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Big Data Analysis Systems in IoE environments for Managing Privacy and Data Protection: Pseudonymity, De-anonymization and the Right to Be Forgotten

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BIG DATA ANALYSIS SYSTEMS IN IOE ENVIRONMENTS FOR MANAGING PRIVACY AND DATA PROTECTION: PSEUDONYMITY, DE-ANONYMIZATION AND THE RIGHT TO BE FORGOTTEN

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Big Data Analysis Systems in IoE Environments for Managing Privacy and Data Protection: Pseudonymity, De-anonymisation and the Right to Be Forgotten

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Abstract of the thesis

This thesis represents the conclusive outcome of the European Joint Doctorate programme in Law, Science & Technology funded by the European Commission with the Marie Skłodowska-Curie Innovative Training Networks actions as part of the H2020, grant agreement no. 814177. The grant supports the *Rights of Internet of Everything* project conceived as a multidisciplinary investigation of one of the major technological trends, going beyond the Internet of Things (IoT) era: the Internet of Everything (IoE). In its primary definition[1], IoE is conceived as the networked connection of people, process, data, and things. The main assumption of the project is that IoE requires knowledge which is not only limited to computer science and engineering, but also includes law, social sciences, philosophy, and ethics. It requests a multidisciplinary perspective. The investigation is organised into five (5) work packages (WP): Internet of Data (WP1), Internet of Things (WP2), Internet of Persons (WP3), Internet of Healthcare (WP4) and Internet of Money (WP5).

This thesis aims to cover the legal part of WP1 (Internet of Data), focusing on Big Data Analysis Systems in IoE environments for managing Privacy and Data Protection: pseudonymity, de-anonymisation and the right to be forgotten.

It is structured in six chapters, and it is based on empirical legal research and legal analytics.

The first chapter aims to present the subject matter and the research strategy, framing the research context, and defining the research questions. Moreover, it presents the methodology of the research, defining the research method.

Chapter two presents the main characteristics of Big Data and Internet of Everything environments and investigates the challenges posed to privacy and data protection by such technologies. It defines the legal framework in force, discussing the meaning of identification and the consequent issue of de-anonymisation/re-identification, in light of Article 17 of the General Data Protection Regulation (GDPR) that grants the right to erasure (*right to be forgotten*). The chapter elaborates on the impasse created by Art. 17 in force and the issue of de-anonymisation, as due to technological development, coordinating law with reality becomes challenging. Therefore, it presents an explorative literature review on the issue of de-anonymisation/re-identification, discussing the technological development of such issue.

[1] Cisco and Qualcomm where among the first companies providing a definition of Internet of Everything. As references: https://www.cisco.com/c/dam/en_us/about/business-insights/docs/ioe-value-index-faq.pdf ; https://www.qualcomm.com/news/onq/2015/05/13/internet-everything-works-everyone

This chapter lays the ground for an objective and subjective analysis on the feasible level of data anonymity in the light of the issue of data de-anonymisation/re-identification, respectively presented in Chapter three and Chapter four.

The Chapter three investigates the issue from an objective perspective, questioning on the meaning of identification and re-identification on a semantic level, as defined in the GDPR and in the Free Flow Data Regulation (FFDR). Starting from the main difference above which the whole legal system on data flow is built, personal data and non-personal data, the chapter questions how to grant anonymity relying on the data processing models introduced by the GDPR: anonymisation and pseudonymisation. The analysis is carried out considering not only the interaction between GDPR and FFDR, but even in the light of the new regulation on data governance, the Data Governance Act (DGA).

The Chapter four explores the issue from a subjective perspective, focusing on how to grant data anonymity with the proliferation of roles and responsibilities among stakeholders involved in the processing and reuses of data. Analysing the different models proposed in the DGA, it investigates the span of the de-anonymisation/re-identification issue in data reuses as framed in the DGA, considering the main technological novelties introduced by the new regulation. In addition, it briefly explores the dialectic tension between the general interest in DGA and the public interest in the GDPR.

The Chapter five presents a legal empirical observation of the data de-anonymisation spectrum in further data processing and data sharing, providing empirical evidence on the reasonability of the in-force art. 17 of the GDPR in the light of the legal framework, considering the forthcoming implementation of the DGA and Data Spaces.

Finally, the Chapter six presents the conclusions of the thesis.

