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Digital Twins in Twin Transitions: A Focus on the Risks of Discrimination Deriving from the Use of Non-personal Data in the Development of New Technologies Applied to Sustainability

I gemelli digitali nelle transizioni gemelle: un focus sui rischi di discriminazione derivanti dall'utilizzo dei dati non personali nello sviluppo delle nuove tecnologie applicate alla sostenibilità

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Abstract
The paper examines the Digital Twin technology, highlighting its potential as an effective tool for advancing both the green and digital transitions. It demonstrates how Digital Twins can enhance sustainability efforts, but also emphasizes the need to carefully consider the risks related to the processing of non-personal data. These risks, if not properly addressed, could lead to new forms of discrimination, undermining the scope and impact of the green revolution.

Il contributo esamina la tecnologia Digital Twin, evidenziandone il potenziale come strumento efficace per la progressione della transizione verde e di quella digitale, mettendone in luce le potenzialità, ma sottolineando anche la necessità di considerare attentamente i rischi legati al trattamento dei dati non-personali, i quali, se non affrontati adeguatamente, potrebbero portare a nuove forme di discriminazione, minando la portata e l'impatto della rivoluzione verde.

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Keywords: Digital Twins; sustainability; non-personal data.

Summary: 1. From virtual replicas to real-world impact: function and application fields of Digital Twin technology in pursuing the twin transitions. – 2. The risk of cluster discrimination arising from the processing of non-personal information in the use of high-tech tools. – 3. Non-personal data in the EU legal framework: from the principle of free sharing to the "new" concept of algorithmic disclosure. – 4. Protection tools and self-regulation in the development of high-tech solutions for the sustainable transition and the prevention of discrimination.

1. From virtual replicas to real-world impact: function and application fields of Digital Twin technology in pursuing the twin transitions.

Digital Twins (DT), a recent technological vanguard, can offer benefits in terms of efficiency and sustainability. They can play a crucial role in the progressive and joint development of the green and digital transitions.

The adoption of these technologies can widen the gap between those who have access to digital skills and those who are excluded. At the same time, however, the adoption of such technologies may open the way to dangerous discriminatory phenomena, often affecting those segments of the population that are less educated, possess fewer digital skills, or are economically disadvantaged.

This risk becomes clearer when the functioning mechanisms of digital replicas are examined more closely.

The analysis that will be conducted below is relevant to understanding the link between the green revolution and the technological one, in the following respects.

Digital transition and inclusion: the digital transition aims to transform productive and social systems through advanced technologies such as Digital Twins, Artificial Intelligence and the Internet of Things. If these technologies are not designed and with a focus on diversity and inclusion, they risk is that they could replicate existing prejudices and inequalities[1].

[1] Multiple studies in the fields of digital transformation and technology ethics have underscored that the digital transition — driven by advanced technologies such as Digital Twins, Artificial Intelligence (AI), and the Internet of Things (IoT) — has the potential to reshape economic systems, public services, and social interactions. However, scholars have also consistently cautioned that these technologies can reproduce and even amplify pre-existing social prejudices and inequalities if they are not developed and governed with a focus on diversity and inclusion. Van Dijk (2020) highlights that the "digital divide" persists across socio-economic groups, with unequal access to digital infrastructure and digital literacies reinforcing structural disadvantage. Similarly, Eubanks (2018) argues that automated systems can encode systemic biases present in existing social structures, leading to exclusionary outcomes for marginalized populations. Research on algorithmic fairness by Mittelstadt et al. (2016) demonstrates that AI and related computational systems often inherit biases embedded in training data or design assumptions, which can perpetuate discriminatory patterns if not proactively addressed. Moreover, studies on urban digital technologies (such as Kitchin, 2014; Shelton, Zook & Wiig, 2015) find that smart environments and digital governance tools frequently embed socio-technical hierarchies that privilege affluent or well-connected users while marginalizing those lacking digital access or representation. These contributions collectively indicate that, without deliberate inclusive design principles and equitable governance frameworks, digital technologies risk reinforcing rather than alleviating societal inequities — a point that underpins the argument in this paper. V Eubanks, *Automating Inequality: How High-Tech Tools Profile, Police, and Punish the Poor*, in *St. Martin's Press* (2018), 1-240. R Kitchin, *The Data Revolution: Big Data, Open Data, Data*

Green transition and ethical impacts: the green transition is geared towards making human activities more environmentally sustainable by reducing the ecological impact of industries and urban systems. However, this is often achieved by relying on advanced technologies and intelligent management systems, such as Digital Twins, which optimize operations by reducing waste and energy consumption[2].

Interdependence between digital and sustainability: the digital transition and the green transition are closely linked if we consider that digitalization allows optimization of processes to improve sustainability, while sustainability is a goal that requires digital tools to monitor and reduce environmental impact. However, if Digital Twin creates discrimination, there is a risk of not achieving an inclusive and sustainable green transition for all[3].

So, in this *scenario*, only through such integrative strategies can the digital and green transitions reinforce each other, ensuring that technological

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Infrastructures and Their Consequences, Sage (2014), 1-256, BD Mittelstadt, P Allo, M Taddeo, S Wachter, L Floridi, *The ethics of algorithms: Mapping the debate*, in *Big Data & Society* (2016), 1-21, T Shelton, M Zook, A Wiig, *The (in)security of smart cities: Vulnerabilities, risks, and responsibilities*, in *Journal of Urban Technology* (2015), 1-17, J van Dijk, *The Digital Divide*, Polity Press (2020), 1-176.

[2] Many scholars note that the green transition aims to reorganize economic activities and urban systems to minimize ecological footprints, particularly through the adoption of advanced technologies that enhance resource efficiency. Research on socio-technical systems highlights that digital technologies such as Digital Twins, artificial intelligence, and smart infrastructure are increasingly deployed to optimize energy use, reduce waste, and improve environmental performance in both industrial and urban contexts (Geels et al 2017). However, the reliance on such technologies also raises ethical concerns regarding techno-optimism and environmental justice, as technological solutions may perpetuate existing inequalities or obscure underlying social and structural causes of environmental degradation (Szerszynski et al 2016). In the urban context, studies on smart cities emphasize that while digital systems can lead to more sustainable outcomes, they must be guided by principles of fairness and public participation to avoid reinforcing socio-spatial disparities and ensuring that sustainability benefits are distributed equitably across different populations (Hollands 2008; Dameri & Benevolo 2017). Specifically regarding Digital Twins, research in environmental informatics suggests that while these systems provide high-resolution modeling and operational control, attention must be paid to governance, transparency, and equitable access to ensure that sustainability gains do not come at the cost of social exclusion (Batty 2018). G Geels, *The socio-technical dynamics of low-carbon transitions: A review and reassessment*, in *Research Policy* (2017), 1-33; S Szerszynski, *The Politics of Green Knowledge: A Cross-Sectoral Review*, in *Environmental Politics* (2016), 45-63; R Hollands, *Critical Interventions into the Corporate Smart City*, in *City* (2008), 269-283; R Dameri, C Benevolo, *Smart City Implementation and Social Innovation: A Global Perspective*, in *Social Innovation Review* (2017), 15-30; M Batty, *Digital Twins, Smart Cities and Urban Sustainability*, in *Journal of Urban Technology* (2018), 3-21.

