurs, so entities operating AI systems often secure coverage for potential damages. Compensation funds provide a mechanism when no insurance exists or the liable party cannot be identified, acting as a form of social liability. They also ensure full reparation when insurance fails to fully compensate the injured party[97].

Compensation funds should be a last-resort mechanism, used only when insurance fails or AI system owners lack coverage[98]. Without mandatory insurance, such funds may be required to cover all damages caused by automated robots, risking financial insolvency due to the volume of claims[99].

Conclusion:

In conclusion, this study highlights the technological advancements achieved through artificial intelligence and smart technologies and their impact on human life, including potential damages and liabilities. Proving fault against machines, robots, smart

cars, intelligent applications, or drones is highly challenging due to the limitations of traditional liability frameworks and the independence of these devices from humans. Therefore, it is necessary to adopt new rules of civil and tort liability, moving away from fault-based concepts. Objective liability, whether based on presumed or established fault regarding the machine or device, provides a more suitable framework, with specific conditions and safeguards. The key findings of this study include:

First: The results

- Difficulty in formulating a comprehensive and legally sound definition of artificial intelligence, as current definitions remain primarily technical.

- Challenges in establishing the relationship between a smart machine or robot and its human operator, or between the device and its manufacturer, particularly given the high level of autonomy and self-control these systems possess.

- The impracticality of applying traditional liability rules for acts of others or liability for living and non-living objects to damages caused by smart machines and systems.

- The potential existence of hidden defects in smart systems or devices, necessitating updates to judicial interpretations and legal frameworks to determine the party responsible for the defect and resultant damage.

- Civil liability for harmful acts arising from AI systems can be grounded in risk-based and guarantee-based frameworks, including insurance mechanisms.

- Establishing liability for smart systems and AI devices may require granting them legal personality and independent financial status separate from humans.

- Civil liability for damages caused by AI systems should be based on objective liability principles, which revolve around three core elements: the act or incident (irrespective of fault or defect), the damage, and the causal link.

Second: suggestions

- Review civil liability rules to align them with the information and technological revolution.

- Adapt general principles in civil law and consumer protection laws to accommodate damages arising from AI technologies, providing temporary judicial protection until a new AI-specific liability framework is established.

- Reevaluate civil law provisions regarding tort liability, particularly Article 138, as society has replaced animals and similar entities with autonomous technological devices, making traditional rules outdated.

- Introduce strict objective liability, independent of fault or even damage, to cover harm caused by smart robots and AI programs.

- Address legislative limitations on vicarious liability, especially concerning smart systems whose operations cannot be confined to the fault of a subordinate during their assigned duties.

- Expand the interpretation of existing civil law texts to encompass emerging risks and technological damages, pending legislative updates to reflect new liability frameworks.

- Shift towards risk-based and guarantee-based liability principles, including mandatory insurance coverage for AI machines and robots to ensure full compensation for any resulting damages.

- Enable civil courts to utilize technical and scientific expertise and draw on judicial precedents from France and the United States, providing flexibility for judicial interpretation that may inform future legislative reforms.

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