List of Acronyms and Abbreviations

CHF Cryptographic Hash Function

DGA Data Governance Act

DP Differential Privacy

FFDR Free Flow Data Regulation

GDPR General Data Protection Regulation

IOE Internet of Everything

IOT Internet of Things

M2M Machines to Machines

MAC Message Authentication Code MAC

NSI National Statistical Institutes

P2M People to Machines

P2P People to People

RNG Random Number Generator

SDC Statistic Disclosure Control

SMC Secure Multiparty Computation

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Chapter 1. *Subject Matter and Research Strategy*

Chapter Index

Short Abstract of the Chapter

This chapter presents the research framework, providing the research background and explaining its main legal premises. The methodology and methods of the research are then presented, which is further supported by an empirical legal observation of technological development on the risk of de-anonymisation/re-identification.

1.1. Research Context

The thesis investigates the *Rights of Internet of Everything* (IoE), conceived as a multidisciplinary perspective of one of the major technological trends going beyond the ongoing Internet of Things (IoT) era [1]. In its primary definition[2], IoE represents an interconnected world, a networked connection of people, process, data, and things.

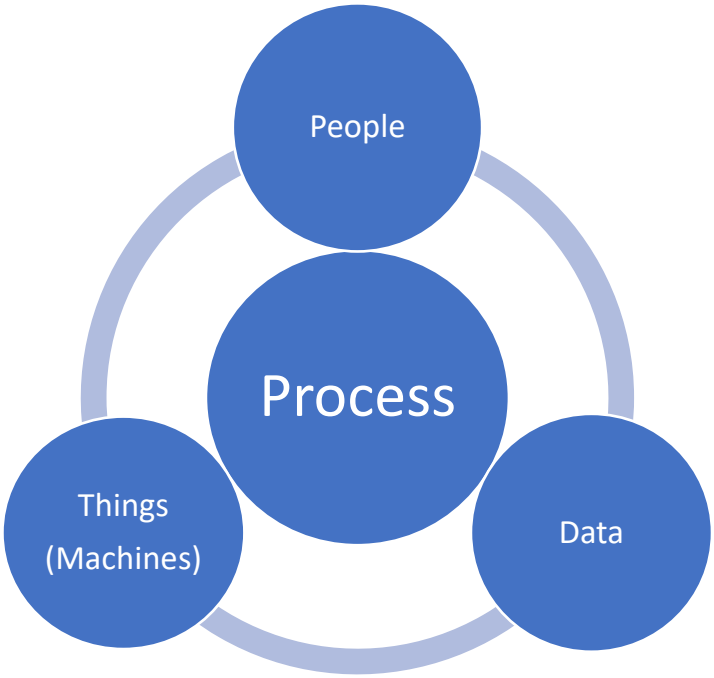

Fig. 1. Internet of Everything (IoE) connecting People to People (P2P), Machines to Machines (M2M) and People to Machines (P2M) relying on Big Data Analytics and granting Knowledge Processes

IoE represents a new paradigm in data processing, extracting, and analysing real-time data collected from heterogeneous sources [25]. Despite the unquestioned potential of IoE, few issues and challenges have been identified, especially regarding insights about the knowledge process [2–4]. This generates the need to design and implement appropriate IoE environments, from the initial phase [5], investigating the relationship between data, information, and knowledge. IoE represents a source of data allowing its processing, analysis, and reuses, to

[2] Cisco and Qualcomm were among the first companies to provide a definition of Internet of Everything. As references: https://www.cisco.com/c/dam/en_us/about/business-insights/docs/ioe-value-index-faq.pdf ; https://www.qualcomm.com/news/onq/2015/05/13/internet-everything-works-everyone

discover patterns, as well as to infer information. In the IoE, the network captures data related to individuals, as nodes of the network connected with non-human objects, like sensors and actuators. As such, from a mere legal point of view, the network captures data related to individuals which, by legal means, are considered personal data as defined in art. 4 of the General Data Protection Regulation[3] (GDPR) like *any information related to an identified or identifiable natural person*.

De facto, according to the European legal framework in force, data management requires the nature of data to be assessed to consequently identify the rules to be applied. While non-personal data can freely flow in the Digital Single Market, personal data can flow provided that some conditions are met. The GDPR imposes certain requirements and limits the free circulation of personal data. Only if the processing grants *anonymity*, thus impacting the nature of data, changing it from personal to non-personal, such requirements and limits no longer apply and the GDPR becomes no longer applicable, giving way to the Free Flow Data Regulation[4] (FFDR).