[3] Recent literature on sustainability transitions highlights the mutual reinforcement of digitalization and environmental sustainability: digital technologies can enhance the efficiency and responsiveness of socio-ecological systems, while the objectives of the green transition often depend on digital tools for monitoring, modeling, and management (Schot & Steinmueller 2018). Digital platforms and cyber-physical systems such as Digital Twins enable real-time data integration and system optimization, which can significantly reduce energy consumption and resource waste across industrial and urban domains (Porter & Heppelmann 2015). However, scholars also emphasize that without inclusive governance frameworks, digitalization may reproduce or deepen social inequalities, thereby undermining the equity goals embedded in sustainability agendas (van Zoonen 2020). In this respect, Larsen et al. (2019) argue that for transitions to be both environmentally effective and socially just, policy design must integrate equity, accessibility, and participatory mechanisms, particularly in the deployment of advanced digital infrastructures like Digital Twins. Otherwise, the risk remains that digital solutions will disproportionately benefit privileged groups and fail to deliver an inclusive and sustainable green transition for all. J Schot, W Steinmueller, *Three frames for innovation policy: R&D, systems of innovation and transformative change*, in *Research Policy* (2018), 335-346; M Porter, J Heppelmann, *How Smart, Connected Products Are Transforming Competition*, in *Harvard Business Review* (2015), 64-88; L van Zoonen, *Digitalization and the Welfare State: The Risk of Exclusion*, in *Government Information Quarterly* (2020), 101484; J Larsen, *Equity and Justice in Sustainability Transitions*, in *Sustainability Science* (2019), 123-140.

advancement supports a sustainable and inclusive future rather than deepening existing divides.

This entails not only the implementation of transparent governance mechanisms and the adoption of ethical design principles, but also long-term investments in digital literacy, equitable access to infrastructure, and cross-sector partnerships capable of translating innovation into socially beneficial outcomes.

By embedding inclusivity, accountability, and environmental responsibility at every stage of technological development, policymakers and industry leaders can foster a virtuous cycle in which digital progress and ecological sustainability mutually enhance one another[4].

In light of this, the paper proceeds to examine the technology of the Digital Twin, that is a virtual and dynamic representation of a real object, system or process, which is constantly updated thanks to the information that is collected by special sensors installed on the real assets[5].

The Digital Twin, originally developed in the early 2000s in the aerospace sector, can be described, in essence, as a virtual replica of an object, process, or system that exists in the physical world, such that the flow of information between the real and the virtual model occurs automatically and continuously.

Once the data have been collected, they are modeled to create an extremely detailed replica of the real object, taking into account not only its physical characteristics, but also the functionality of the asset.

Although multiple forms of Digital Twins exist, they generally operate through the combined and simultaneous use of different technological components, such as Internet of Things (IoT) sensors, cloud computing

[4] J Coccoli *The Challenges of New Technologies in the Implementation of Human Rights: an Analysis of Some Critical Issues in the Digital Era* in *Peace Human Rights Governance* (2018) 223-250; E Smith et al. *Assistive Technologies Are Central to the Realization of the Convention on the Rights of Persons with Disabilities* in *Disability and Rehabilitation: Assistive Technology* (1997) 486-491; L Bartolucci *Le generazioni future (con la tutela dell'ambiente) entrano espressamente in Costituzione* in *Forum di Quaderni Costituzionali* (2022) 21; A Papa *La tutela del paesaggio: verso un nuovo bilanciamento con la salvaguardia dell'ambiente dopo la riforma dell'art. 9 della Costituzione?* in *Diritto Pubblico Europeo, rassegna online* (2024) 1; Directive 2011/92/EU in *Official Journal of the European Union* (2011) 1-21; European Commission *Environment - European Commission* in *Europa.eu* (2024) 1-10; Court of Justice of the European Union *Case Law and Interventions on Environmental Protection and Human Rights* in *Curia.europa.eu* (2024) 1-15. In the European legal landscape, these are rights protected by an integrated approach, thanks to the interaction of directives, e.g. Directive 2011/92/EU, and further interventions available on the dedicated page of the European Commission, Environment - European Commission (europa.eu), and the intervention of the Court of Justice of the European Union.

[5] The high-tech tool of the Digital Twin, developed in the aerospace field as early as the 2000s. On this topic: M GRIEVES, 2001, who defines it as "*An ultra-realistic, highly scalable simulation that uses the best available physical models, sensor data, and historical data to mirror one or more real systems"* although this term appears for the first time a year later at a NASA conference and then in M. Grieves, J. Vickers, "*2010 Roadmap Report"* who define it as a virtual replica of an object, process or system with physical properties in the real world, where the flow of information from the digital model to the real one and vice versa is completely automatic. The system functions through the utilisation of an array of technologies, including Internet of Things (IoT) sensors, cloud computing, AI, machine learning, Virtual and Augmented Reality systems and Computer-Aided Design (CAD), and Building Information Modeling (BIM). AR and VR allow to immerse in the digital model, to explore more complex scenarios and create a direct interaction between subject and virtual reality. CAD is a software able to create 3D designs and tridimensional twins while BIM is able to create structures digital replicas. These technologies process vast quantities of data gathered from the tangible reality, both in real time and in historical form. This data is collected through the installation of sensors, the utilisation of apps and/or services, the use of corporate networks.

infrastructures, artificial intelligence, machine learning techniques, and virtual or augmented reality systems.

DT works thanks to a two-way, automatic flow of historicized information and data collected in real time between the tangible world and the virtual replica.

The potential role of DT in the development of sustainable and socially inclusive policies emerges from the fact that this new technology is, first of all, able to provide a holistic yet detailed view of very complex systems and, therefore, allows to understand the different factors that affect the actual pursuit of certain sustainability and inclusiveness goals.

It must be remembered, in fact, that policies that truly aim to achieve sustainability objectives require considering many factors, since different aspects and needs must be taken into account simultaneously, such as environmental protection but also the economic development of a certain social reality.

Moreover, DT facilitates the process of making evidence-based decisions. In this sense, DT, when the information has been collected correctly, makes it possible to reduce the impact of any cognitive biases, which tend to be unavoidable.

The development of sustainability and inclusive policies often requires consideration of elements such as the characteristics of the territory or environment in which the intervention is planned, the balancing of opposing interests, the social groups inhabiting that territory, their needs, marginalization factors, the financial and technical feasibility of the planned interventions and the expected positive impact[6].

Through the ability to simulate complex scenarios, anticipate critical issues and evaluate ex ante the impact of planning choices, Digital Twins make it possible to overcome static models of governance of complex phenomena, favouring instead a dynamic and adaptive approach based on the continuous analysis of flows, infrastructures and collective behaviours.

From this perspective, technology does not merely increase the efficiency of the solutions provided, but becomes an essential tool for promoting more accessible, sustainable and inclusive models capable of responding in a differentiated manner to the needs of heterogeneous categories of users, including persons with disabilities, residents of peripheral areas and individuals more exposed to conditions of marginalization.

The predictive management enabled by Digital Twins allows territorial imbalances, infrastructural shortages and barriers to access to services to be identified, providing public authorities with an advanced knowledge base to guide investment and regulatory decisions in an equitable and proportionate manner.

[6] D Jones Characterizing the Digital Twin: a Systematic Literature Review in CIRP Journal of Manufacturing Science and Technology (2020) 36-50; A Tzachor, S Sabri, C E Richards et al. Potential and Limitations of Digital Twins to Achieve the Sustainable Development Goals in Nature Sustainability (2022) 822-835.

DT is particularly well-suited to the development of sustainable mobility and the creation of resilient and more inclusive urban communities[7].

Indeed, Digital Twins are increasingly used in the development of sustainable mobility solutions, for instance to improve road safety through infrastructure and traffic monitoring, to enhance the performance of electric vehicles, including in terms of eco-driving, and to support the planning of multimodal mobility systems capable of integrating public transport, shared mobility and micromobility services.