However, the border line between anonymity and identifiability introduced in the GDPR, albeit in its non-compulsory part, in *Recital 26*[5], seems uncertain and unclear [6, 7]. Moreover, in line with the accountability principle, the GDPR does not request any specific control, or audit on the anonymous nature of data for allowing further processing. As anticipated, anonymised data will fall outside of the scope of the regulation, provided that personal data are rendered *anonymous in such a manner that the data subject is not or no longer identifiable*.[6]

[3] Regulation (EU) 2016/679 of the European Parliament and Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

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

[5] Recital 26 of the GDPR states: "*The principles of data protection should apply to any information concerning an identified or identifiable natural person.*
Personal data which have undergone pseudonymisation, which could be attributed to a natural person by the use of additional information should be considered to be information on an identifiable natural person.
To determine whether a natural person is identifiable, account should be taken of all the means reasonably likely to be used, such as singling out, either by the controller or by another person to identify the natural person directly or indirectly.
To ascertain whether means are reasonably likely to be used to identify the natural person, account should be taken of all objective factors, such as the costs of and the amount of time required for identification, taking into consideration the available technology at the time of the processing and technological developments.
The principles of data protection should therefore not apply to anonymous information, namely information which does not relate to an identified or identifiable natural person or to personal data rendered anonymous in such a manner that the data subject is not or no longer identifiable.
This Regulation does not therefore concern the processing of such anonymous information, including for statistical or research purposes."

[6] See Recital 26 of the GDPR.

Therefore, the importance of exploring this field lies in the growing need to ensure data re-uses without sacrificing privacy and data protection.

In recent decades, the most traditional technical approach for rendering data anonymous has been anonymisation. It stemmed from the statistical community with the establishment of National Statistical Institutes (NSI), but recently, it has been proven that such an approach does not work effectively in many cases [8–11]. However, the GDPR still recalls it with pseudonymisation, as one of the two models for granting compliancy while protecting data and privacy of the data subjects.

In this sense, current trending topics in the field mainly investigate new technologies for granting data anonymity, allowing sharing and reusing, or eventually developing new models and methods that are able to measure information loss, quantify and measure the grade of anonymity.

Among the first, mainly investigated by the computer science communities, we can name blockchain technology [12], federated learning [13], and secured multiparty computation [14]. The scientific communities welcome these technological novelties with enthusiasm; however, they are subject to obsolescence. Moreover, as said, it should be taken into account that even the technological environment that these technologies rely on are in constant evolution, challenging their limits and potentials.

Among the second, mainly investigated by the statistical and mathematical communities, are some projects based on new models of anonymisation, which test the output of anonymised dataset, measuring the efficiency and extent of anonymisation[7].

From a mere legal point of view, tumultuous legislative activity in the digital field provides a dynamic ground. On one hand, it confirms that anonymisation is not a totally reliable model for protecting data [15] or for safeguarding people' privacy, while on the other believing that a feasible trade off can always be reached [16], especially if combined with a context-dependant evaluation [17].

This situation can be considered as characterised by techno-legal uncertainty: if on one hand it grants a certain flexibility in reusing data, on the other hand, it represents the root of many risks in the context of data protection and privacy.

Among these, the thesis aims to specify the investigation of the risk of *de-anonymisation*/*re-identification*, considered as the possibility of matching anonymous data (de-identified data,

[7] Among the projects: https://amnesia.openaire.eu/ ; https://arx.deidentifier.org/

thus processed personal data) with other available auxiliary data (publicly or privately available) [18, 19]. It is a risk mainly inherent to data sharing and data re-uses, implying appropriate designs of data governance for granting security and protection of data.

Such a risk is mentioned in Recital 9[8] of the FFDR, considered as the possibility of matching anonymous data (de-identified data, thus processed personal data) with other available auxiliary data (publicly or privately available). This practice is made possible using modern technologies such as Internet of Things, Artificial Intelligence, and Machine Learning.

In this regard, the legal approach to technological development is mainly based on soft law, relying on non-binding tools to prevent a hindrance to innovation.

Therefore, granting privacy and data protection in the IoE environment becomes challenging. In this sense, the European legal framework recalls a linear reality - *requesting to assess the nature of data referring to personal and non-personal data* – which, in practice, appears to be remarkably difficult to ascertain.

Data has a physiological nature to be streamed, processed, shared and re-used, thus its processing constantly impacts its nature. Moreover, it must be said that the de-anonymisation risk can pertain not only to processed personal data, but also to mixed datasets composed of both personal and non-personal data.

In keeping these premises, the thesis aims to investigate the de-anonymisation/re-identification risk in the evolution of the data policies and legislations proposed by the European Institutions. It focuses on the need to not sacrifice the potential of data sharing and data re-uses, unlocking the potential of *big data*, and analysing the tension between privacy and data protection posed by the risk of de-anonymisation/re-identification.

As a case study, the thesis provides a legal empirical observation on the technological development behind such risk, questioning the extent of the currently in-force art. 17 of the GDPR, the right to erasure (*right to be forgotten*).

Investigating the tension between data protection and privacy on the one hand, and the need to grant further uses of processed personal data, the thesis out lines the technological development of the de-anonymisation/re-identification risk, with an explorative literature review. After

[8] Recital 9 of the FFDR states: "*The expanding Internet of Things, artificial intelligence and machine learning, represent major sources of non-personal data, for example as a result of their deployment in automated industrial production processes. Specific examples of non-personal data include aggregate and anonymised datasets used for big data analytics, data on precision farming that can help to monitor and optimise the use of pesticides and water, or data on maintenance needs for industrial machines. If technological developments make it possible to turn anonymised data into personal data, such data are to be treated as personal data, and Regulation (EU) 2016/679 is to apply accordingly.*"

acknowledging its extent, it questions whether a certain degree of anonymity can still be granted, focusing on a double perspective: an objective and a subjective perspective. The objective perspective focuses on the data processing models *per se*, while the subjective perspective investigates whether the distribution of roles and responsibilities among stakeholders can have a role in ensuring data anonymity.

The objective perspective investigates the models of data processing as regulated by the GRPR, namely anonymisation and pseudonymisation. It frames the state of the art in the evolution of these data processing models and the degree of anonymity recognised by the various scientific communities (as anticipated, e.g. statistical, computer science). According to this perspective, it questions the relations between the traditional binary category of *anonymisation/irreversibility* and *pseudonymisation/reversibility*. In this sense, a new studied approach based on pseudonymity is introduced, discussing a new paradigm of data protection and privacy, still based on the semantic legal dichotomy between personal and non-personal data[9].

Conversely, the subjective perspective investigates whether a certain degree of anonymity can eventually be granted, relying on the proliferation of roles and responsibilities among stakeholders, analysing data governance models and especially in Government to Business (G2B) data sharing. In this investigation, the focus is on the European Data Governance Regulation COM/2020/767[10], the Data Governance Act presented as a natural evolution of the data policies in data flow.

To this end, the thesis investigates the legal framework that has been in force since 2018[11] when, confident of having settled the main ground for the protection of citizens' rights with the GDPR, the European Commission began to brainstorm new models of data sharing. In 2020, with the Data Strategy[12], it stressed a main *subjective* point, highlighting that "*Citizens will trust and embrace data-driven innovations only if they are confident that any personal data sharing in the EU will be subject to full compliance with the EU's strict data protection rules".*

A decade ago, [20] data governance was perceived and understood to be control over and management of data, connoted by a mere internal interest, as a company task granting clarity

[9] In this sense: http://infolegproject.net/

[10] https://eur-lex.europa.eu/legal-content/IT/TXT/PDF/?uri=CELEX:52020PC0767&from=EN

[11] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2018:0232:FIN

[12] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A European strategy for data, Brussels, 19.2.2020, COM(2020) 66 final.

of information. This concept has evolved over time and the literature has investigated a more holistic perspective [21]. Nowadays the concept *encompasses the entirety of transnational and trans-organisational data flows, from the macro-level of nation-states to the micro-level of citizens* [22]. Therefore, in the modern context, data governance can be organised differently, depending on the interests of the stakeholders involved.

The legal evolution in the technological domain is mainly based on soft law [23], mainly relying on non-binding tools for avoiding suffocating innovation. European legislation is mainly based on several hard law corpuses and on many soft laws [24]. This approach is aimed at avoiding overruling a sector, such the technological one, which is in constant development and in need of freedom in order to innovate. Moreover, traditional governance structures are becoming more difficult to impose, due to the ubiquitous nature of technology, as well as the ubiquitous nature of data. While fostering innovation linked to granting a certain freedom in the sector, such freedom might clash with other citizens' rights, with their fundamental rights.