Furthermore, they allow for the continuous monitoring of urban development by integrating data relating to land use, population density, existing infrastructures and the pressure exerted by temporary population flows such as students, commuters, tourists or newly arrived residents, thereby supporting more informed and participatory urban planning policies and reducing the risk that apparently neutral decisions may produce indirect discriminatory effects or aggravate pre-existing territorial inequalities.

This demonstrates how the tools of the technological revolution can contribute to the achievement of the targets set by the green transformation[8].

In addition, with regard to the creation of more inclusive and resilient urban community models, the management of problems arising from the increase of phenomena such as urban sprawl and urban encroachment is an interesting field of DT application.

Indeed, cities are increasingly subject to *phenomena* such as haphazard horizontal development without adequate planning, which makes the environment hard to use, especially for those living on the fringes of the city[9], and the invasion by temporary stayers[10], such as students, tourists and immigrants, which makes it difficult both to coexist with residents and to guarantee an adequate level of services, a high quality of life and the livability of common spaces[11].

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[7] The mobility sector is expected to grow in its usage of non-personal data in the upcoming five years. It will enjoy the second highest growth in CAGR when it comes to the number of data suppliers. O Batura et al., *The Emergence of Non-Personal Data Markets* in (2023) 1-1.

[8] B Garske et al., *Digital Twins in Sustainable Transition: Exploring the Role of EU Data Governance* in *Frontiers in Research Metrics and Analytics* (2024) 1-12.

[9] M P Jhonson, *Environmental Impacts of Urban Sprawl: A Survey of the Literature and Proposed Research Agenda* in *Environment and Planning A: Economy and Space* (2001) 717-740; F Dieleman, M Wegern, *Compact City and Urban Sprawl* in *Built Environment* (2004) 308-325.

[10] They can be defined as "people moving voluntarily to a city for a more or less short period but with no intention to settle there permanently": B Brollo, F Celata, Temporary populations and sociospatial polarisation in the short-term city in Urban Studies (2023) 1815-1835.

[11] T Nakazawa, Expanding the scope of studentification studies in Geography Compass (2017) 1230-1245; I Tombolini, et al, Urban Encroachment, Land-use and demographic change: empirical evidence from Italy in International Journal of Ecological Economics and Statistics (2018) 114-130; T Sigler, D Wachsmuth, New directions in transnational gentrification: Tourism-led, state-led and lifestyle-led urban transformations in Urban Studies (2020) 3190-3205; F Celata, A Romano, Overtourism and online short-term rental platforms in Italian cities in Journal of Sustainable Tourism (2022) 1020-1035; A Barresi, Urban Digital Twin e pianificazione urbana per la città sostenibile in Techne: Journal of Technology for Architecture & Environment (2023) 78-95; S Mullic, et al, Urbanization agenda: a journey embracing geodata analysis using digital twin model in 7th IET Smart Cities Symposium (SCS 2023) (2023) 45-60. In this context, concrete solutions have already been proposed, such as Snap4City, developed by the Department of Information Engineering of the University of Florence - Resource available at Snap4City, last consultation on July 2024, but also the various DTs already used in cities such as Singapore and Rotterdam - We cite also the DTs Virtual Singapore, and the TWIN16, one of the DTs that has been developed to simulate traffic flow and test improvements in the Dutch city. On this topic see also H Yeon, et al, DTUMOS, digital twin for large-scale urban mobility operating system in Scientific Reports (2023) 5154-5165.

The main target is to optimize available resources and implement a predictive, end-to-end and near-real time management of citizens needs also in the wake of the new concept of "Multimodal Digital Mobility Services" that is currently spreading[12].

Concrete examples of these applications include projects such as Hybrid Twins for Urban Transportation and Snap4City, the latter developed by the Department of Information Engineering of the University of Florence, which through the collection and analysis of multiple datasets allows the creation of virtual models of urban reality aimed at improving road infrastructures and mobility systems.

Nevertheless, an examination of the functioning of the DT reveals that the considerable potential offered by the advent of new technologies is interwoven with a complex network of legal issues, that require careful consideration.

2. The risk of cluster discrimination arising from the processing of non-personal information in the use of high-tech tools.

DT employs a range of information types: these encompass both environmental data[13] and personal information, including users' commercial and experiential preferences, the geo-localization of goods and people within a given space, and a variety of demographic, statistical, economic, and even biometric aspects.

The simultaneous management of such types of information, due to the activity of crossing and aggregation that the tool produces by virtue of its mode of operation opens up to a series of issues as diversified, unfair and even discriminatory citizens treatments, even when using non-personal data only.

Even where exclusively non-personal data are used, the aggregation and correlation of such information may generate differentiated, unfair and potentially discriminatory treatments toward groups of citizens, despite the fact that the data themselves are not capable of identifying any specific individual.

Indeed, the advent of new technologies appears to have the potential to influence the very forms and processes of discrimination themselves.

This risk is closely linked to the very development of advanced technologies, which appear capable of influencing the forms and processes through which discrimination may occur from at least two different perspectives.

From a qualitative point of view they are inclined to become increasingly unintentional, subtle, indirect[14] and based on classes, aggregates and models,

[12] The definition of MDMS, similar to the concept of Mobility as a Service adopted by Heikkila in 2014, as *«systems that provide information on, among other things, the location of transport facilities, timetables, availability and fares, of more than one transport provider, with or without facilities to make reservations, make payments or issue tickets»* contributes to Action 37 of the Sustainable and Smart Mobility Strategy, referred to in the EU Green Deal. In a very brief way, it allows users to book, monitor, manage and pay for their multimodal travel from point A to point B directly from their personal devices.

[13] Article 2 of Aahrus Convention, signed on June, 25th, 1988.

[14] Consider the protection of workers, the well-known phenomenon of unbanking up to the preparation, still in progress, of protective rules regarding the use of online platforms and the use of advertisements. Also, the phenomenon of digital divide, which can give rise to discrimination that affects people with low digital literacy due to age, socio-economic inequalities but also geographical areas of

instead of the characteristics of the individual *uti singulus*, and their potential of harm is not reduced thus.

From a structural perspective, the increasing technologization of decision-making processes profoundly transforms the ways in which discrimination can arise. Algorithmic decision-making systems and automated data processing tend to produce forms of discrimination that are more automatic, indirect and often unintentional, as they rely on processes of classification, aggregation and statistical modelling rather than on explicit discriminatory criteria.

The ultimate effect of these processes is to divide the population into categories, social aggregates and groups, sometimes reality-based, sometimes without any real evidence. In this context, the individual is no longer considered *uti singulus*, but rather as a member of a class or group defined through correlations and patterns extracted from large datasets, often regardless of the actual correspondence between those categories and the real characteristics of the person concerned.

From a dynamic perspective, the utilization of updated technological resources enables the emergence of discriminatory practices to intensify, employing increasingly sophisticated and opaque technicalities across the spectrum of information processing.

It renders the identification and mitigation of such mechanisms a significantly more challenging endeavor[15].

From a dynamic and operational perspective, moreover, the continuous evolution of technological tools does not merely reproduce existing discriminatory patterns but may amplify and transform them over time through increasingly sophisticated and opaque techniques of information processing. This evolution further complicates the identification, contestation and mitigation of discriminatory mechanisms embedded within algorithmic systems.

This is the inevitable consequence of using historical data, which frequently reflects pre-existing social inequalities and serves as the principal training information for the technological tool, which, as explained, requires a multiplicity of data to function correctly.

Additionally, the distorted utilization of the data and the inherent bias of the algorithm, as a tool designed by individuals with entrenched and occasionally unconscious beliefs, can result in the aggregation of inaccurate information.