Certainly, the increasing availability of data is impacting our societies and our economies, developing data-driven societies and data-driven economies. Every aspect of modern life is represented by data, allowing information to be derived from any kind of activity in the world - human and non-human - *captured* by the digital environment. With the increase of connected devices, the human presence – *per se* – will be captured by the digital environment and *datified.*

Regarding the need to investigate feasible policies in data governance, and overcome the initial perspectives on data ownership, the European legislator has refined traditional concepts of data access and data sharing for granting re-uses beyond the initial purpose of collection, and introducing the new legislation on Data Governance. Regulating the management of data and its availability, by increasing trust in data intermediaries and strengthening data-sharing across Europe and beyond, has impacted the research trend.

This thesis highlights the fragmentation of the topic, prior to the proposal presented in 2020: some publications addressed it with a specific focus on data quality, data security and data lifecycle year [21, 25, 26], while others focused on a review of the existing literature [21, 25, 27, 28]. Recently, the focus changed in favour of the balance between trust and accountability in developing new models of data governance, not only compliant with the GDPR but with technological development [22, 30–33]. In this regard, this research shows that a decade ago [20], data governance was perceived and understood as control over and management of data, connoted by a mere internal interest, as a company task granting clarity of information. This concept has evolved over time and academia has investigated a more holistic perspective,

referring to a concept which *encompasses the entirety of transnational and trans-organisational data flows, from the macro-level of nation-states to the micro-level of citizens* [26, 29]. Therefore, in a modern context, data governance can be organised differently, depending on the interests of the stakeholders involved.

Finally, the last part of the thesis proposes an empirical observation of the de-anonymisation issue, as recalled in the main document on anonymisation, the Working Party 29 Opinion 05/2014 on Anonymisation Techniques, strictly dependant on the legal dichotomy between personal and non-personal data. Using this approach, the thesis aims to perform an empirical observation of the semantic difference between personal and non-personal data broadening the perspective on the issue of de-anonymisation/re-identification, regardless of the infrastructure used.

Therefore, after analysing the extent of the de-anonymisation risk, the research aims to investigate the grounds on which the entire European system is built, namely the GDPR and the FFDR, which introduce the main semantic differences between personal data and non-personal data. In line with this premise, it questions the nature of data in the further uses of data and especially data sharing in Government to Business, as introduced in the new legislation on Data Governance. Overall, the thesis aims to evaluate two linked and underpinned vulnerabilities of the whole legal system regulating data flow in the Digital Single Market: the semantic difference between personal and non-personal data in granting anonymity, and the consequent issue of de-anonymisation in light of the right to erasure *ex* art. 17 of GDPR as a citizens' right granting anonymity.

The main new factor of the thesis is an empirical evaluation of the de-anonymisation/re-identification risk linked to identification and the right to be forgotten, as empirical legal studies on the topic are lacking. Moreover, in line with the last EU research foresight[13] the thesis prepares the ground for the future research and innovation policy, confirming that 2020 opened a transitional period based on the Digital Turn. Such change, where the dependency on technology is rapidly growing, imposes a multifaceted approach and a multidisciplinary perspective of the future challenges posed by technology, highlighting the importance of social sciences and empirical studies.

The need to develop new approaches for overcoming this issue is increasing over time, relying especially on perspectives which are not exclusively and purely technological, or legal, but is

[13] European Commission: After the new normal: Scenarios for Europe in the post Covid-19 world (2022).

a multidisciplinary approach which considers technology as the main basis to be observed reality.

1.1.1. Research Question

The research will be organised into two main questions and their sub-questions.

The first main question is the following:

- RQ1: In light of the increasing risk of de-anonymising data, turning non-personal data into personal data, are the two mutually exclusive definitions of personal and non-personal data relevant in tackling such a risk?

  This first question will be empirically researched, investigating the following sub-questions:

- RQ1.2: How does this semantic difference stands out in worldwide continental jurisdictions, in the research and development of de-anonymisation techniques based on singling-out, linkability and inference (as namely advised in the WP29 05/2014)?
- RQ1.2: How has the de-anonymisation issue evolved over time and what is the correlation between time and continental jurisdictions?

The second main question is the following:

- RQ2: How can the de-anonymisation risk be tackled from both an objective perspective (namely with reference to *privacy models*, *statistical disclosure control* and *encryption*) and a subjective perspective (with reference to the data governance models, especially G2B)?

The second main question leads to the following sub-question:

- RQ2.1: In light of the level of anonymity that data processing and data sharing can ensure, can the right to be forgotten still represent a remedy against the harmful disclosure of personal information?

1.2. Methodology

The research methodology is based on the merging of two methodologies: qualitative and quantitative.

The qualitative methodology relies on an analytical approach used for analysing all relevant European legislation in data flow. The analysis focuses on the main rules and principles to frame and investigate the risk of de-anoymisation/re-identification in modern digital environments, with a particular interest in legal terminology stemming from the *corpus* of the GDPR and the FFDR, namely referring to the concept of anonymous data and how to grant data anonymity for tackling the investigated risk. This approach develops a description of the processing from two different perspectives: one objective and the other subjective. The objective perspective explores the legal extent of terms relating to data processing, such as anonymisation and pseudonymisation, theorising on the extent of data anonymity. The subjective perspective explores the possibility of granting data anonymity, focusing on the proliferation of roles and responsibilities of the stakeholders involved in data processing, sharing, and reusing.

The qualitative methodology explains, interprets, and understands the issue of de-anonymisation/re-identification from a theoretical point of view, applying the rules and principles in force governing dataflow. Moreover, it sets the ground for the quantitative methodology, ensuring a further investigation of the de-anonymisation/re-identification risk from a practical perspective. The quantitative methodology is developed on the outcome of the qualitative one, performing a statistical analysis on the main premise of the thesis, the de-anonymisation risk in its global extent first of all, and secondly recalling the Working Party 29 Opinion 5/2014 on anonymisation techniques.

Merging both qualitative and quantitative methodologies aim to formulate the proposal of possible solutions to a real-life problem that require an action or policy decision, after an empirical observation of said problem.

Therefore, the research is built on the design of an empirical research which involves:

1- Defining the research questions
2- Theorising and extracting observable implications from the theory
3- Identifying rival hypothesis
4- Proposing solutions

1.2.1. Methods

The main method of the research is based on empirical legal research, involving a research design that relies on the collection of the relevant legal-tech terminology.
The research is focused on a systematic literature search in *Arxiv*, performing an explorative network analysis of keyword co-occurrences and a content analysis of these publications.
This approach allows an empirical observation of the technological development of the de-anonymisation/re-identification risk. A statistical analysis will be performed on the outcome of data collection, relying on a designed codebook [30] hereinafter described.

1.2.2. Codebook

The empirically searchable empirically searchable research question is the first one listed in the specific session, and its sub-questions above.
The empirical legal study is supported by the following main theory. Market and technological developments of Internet of Things, Artificial Intelligence and Machine Learning applications rely on a conspicuous set of data, which may comprise both personal and non-personal data. This situation expands the possibilities of de-anonymising data thus, the possibility of transforming non-personal data into personal data.
To this extent, art. 8(1)(a) of the FFDR namely establishes that *No later than 29 November 2022, the Commission shall submit a report to the European Parliament, to the Council and to the European Economic and Social Committee evaluating the implementation of this Regulation, in particular in respect of the application of this Regulation, especially to data sets composed of both personal and non-personal data in the light of market developments and technological developments which might expand the possibilities for de-anonymising data.*

The legislator explicitly recognises that processing personal data as *input* may not necessarily lead to non-personal data as *output*. Therefore, neither data quality nor security can be totally ensured, unleashing potential misuses and abuses in secondary uses of processed personal data.

The whole legal regime ruling data circulation is anchored to two mutually exclusive definitions: personal data and non-personal data. *Ex* Art. 4(1) of the GDPR[14], Personal Data is *any information related to an identified or identifiable natural person*, while *ex* Art. 3(1) of the FFDR[15], Non-Personal Data is *data other than personal data as defined in point (1) of Article 4 of the GDPR.*

As such, the *nature* of data determines the legal framework and the rules to be applied: while non-personal data can flow freely in the Digital Single Market, personal data can circulate provided that some conditions are met.

However, data processing, circulation and re-use naturally imply a change in the nature of data. Moreover, as anticipated, most of the time datasets are combined by both personal and non-personal data thus, ascertaining the nature of data and consequently the legal framework to be applied may be extremely complicated.

This difficulty has even been explicitly recognised by the European Commission[16] concluding that, in mixed datasets if the non-personal data part and the personal data part are '*inextricably linked*' the data protection rights and obligations stemming from the General Data Protection Regulation fully apply to the whole mixed dataset, also when personal data represent only a small part of the dataset. Despite that, the protection risks being merely fictitious due to the fact that personal data processing does not necessarily lead to non-personal data.

Coordinating law with reality is not easy and such open standards create legal uncertainties, especially as there is a total lack of *ad hoc* controls on the nature of data.