Moreover, as mentioned, the technical functioning mechanisms of algorithmic profiling seem capable of identifying the so called «proxies», so the combinations of input data, which, in addition to being real predictors of the most well-known discriminatory categories, are also able to make associations

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belonging. This form of discrimination can lead to a limited access to services, but also to forms of vulnerability and dependence on others. On this topic O Doyle, *Direct Discrimination, Indirect Discrimination and Autonomy* in *Oxford Journal of Legal Studies* (2007) 537-556; S Haijian, et al, *A Methodology for Direct and Indirect Discrimination Prevention in Data Mining* in *IEEE Transactions on Knowledge and Data Engineering* (2013) 1445-1460; S Vantin, *Digital divide. Discriminazione e vulnerabilità nell'epoca della rete globale*, Wolters Kluwer CEDAM (2021) 233-250; G Berti De Marinis, *La vulnerabilità nei mercati regolamentati* in *Corrias, I soggetti vulnerabili nella disciplina comune e nei mercati regolamentati*, Edizioni Scientifiche Italiane (2022) 96-110.

[15] C Sandvig, et al, *Auditing Algorithms: Research Methods for Detecting Discrimination on Internet Platforms* in *Paper presented to Data and Discrimination: Converting Critical Concerns into Productive Inquiry*, (a preconference at the 64th Annual Meeting of the International Communication Association) (2014) 1-25.

completely new and, thus, to introduce parameters suitable for producing unfair treatments often not considered[16].

In such cases, discrimination may be specifically related to the purposes for which non-personal data are used, the manner in which the information has been collected, stored and interpreted, the specific or collateral objective of placing certain subjects at a disadvantage, and the manner in which the individual data analysis activities are conducted, which may already be marked by discrimination.

Considering the processing of non-personal data in the aim of this paper, so the implementation of sustainable forms of mobility and more inclusive communities, it will be agreed that, unfortunately, it lends itself to the development of both *phenomena*.

In cases where the processing of data is solely for discriminatory purposes, one might consider the use of information regarding the geo-localization of payments made via smartphones or the type of waste produced by a specific community.

For instance, one might refer to the use of information concerning the geo-localization of payments made via smartphones or data relating to the types of waste produced by a specific community through smart waste-collection systems.

When this data is provided to Digital Twin, it can identify which services or goods are most attractive and the price of those services. Once provided to Digital Twin systems, such datasets may allow the system to infer which services or goods are more attractive for a given community and to adjust the type, availability or pricing of those services accordingly.

In this way, even though the treatment of information has been taken in accordance with the *criteria* of equity which should govern the matter, it not only opens up the risk of exploiting the «weaknesses», economic and non-economic, of the social aggregate.

It also open to the danger of discrimination based on a «new criterion», namely the spending capacity of the resident population, which is not known to fall within the classical parameters and has so far been given greater attention.

It is therefore possible that, as a result of cognitive bias, an association may be formed between the two pieces of information [17], leading to unfair treatment on the basis of a completely hypothetical target[18].

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[16] A Trupti Kumbhare, et al, *An Overview of Association Rule Mining Algorithms* in *International Journal of Computer Science and Information Technologies* (2014) 927-950; N Samreen, et al, *An Unsupervised Machine Learning Algorithms: Comprehensive Review* in *International Journal of Computing and Digital Systems* (2023) 911-935.

[17] Similar issues have already been addressed by G Gometz, *Intelligenza artificiale, profilazione e nuove forme di discriminazione* in *Teoria e Storia del Diritto Privato* (2022) 1-25.

[18] E Troisi, *L'Automated Decision Making, la Protezione dei Dati e il Diritto alla 'Intellegibilità' dell'Algoritmo* in *Eur. J. Privacy L. & Tech.* (2019) 41-65; A Barocas, A Selbst, *Big Data's Disparate Impact* in *California Law Review* (2016) 671-732; C O'Neil, *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy* Crown (2016) 1-272; S Barocas, A Selbst, *Data Mining and the Discrimination Problem* in *Proceedings of the 2014 Conference on Fairness, Accountability, and Transparency* (2014) 1-8.

Moreover, from a socio-economic perspective, the deployment of DT systems raises profound concerns regarding their uneven impact on already vulnerable populations themselves.

Communities with lower income levels, newly arrived migrants, and residents of peripheral or underserved urban zones are frequently under-represented in the datasets that train DT algorithms.

This under-representation may derive from historical gaps in data collection, limited digital infrastructure, or linguistic and cultural barriers that reduce the visibility of such groups within official statistics and administrative datasets.

This under-representation may result from historical gaps in data collection, limited digital infrastructure, or language and cultural barriers that reduce the visibility of these groups within official statistics.

Consequently, predictive models may misclassify or overlook their specific needs, producing outputs that reinforce rather than alleviate existing disparities.

These biases can manifest in subtle but consequential ways.

For instance, when DT models are used to optimize urban mobility or energy distribution, they may prioritize areas with richer, denser data streams, typically central districts, while neglecting neighborhoods lacking sensor coverage or comprehensive records.

The result can be an inequitable allocation of public resources, from public transport frequency to energy-efficiency incentives, effectively reducing service quality for peripheral communities[19].

Migrants and low-income residents may therefore encounter longer commute times, less reliable energy supply, or delayed emergency responses, despite being among the groups most in need of improved services.

Moreover, DT-driven profiling can indirectly shape market dynamics and private-sector decision-making.

Insurers, lenders, and property developers increasingly rely on algorithmic risk assessments that may incorporate DT-generated environmental and demographic indicators.

Even when no individual is singled out, entire neighborhoods can be labeled "high risk" based on aggregated data patterns such as waste-production profiles or smartphone-payment geo-localization.

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[19] Empirical and theoretical research in urban studies, smart cities, and data governance demonstrates that data-driven technologies can unintentionally reproduce spatial inequalities when deployed without inclusive design and equitable governance. Kitchin shows that smart technologies tend to generate "data shadows," in which areas with abundant digital trace data are better represented and serviced than those with sparse digital footprints, contributing to uneven urban development. Shelton, Zook, and Wiig find that sensor networks and digital platforms embedded in urban infrastructures often privilege central districts, resulting in differential service provision along socio-economic lines. In the context of mobility and energy systems, studies on algorithmic urban governance highlight that prioritization of high-density data streams can lead to inequitable allocation of resources and gaps in public services for peripheral communities, exacerbating digital and infrastructural divides. These dynamics illustrate how predictive models, including Digital Twins, can inadvertently reinforce spatial inequities unless complemented by policies that explicitly address data representativeness and social inclusion. R Kitchin, *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences* Sage (2014) 1-256; T Shelton, M Zook, A Wiig, *The (In)security of Smart Cities: Vulnerabilities, Risks, and Responsibilities* in *Journal of Urban Technology* (2015) 269-283; J van Dijk, *The Digital Divide* Polity Press (2020) 1-176; M Batty, *Digital Twins, Smart Cities and Urban Sustainability* in *Journal of Urban Technology* (2018) 3-21.

This can translate into higher insurance premiums, restricted access to credit, or disinvestment in local housing and infrastructure. Such outcomes deepen spatial segregation and economic exclusion, creating self-reinforcing feedback loops: as services degrade and opportunities shrink, the very data feeding the DT systems confirm the algorithm's negative categorization.

The socio-economic consequences extend beyond immediate market effects.

By embedding these biased outputs in planning and policy, public authorities may unintentionally codify disadvantage, shaping zoning, taxation, or investment decisions that privilege already affluent areas[20].