The main example of this uncertain scenario concerns anonymisation. The legislation in force recalls anonymisation as data processing able to determine a change in the nature of data: the *input data* (personal data) undergoing anonymisation leads to anonymous data as *output data* (thus, non-personal data). Consequently, data which have undergone a process of anonymisation fall outside the scope of data protection legislation, as they are considered

[14] Regulation (EU) 2016/679 of the European Parliament and Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

[15] Regulation (EU) 2018/1807 of the European Parliament and Council of 14 November 2018 on a framework for the free flow of non-personal data in the European Union (Free Flow Data Regulation).

[16] Communication from the Commission to the European Parliament and the Council, Guidance on the Regulation on a framework for the free flow of non-personal data in the European Union COM/2019/250(final).

anonymous data, not related to an identified or identified natural person. Eventually, as recalled in a non-binding part of the GDPR - Recital 26, *to ascertain whether means are reasonably likely to be used to identify the natural person, account should be taken of all objective factors, such as the costs of and the amount of time required for identification, taking into consideration the available technology at the time of the processing and technological developments.*

The objectivity of these factors is certainly questionable, especially in the global context. Case studies and research publications have shown how difficult it is to create a truly anonymous dataset [8][17] [31][18] [32][19] [33][20] [34][21].

This premise makes anonymisation one of the most controversial topics discussed in legal-tech literature, as the assessment of whether data is properly anonymised depends on specific and unique circumstances of each individual case.

It must be said that the legislation in force does not provide any specific check or control to confirm and assess this change in nature; nor is a *prescriptive* standard determined for anonymisation processing. There is a remarkable need to ethically audit data processing, ensuring not only the protection of data but also the quality of data.

The sole institutional reference to anonymisation stems from Opinion 05/2014 issued by the Working Party 29 (WP29) on Anonymisation techniques[22], although it is non-binding. In this Opinion, the WP29 *analyses the effectiveness and limits of existing anonymisation techniques against the EU legal background of data protection and provides recommendations for a cautious and responsible use of these techniques to build a process of anonymisation.*

The WP29 stresses the inherent risk in anonymisation, which has to be considered in assessing the validity of any anonymisation technique. Here it advises testing the effectiveness and limits of each anonymisation technique against three main criteria:

- Singling-out (it is still possible to single out an individual)
- Linkability (it is still possible to link records relating to an individual)

[17] It was demonstrated that the governor of Massachusetts could be re-identified from de-identified medical data by cross-referencing the de-identified information with publicly available census data used to identify patients.
[18] In 2009, Netflix released an anonymised movie rating dataset as part of a contest, and researchers successfully re-identified the users.
[19] In 2013, another study, conducted on anonymised cell phone data, showed that "*four spatio-temporal points are enough to uniquely identify 95% of the individuals*".
[20] In 2017, researchers released a study stating that "*web-browsing histories can be linked to social media profiles using only publicly available data*".
[21] Recently, studies have shown that de-identified data was in fact re-identifiable, and researchers at UCL in Belgium and Imperial College London found that "*99.98% of Americans would be correctly re-identified in any dataset using 15 demographic attributes*".
[22] Opinion 05/2014 on Anonymisation Techniques Adopted on 10 April 2014.

- Inference (information concerning an individual can be inferred).

Therefore, an effective anonymisation solution should *prevent all parties from singling out an individual in a dataset, from linking two records within a dataset (or between two separate datasets) and from inferring any information in such dataset*.

The main objective is to contain the risk of de-anonymisation which may prevent other correlated risks (e.g. profiling).

The empirical study aims at observing the technological development of the de-anonymisation issue from a legal perspective, considered as the possibility to turn non-personal data into personal data.

As a main reference for performing this observation, the three criteria listed by the WP29: singling out, inference, linkability, are used as words for filtering the papers published in an Open Access repository: Arxiv (https://arxiv.org/).

The observation will be performed over a span of 6 (six) years, from 2016 (data in which the two main regulations ruling on data flow entered into force) until 2022.

For each paper a number of 6 (six) variables (quantitative and qualitative) will be observed:

1. Year of publication in the timeframe 2016 to 2022 (transition period from the Directive 95/46/CE to the GDPR EU 2016/679).
   Qualitative Variable.
2. Jurisdiction (author's jurisdiction based on affiliation) as EU, US, Asia, Africa.
   Qualitative Variable.
3. De-anonymisation risks/technique as singling out, linkability, inference.
   Qualitative Variable.
4. The nature of data used for performing de-anonymisation as personal data (1), non-personal data (2), mixed data (3).
   Qualitative Variable.
5. The number of publications.
   Quantitative Variable.
6. The number of publications compared with the year of publication.
   Dummy Variable.