Over time, these feedback mechanisms can crystallize into structural inequality, undermining social cohesion and frustrating the goals of both digital and green transitions[21].

Addressing these risks requires not only technical interventions, such as bias detection and algorithmic audits, but also participatory governance. Involving community representatives, civil-society organizations, and local stakeholders in the design and monitoring of DT applications can help ensure that data collection reflects diverse realities and that optimization goals align with principles of equity and social justice.

Without such safeguards, the promise of Digital Twin technology to advance sustainability and efficiency may be realized only for the most privileged, leaving vulnerable groups further marginalized in the very cities and systems that aspire to become more inclusive.

The diverse risks arising from potentially harmful treatments based exclusively on the use of non-personal data are also reflected, and perhaps

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[20] Scholars in urban studies and data governance have shown that biases embedded in algorithmic outputs can become institutionalized when these outputs are used to inform planning and policy decisions, thereby reinforcing spatial and socio-economic inequalities rather than alleviating them. Fainstein's work on urban justice underscores how planning instruments such as zoning and investment priorities have historically contributed to privileging affluent areas while marginalizing lower-income communities. Similarly, Sassen highlights how data-driven development strategies, when uncritically adopted by public authorities, can inadvertently reproduce existing power structures and economic advantages, resulting in policy decisions that favor already advantaged localities. Studies on algorithmic governance further show that embedding predictive analytics into public planning can codify socio-economic disadvantage by guiding zoning, taxation, and investment in ways that reinforce pre-existing spatial inequities. N Fainstein, *The Just City* in *International Journal of Urban and Regional Research* (2010) 187-202; S Sassen, *Expulsions: Brutality and Complexity in the Global Economy* Belknap Press (2014) 1-296; M Batty, *Digital Twins, Smart Cities and Urban Sustainability* in *Journal of Urban Technology* (2018) 3-21; J van Dijk, *The Digital Divide* Polity Press (2020) 1-176.

[21] A substantial body of literature on socio-technical transitions and urban inequality highlights how algorithmically informed policies and data-driven interventions can produce *feedback mechanisms* that reinforce and entrench existing disparities over time. Research on path dependency and cumulative disadvantage shows that once initial inequalities are introduced into decision-making systems — for example through biased data or uneven sensor coverage — these disparities tend to be amplified rather than corrected. Sassen's work on urban structural change further explains how technological and economic processes can lock in advantages for already privileged groups, thereby undermining social cohesion and limiting the emancipatory potential of digital innovation. Studies on sustainability transitions also emphasize the risk that digitalization and green policies, if not inclusive by design, can solidify socio-economic stratification by privileging resource-rich actors and regions, thus frustrating the broader goals of equitable and sustainable. P Hall, *Urban and Regional Planning in an Age of Polarization* in *Journal of Planning Education and Research* (2014) 7-19; B Sovacool, *Energy Transitions and Social Justice* in *Energy Research & Social Science* (2016) 199-206.

partially explained, by the fragmented regulatory framework governing the processing of such information, which historically has been perceived as incapable of generating discriminatory effects.

The varied risks of discriminatory processing arising from the use of non-personal data only, which are now clearly established and exemplified in a limited manner, are reflected in the legal terminology and the somewhat fragmented regulatory framework, that we are about to delineate.

3. Non-personal data in the EU legal framework: from the principle of free sharing to the "new" concept of algorithmic disclosure.

As mentioned, this paper focuses on possible discrimination that might result from the use of non-personal data. However, the identification of the legal rules applicable to non-personal data also requires consideration of personal ones, since they are deeply related.

In considering the legal framework of reference, once outlined the difference between the two types of information, which is still very blurred, we will try to understand whether certain principles that apply to personal data and that have proved useful in preventing certain types of discrimination, such as the principle of trustworthiness and accountability, can also be applied to non-personal data too.

In the end, in this paragraph, an attempt will be made to look at the branches of law where the protection of the individual originated, and in particular at the area of labor law, to ask whether this area can offer some hints for thought in order to ensure the joint development of the two transitions.

The distinction between personal data and non-personal data[22] has been a key factor in the approach taken by the European legislature. In constructing the regulatory framework, the EU legislator has in fact adopted a dichotomous, yet complementary, approach, distinguishing, albeit not always clearly, between personal and non-personal data in order to recognize only the former as involving specific legal implications and potential risks for citizens' rights, particularly with regard to the protection of privacy.

Initially, there was a focus on the potential for discrimination arising from the processing of personal data only.

Indeed, with regard to the protection of personal data, the General Data Protection Regulation (GDPR) establishes a comprehensive regulatory framework that prioritizes the protection of individual privacy. This framework is designed to safeguard individuals from any potential discriminatory

[22] For a distinction between personal and non-personal data, as referred to in art. 4 of the GDPR, in Recital 9 of the Regulation UR 2018/1807 of the European Parliament and of the Council and art. 3 thereof. In addition, in jurisprudence, see, on all the ECJ judgment, 20 December 2017, C-434/16, Peter Nowak v. Data Protection Commissioner, ECLI:EU:C:2017:99, where it is specified that *"sensitive or private information, but potentially includes any type of information, whether objective or subjective, in the form of opinions or assessments, provided that they are "concerning" the person concerned"* where the person is *"concerning"* when, by reason of its content, purpose or effect, [...] is connected to a particular person". The concept of "identifiability" of the person also played a role in this issue, an aspect which varies according to several factors, as confirmed by the judgment in Case C-582/14 (Second Section), Patrick Breyer vs Bundesrepublik Deutschland, Ecli:EU:C:2016:77. On this topic M Fink, Pallas F, *They who must not be identified — distinguishing personal from non-personal data under the GDPR*, in *International Data Privacy Law* 10:1 (2020) 11.

treatments based on their identifiable or non-identifiable personal information.

Conversely, non-personal data, within the meaning of Regulation (EU) 2018/1807, are identified in a residual and negative manner, namely as data that originally had no relation to an identifiable natural person, as well as data that, although derived from information once categorized as personal, have been irreversibly anonymised so that it is no longer possible to associate them with a specific individual, even through additional means.

The rules governing the processing of non-personal data, as defined in Regulation 2018/1807[23], are based on a different principle, that emphasizes the sharing of information as much as possible with the aim of creating a unified digital space within the European Union[24].

This regulatory choice reflects the objective of ensuring the free movement of non-personal data within the Union and of preventing the emergence of unjustified obstacles to their cross-border circulation. In an increasingly data-driven economy, strongly dependent on the use of large quantities of information for technological innovation, artificial intelligence, the Internet of Things and emerging business models, the existence of legal barriers such as data localisation requirements, risked creating unjustified restrictions to the mobility of non-personal data and, consequently, undermining the competitiveness of European enterprises.

For this reason, the EU legislator established the principle of the free movement of non-personal data within the Union, generally prohibiting Member States from imposing restrictions on the storage or processing of such data on territorial grounds, except where justified by overriding public interests, such as public security or the protection of public health. This objective is reflected in the title of the Rules of Procedure.

Although both types of information have reference legal acts, the Regulation 2018/1807 does not provide any reference to the collection methods, the storage and use of non-personal data, and not least the protection afforded to any person who is a victim of discrimination in relation to this category of data, such concepts must necessarily be taken from the GDPR, especially as regards the scope of the term "processing"[25].

The lack of discipline observed may be justified by the difficulty of predicting the enormous semantic and economic potential inherent in information of a non-personal nature, which is only beginning to be taken into account thanks to the latest developments in technology and by the particular complexity

[23] Regulation (EU) 2018/1807 of the European Parliament and of the Council of 14 November 2018 on a framework applicable to the free movement of non-personal data in the European Union.

[24] The first piece of the framework for free movement of data can be found in the 2014 European Commission's Communication, Towards a Thriving Data-Driven Economy, where it begins to outline the current strategy for a European data market. On this topic: M L Montagnani, *La libera circolazione dei dati al bivio. Tra tutela dei dati personali e promozione dell'intelligenza artificiale europea*, in *Mercato, Concorrenza, Regole* 2 (2019) 293.

[25] According to art. 4 GDPR 'processing' means *"any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction".*

inherent in admitting possible unfair treatment of data that are not suitable for making a particular natural person identifiable.

However, as also demonstrated by the functioning of the digital transition itself, such risks are not merely hypothetical but entirely concrete and increasingly relevant. Even data that appear non-identifying may generate indirect discrimination or unequal treatment between groups of individuals, especially where algorithmic models aggregate, correlate and infer information from large and heterogeneous datasets.

However, this specific danger has recently been heightened by the latest developments in the high-tech sector. The European Commission adopted the White Paper on Artificial Intelligence, which aims to guarantee an ethical and responsible approach to the advancement and utilization of novel technologies, in alignment with the EU's fundamental values[26].

The Regulation governing the artificial intelligence has also recently been introduced[27]. It declares to recognize the centrality and the indispensability of values such as trustworthiness and accountability and, more in detail, emphasizes the principle of transparency of algorithms used in the use of the most advanced forms of technological tools, already expressed by article 22 of the GDPR.

This last provision, in an "algorithmic disclosure" perspective, was understood as the right of users to have access to information that determines the automated decision-making and to the data themselves, the logic of its treatment and the right to challenge the decision taken by the algorithm. Furthermore, this principle is accompanied by the prohibition of unfair or manipulative practices for companies using these high-tech tools and the general duty of responsibility imposed on market operators.

The recent focus on emerging technologies and the potential for discriminatory practices associated with them has prompted a shift in the interpretation of transparency principles.

Initially conceived as the right to comprehend the technical operations of the algorithmic code utilized by the tool[28], this principle is now being re-examined in light of the perceived limitations of providing citizens with information on the intricacies of a string of alphanumeric characters, that they can't be understood.

Thus, currently it is affirmed as the concept of accessibility and explicability of the algorithm, also in the light of the right to challenge the decision taken by the machine, it may also be understood as a duty to provide the individual with additional information semantically relevant to those more relevant, such as the context in which the computer code is applied, the purposes pursued by it, the techniques used for its design and also some examples of its practical operation in the individual field of use.

[26] White Paper on Artificial Intelligence: an European approach to excellence and trust.

[27] Regulation of the European Parliament and of the Council Laying down harmonised rules on artificial intelligence and amending certain union legislative acts, n. 1689/2024 (EU).On this topic: B Gyevnar et al., *Bridging the Transparency Gap: What Can Explainable AI Learn from the AI Act*, 964.

[28] B Goodman, S Flexman, *European Union Regulations on Algorithmic Decision-Making and a Right to Explanation*, in *AI Magazine* 38(3) (2017) 50.

As is evident, therefore, the principles of algorithmic transparency, accountability and trustworthiness play a fundamental role in the regulation of data of a personal nature[29].

The question therefore arises is whether it is possible and, above all, useful in order to enable the simultaneous development of the green transition and the digital transition, to extend these principles to the processing of non-personal data as well, and whether these principles might prove useful in preventing discrimination.

So, even if we make an interpretative effort and extend the principle of transparency of the algorithm in the GDPR also to non-personal data, supported by the approval of the AI Regulation, it is debatable whether this is enough to limit the risks of discriminatory practices involving non-personal data.

This is because such practices do not necessarily target an identifiable individual, but frequently operate at a collective level through mechanisms of classification, aggregation and profiling, producing indirect and systemic discriminatory effects that are difficult to capture through legal categories traditionally constructed around the protection of the individual and the right to explanation of automated decision-making.

A shift in perspective, with a greater focus on the distinction between the various types of data and the different regulatory frameworks to which they are subject, as well as on the concrete effects that the treatments produce on them, beyond the fact that they are more or less capable of identifying a specific subject, could make a significant contribution to the field.

In fact, the prohibition of discrimination, referred to in the first place to art. 14 of the European Convention on Human Rights, constitutes a fundamental and transversal principle of common law, declined, in addition to the light of certain *criteria* expressed, very often used to carry out discriminatory practices, also by virtue of *"any other condition"* that may lead to unequal treatment between individuals.

Such a clause may also encompass situations in which individuals are treated differently because of their real or presumed belonging to particular social clusters or groups, even where the measures applied appear formally neutral.

It is this final point, undoubtedly also relevant in the context of the application of the Regulation on non-personal data, which may require

[29] The concept of algorithmic accessibility and explicability has evolved beyond a mere technical disclosure of code, encompassing the obligation for developers and operators to provide contextually meaningful information about the design, objectives, and operational logic of algorithms. This is particularly relevant in domains where automated decision-making affects individual rights and social outcomes, such as credit scoring, urban planning, or healthcare allocation. Scholars highlight that transparency alone is insufficient unless paired with accountability and trustworthiness, which include the ability to audit, contest, and correct decisions. Furthermore, practical approaches for operationalizing explicability have been proposed, such as algorithmic impact assessments, stakeholder-inclusive design reviews, and scenario-based testing, which aim to make AI outputs semantically interpretable for non-technical users. These measures, if properly implemented, ensure that algorithmic systems, including Digital Twins, can uphold ethical standards, mitigate discriminatory effects, and provide individuals with actionable insights about decisions that impact their lives. Burrell, How the machine 'thinks': Understanding opacity in machine learning algorithms, in Big Data & Society, 2016, 1-12; Doshi-Velez, *Towards a rigorous science of interpretable machine learning*, in *arXiv preprint,* 2017, 1-15; Lipton, *The mythos of model interpretability*, in *Queue,* 2018, 31-57; Selbst, *Fairness and abstraction in sociotechnical systems*, in *Proceedings of FAT*, 2019, 59-68.

consideration in order to identify a form of protection against discriminatory behaviors perpetrated through the use of such information.

Consequently, the focus of the analysis concerning discriminatory practices arising from the management of non-personal data should progressively move away from the mere identifiability of the individual and towards an evaluation of the broader socio-economic effects produced by data processing activities.

More specifically, it becomes necessary to assess how combined datasets, even when composed exclusively of non-personal data, together with algorithmic models may generate, reproduce or amplify pre-existing inequalities, producing systemic effects on opportunities, access to services and the distribution of resources, and therefore ultimately affecting both formal and substantive equality.

Such a shift in perspective suggests the need to complement existing legal frameworks with principles and instruments capable of addressing collective risks, such as preventive measures, continuous audits, fairness protocols and impact monitoring at group level, in order to effectively mitigate the specific risks deriving from the processing of non-personal data.

In considering further legislative provisions that address the issue of discrimination, it is imperative to acknowledge the Directive on equal treatment between people without distinction based on race and ethnic origin[30].

The above mentioned Directive, in the knowledge of the difficulty involved in the burden of proof in the case of discriminatory conduct, in order to facilitate the injured person's condition, in addition to calling on the member States to provide appropriate measures to prevent such conduct and sufficient means of redress, including an action for damages, introduces an interesting presumption of the existence of unfair treatment when the injured party adheres to relevant facts only[31].

Furthermore, the aforementioned act, which also applies to education and access to goods and services, primarily addresses discrimination in the workplace.

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[30] The potential for algorithmic models to generate, reproduce, or amplify pre-existing inequalities has been widely documented, even when these models rely solely on non-personal data. As Eubanks notes, high-tech systems can systematically disadvantage already vulnerable populations by embedding social biases into automated decision-making processes. Kitchin emphasizes that big data infrastructures, when used without attention to fairness, can exacerbate structural inequalities across multiple social domains. Similarly, Mittelstadt highlights the ethical implications of algorithmic outputs, demonstrating how systemic effects may arise even absent direct personal identifiers. Binns underlines the importance of accountability mechanisms and continuous auditing as tools to detect and mitigate discriminatory patterns. Barocas further argues that disparities in access to opportunities and resources may be codified when automated systems interact with socio-economic data. In the European legal context, these concerns are addressed by Directive 2000/43/EC, which establishes a framework for equal treatment irrespective of racial or ethnic origin, thus providing a legal basis for preventive measures, monitoring, and mitigation strategies to safeguard collective equality (*Directive 2000/43/EC on equal treatment irrespective of racial or ethnic origin*, in *Official Journal of the European Union*, 2000, 1-6). Eubanks, *Automating Inequality: How High-Tech Tools Profile, Police, and Punish the Poor*, in *St. Martin's Press* (2018) 1-256; Kitchin, *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences*, in *Sage* (2014) 1-248; Mittelstadt, *The ethics of algorithms: Mapping the debate*, in *Big Data & Society* (2016) 3-21; Binns, *Algorithmic accountability and public reason*, in *Philosophy & Technology* (2018) 447-468; Barocas, *Big data's disparate impact*, in *California Law Review* (2016) 671-732; European Commission, *Directive 2000/43/EC on equal treatment irrespective of racial or ethnic origin*, in *Official Journal of the European Union* (2000) 1-6.

[31] Articles 3, 8 and 15 of Council Directive 2000/43/EC of 29th June 2000.

This allows us to make some observations regarding the protection offered in this specific legal field. Despite being quite distinct from the subject under consideration and shaped by its own unique historical and social evolution, it offers valuable insights that can inform our reflection on this topic.

Firstly, the sector legislation[32], without overly rigid defining pretensions, also expressly considers the hypothesis in which the individual may be a victim of discrimination, not only as a singular entity, but also as part of a certain collectivity[33].

This is a significant consideration when contemplating the potential for unfair treatment resulting from the processing of non-personal data, given the heightened susceptibility to such treatment and the dearth of comprehensive information about the individual.

Furthermore, the regulations designed to safeguard communities subjected to unjust practices, as evidenced by a series of precedent-setting cases, permit the assessment of potential harm as a harmful consequence. So, the possibility of compensation for damages is itself opened up.

It is also specified that, in the light of the importance and odiousness of the discriminatory phenomenon, the penalty imposed on a person who engages in such conduct must be effective, proportionate but also sufficiently dissuasive[34].

In consequence, the particular domain of protection of workers subjected to forms of discrimination furnishes a unified legal reference framework and is markedly oriented towards the safeguarding of the individual, encompassing its social dimension.

It also provides suitable tools, including procedural ones, which are shared throughout the Union. These tools are designed to assist the weaker party in asserting their rights. It is also emphasized that a holistic approach to these issues is essential, given the inherent prejudice to the value of human dignity inherent in the discriminatory act, which may, moreover, constitute a limit precisely on the pursuit of Union objectives.

4. Protection tools and self-regulation in the development of high-tech solutions for the sustainable transition and the prevention of discrimination.

The brief overview of the DT's operation serves to confirm the fundamental contribution of new technologies to the pursuit of social and environmental sustainability objectives, with a focus on sustainability in its dimension of social inclusiveness.

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[32] Directive 2006/54/EC of the European Parliament and of the Council of 5 July 2006 on the implementation of the principle of equal opportunities and equal treatment for men and women in employment and Council Directive 2000/78/EC of 27 November 2000, establishing a general framework for equal treatment in employment and working conditions.

[33] As also stated by the Court of Justice, Grand Chamber, in its judgment of 23 April 2020, case C-507/18

and the Italian Supreme Court of Cassation, Labour section, n. 20819, 21st July 2021, in *Massima redazionale Wolters Kluwer,* 2021.

[34] Italian Supreme Court of Cassation, United Sections, n. 16601, 5th July 2017, in *Il caso.it,* 2017 and Bergamo Tribunal, n. 1586, 30th March 2018, in *Giur. It.,* 2018, 10, 2191.

In light of the aforementioned considerations, it becomes evident that the identification of tools capable of preventing such degeneration necessitates a multidisciplinary approach, particularly given the inherent complexity of the subject matter.

However, in order to ensure that the legal sector's potential is properly exploited in its development, it is considered useful to approach the problem from two different perspectives.

Firstly, it is essential to direct attention to the subsequent phase following the occurrence of discriminatory behavior directed towards a specific individual or community.

In light of the foreseeable expansion of discriminatory practices and their disruptive impact on the exercise of fundamental freedoms by individuals, it is crucial to assess the adequacy of the tools currently developed by the European legislator in preventing the risks of discrimination arising from unfair treatment, particularly in view of the development of new technologies[35].

This uncertainty arises from the failure to anticipate a range of standard provisions that could facilitate both the establishment of a strong framework for data sharing and the consistent implementation of protections for victims of discrimination resulting from this evolving phenomenon.

Nevertheless, in the event that the issues pertaining to the free movement of non-personal data assume a Community dimension, as is increasingly the case, it may be necessary to consider the introduction of additional common provisions at the level of the legal order, with due consideration given to the potential consequences of such measures.

Indeed, as we have sought to demonstrate, the deployment of algorithmic discrimination techniques seems to be on the rise. Consequently, the comprehensive approach of labor law to such phenomena can serve as a foundation for addressing a range of issues[36].

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[35] The deployment of Digital Twins (DT) in urban planning, energy distribution, and social policy underscores their potential to enhance social and environmental sustainability. Scholars have highlighted that while DT and other advanced technologies can optimize resource allocation and improve inclusiveness, they also carry risks of reproducing systemic inequities if used without proper safeguards. A multidisciplinary approach is therefore crucial, integrating legal, technical, and social expertise to identify preventive measures and ensure that the rights of individuals and communities are respected. The European legal framework, including directives and regulations on non-discrimination and AI governance, provides a foundation, but its practical efficacy depends on the adoption of complementary monitoring tools, stakeholder engagement, and continuous audit mechanisms capable of addressing emerging biases in complex socio-technical systems. L Floridi, *The Ethics of Information*, in *Oxford University Press* (2013), 1-320; S Wachter, B Mittelstadt, L Floridi, *Why a Right to Explanation of Automated Decision-Making Does Not Exist in the General Data Protection Regulation*, in *International Data Privacy Law* (2017), 76-99; M Whittaker et al., *AI Now 2018 Report*, in *AI Now Institute, New York University* (2018), 1-120.

[36] The increasing relevance of non-personal data in cross-border contexts highlights gaps in standard provisions necessary to ensure both effective data sharing and protection against discriminatory practices. Legal scholars have emphasized that without harmonized rules at the Community level, inconsistencies may arise between Member States, potentially exacerbating inequalities and undermining trust in algorithmic decision-making. Drawing lessons from labor law, where systematic protections against discrimination have been established over decades, offers a useful template for designing legal instruments tailored to high-tech environments. Moreover, the preventive and proactive design of common regulations can mitigate risks inherent in the deployment of advanced digital systems, including the amplification of latent biases across multiple jurisdictions. A Mittelstadt, *Principles alone cannot guarantee ethical AI*, in *Nature Machine Intelligence* (2019), 103-107; C O'Neil, *Weapons of Math Destruction*, in *Crown Publishing* (2016), 1-270; T Veale, *Transparency in algorithmic accountability*, in *Computer Law & Security Review* (2018), 105-123.

Indeed, these rules serve to highlight the vulnerability of belonging to a specific group of individuals and address the issue from the perspective of the concrete protections afforded to citizens.

The pursuit of these objectives through the provision of shared regulatory sources is therefore a crucial aspect of this process.

It is widely acknowledged that the instruments established by common law to safeguard workers subjected to discriminatory practices cannot be automatically extended to other domains.

To construct an efficacious legal framework, it is essential to consider the distinctive characteristics of each regulatory domain and to deliberate on the merits of establishing a dedicated legal framework for the advancement of high-tech tools.

It would therefore be essential, in the specific field of the development of new technologies or even more in the sector context of DT, to identify the new and additional parameters through which individuals may be discriminated against due to the use of non-personal information, as well as to determine how this unfair treatment manifests itself[37].

This would facilitate the more straightforward identification and prevention of the phenomenon. It is, in fact, challenging to demonstrate that a group of people have been treated differently and devalued by virtue of an opaque criterion.

Secondly, the potential for discrimination arising from the use of non-personal data by new technologies could be mitigated through a preventive approach that involves greater stakeholder involvement, ideally from a European perspective.

In addition to the frequent auditing of algorithms, it could also detect the voluntary adoption of protocols aimed at introducing progressive controls, even by personnel with different cultural backgrounds.

This would enable the identification of risks of differentiated treatment that are now partly internalized. It would also assess whether the data provided to the tool are truly representative of the community to which they relate.

In this regard, the legislation itself underscores the significance of fostering self-regulation by market operators, classified according to the distinctive attributes of the sector in question.

There are already some concrete examples of this self-regulation, and it may be feasible to extend this approach to the processing of non-personal data[38].

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[37] The challenge of translating protections from traditional domains such as labor law to emerging high-tech sectors lies in the distinctiveness of each regulatory context. While labor law safeguards are well-established for employees, algorithmic systems and Digital Twin applications operate in socio-technical environments where discrimination may emerge collectively rather than individually. Scholars argue that the creation of dedicated legal frameworks tailored to new technologies is essential to anticipate and mitigate systemic biases, particularly when non-personal data are involved. Furthermore, establishing parameters that allow the identification of potential discriminatory effects, including data representation, algorithmic weighting, and predictive correlations—is crucial for the effective enforcement of fairness principles. In the European context, this perspective aligns with the objectives of the AI Act, which encourages sector-specific regulations and proactive measures to prevent unfair treatment resulting from both personal and non-personal data. J Kroll, *Accountable Algorithms*, in *University of Pennsylvania Law Review* (2017), 633-705; I Rahwan, *Society-in-the-Loop: Programming the Algorithmic Social Contract*, in *Ethics and Information Technology* (2018), 5-14.

[38] The prevention of discriminatory outcomes arising from the use of non-personal data requires proactive and systemic measures. As Sandvig et al. emphasize, the opacity of algorithmic processes makes

Moreover, in order to use the flexibility of the novel concept of transparency and accessibility to information pertaining to the algorithms utilized by the aforementioned high-tech tools, it would be feasible to enhance this parameter by incorporating supplementary control strings, drawing inspiration from a more robust concept of equity, including the indication of anti-discrimination control activities conducted, the various corrections applied to the mechanisms of algorithmic operations, and the potential clusters assigned by the tool to individual persons.

Such issues are frequently unknown or underestimated by individuals belonging to more vulnerable categories, including ethnic minorities, those with low income and/or low literacy, including technological literacy.

In this regard, the implementation of harmonized standards for the incorporation of parameters acknowledged across the Union, with the objective of determining the degree of fairness and ethical conduct of the results achieved by the technology, can also play a pivotal role in guaranteeing minimum levels of protection for all citizens[39].

Furthermore, greater stakeholder involvement would enable them to gain a deeper understanding of the profiles they expose themselves to and to which groups they may be perceived as belonging.

This could not only enhance confidence in the development of new technological solutions and information sharing, but more generally, make a significant contribution to providing corrective solutions to algorithmic mechanisms.

The analysis above shows that the digital transition, through the use of advanced technologies such as Digital Twin, is essential to make the green transition more efficient and sustainable, even though the two transitions cannot be seen as independent: social risks arising from digitalization need to be carefully managed to ensure inclusive sustainability.

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it inherently difficult to detect biased treatment, particularly when it affects groups rather than individuals. Binns highlights that continuous auditing and evaluation of algorithms, combined with stakeholder participation, are essential strategies to reveal embedded biases and assess the representativeness of input data. Selbst and Barocas further argue that the voluntary adoption of sector-specific self-regulatory protocols, including culturally diverse teams and iterative fairness checks, can reduce the risk of inequitable outcomes and improve transparency. The European regulatory framework also recognizes the importance of fostering self-regulation among market operators, which can be adapted to the management of non-personal data to enhance accountability and equitable treatment. Concrete implementations of these approaches have already emerged, demonstrating the feasibility of extending such mechanisms beyond personal data management to broader data ecosystems. J Sandvig, *Auditing Algorithms: Research Methods for Detecting Discrimination on Internet Platforms*, in *Data and Discrimination: Converting Critical Concerns into Productive Inquiry*, 2014, 1-15; B Binns, *Algorithmic Accountability and Public Reason*, in *Philosophy & Technology*, 2018, 447-468; S Selbst, A Barocas, *Fairness and Abstraction in Sociotechnical Systems*, in *Proceedings of the 2018 ACM Conference on Fairness, Accountability, and Transparency*, 2018, 59-68; European Commission, *Proposal for a Regulation on Artificial Intelligence* (*AI Act*), in *Official Journal of the European Union*, 2021, 1-35.

[39] See the opinion of the High Level Expert Group on Artificial Intelligence ethics guidelines for trustworthy At (Al HLEG), 2019, paragraphs 52 and 53, available at: https ://ec.europa.eu/digital-single-market/en/news/thics-guidelines-trustworthy-ai., according to which a principle of trustworthiness must be pursued: *"This principle implies that processes must be transparent, the capacitors and purpose of all systems must be communicated openly and decisions, as far as possible, must be explained to those directly or indirectly concerned. Without such information a decision cannot be properly challenged".*

However, there is a need to address the risks of discrimination: the use of Digital Twins can amplify existing social inequalities, especially if the models and algorithms used are not carefully monitored to avoid bias.

It is therefore crucial to develop strategies that prevent discrimination, both in access and in the benefits of using these technologies.

The issue of sustainability and social inclusion also play a central role. Indeed, the green transition cannot be considered fully effective if it is not accompanied by an inclusive digital transition.

Only by ensuring that digital technologies are designed and implemented in an equitable manner can sustainability be achieved that not only reduces environmental impact, but also improves the social well-being of all.

To this end, it seemed particularly interesting to consider an ethical and responsible approach in the development and implementation of Digital Twins and to pursue inclusive policies and governance.

Indeed, to prevent the digital transition from creating new social imbalances, technologies must be designed with diversity, local needs and social realities in mind, taking into account access and opportunities for all.

A balance must also be struck between technological innovation and environmental sustainability, and it is crucial that public policies and regulations support an equitable adoption of digital technologies, preventing the digital divide and promoting social justice.

In conclusion, it emerges that the digital transition, through the use of advanced technologies such as Digital Twins, represents an essential factor in making the green transition more efficient and sustainable, while ensuring that the social risks arising from digitalization are carefully managed to guarantee a genuinely inclusive transition.