If the theory is correct, the empirical study would show whether the semantic difference - introduced by the legislation as a main filter of data protection - has an impact on the issue and risk of data de-anonymisation.

The observation of the variable concerning authors' jurisdiction may/may not eventually confirm that the semantic difference has/has no impact on tackling and containing the risk of de-anonymisation.

a) Outlining how the concepts can be measured

Selection of papers on de-anonymisation (by singling-out, linkability, inference) using an open access repository. A text analysis on each paper will be conducted, collecting the above-mentioned information.

b) Identifying the values of the measures

Variable n.1: 2016 to 2022

Variable n.2: Europe (1), America (2), Asia (3), Africa (4)

Variable n.3: Singling-out (1), Linkability (2), Inference (3)

Variable n.4: Personal Data (1), Non-Personal Data (2), Mixed Data (3).

Variable n.5: number of published papers

Variable n.6: relationship between the number of papers and the year of publication to observing whether implementation of the GDPR has generated an increase in the paper publications. Dummy variable as No (0), Yes (1)

The combination of qualitative and quantitative variables will allow a statistical analysis of the outcome to be performed.

c) Evaluating measures and measurement methods

c.1. Reliability

The nature of data, as indicated in the legal regulations (GDPR & FFDR), will allow the paper to be legally categorised. There may be a lack of reliability in the textual analysis as interpretation of the rules may prove challenging in some borderline cases.

c.2 Validity

As above: the nature of data as indicated in the legal regulations (GDPR & FFDR) will allow the paper to be legally categorised. There may be a lack of reliability in the textual analysis as interpretation of the rules may prove challenging in some borderline cases.

d) Data Collection

d.1 Target population

The analysis will be carried out by collecting and indexing papers published in one OpenAccess publications repository (*arxiv*) referring to the following keywords:

- Singling-out

- Linkage
- Inference

The observation period spans from 2016 to 2022.

d.2 Locating data

The dataset will be created based on the data collected in the previously mentioned OpenAccess publication repository and saved in the OneDrive belonging to Alma Mater Studiorum – Università di Bologna (shared file with main supervisor Professor Monica Palmirani)

d.3 Generating Data

The collection of data will be conducted using the following keywords:

- Singling-out
- Linkage
- Inference

Each paper that contains at least oneof these keywords should be included in the dataset.

A classification of the papers will then be conducted to grasp possible future relations and insights.

The parameters observed will be:

1 – year of publication
2 – continental jurisdiction (author's jurisdiction based on affiliation)
3 – nature of the data used for de-anonymise
4 – de-anonymisation risks/techniques as singling out, linkability, inference
5 – number of publications
6 – number of publications compared with the year of publication

d.4 Amount of data to be collected

The dataset will include all the data collected for the timeframe spanning from 2016 to 2022.

e) Coding, Analysing and Communicating results

The research will be based on both quantitative and qualitative data.

Therefore, both inductive and deductive coding techniques will be applied.

1.1 exhaustivity of variables' values

N/A

1.2 mutual exclusivity of variables' value

N/A

The collection of data using the above-mentioned parameters and observing the different variables will allow mainly exploratory data analysis and statistical analysis to be performed, using an Open-Source Data Analytics Platform: *Knime* https://www.knime.com/

The communication of data and results will be part of the penultimate chapter of the thesis, including graphs on statistical analysis for representing data after observation.

Chapter 2. *Governing Data Collected through Datafication: an Objective Perspective*

Index of the Chapter

Short Abstract of the Chapter

This chapter presents an objective perspective on the issue of deanonymisation.
Specifically, it investigates whether a certain degree of anonymity can be granted relying on the two main data processing methods considered by the GDPR: anonymisation and pseudonymisation.
It shows the state of the art of such data processing, investigating the extent of the anonymity they can grant.

2.1. The Represented Linear Reality of Personal Data and Non-Personal Data in the European Data Flow

The European data flow relies on a represented linear reality of personal and non-personal data, anchored to two mutually exclusive definitions.

These concepts are established into two different bodies of legislation:

- *Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation),* hereinafter referred as GDPR
- *Regulation (EU) 2018/1807 of the European Parliament and of the Council of 14 November 2018 on a framework for the free flow of non-personal data in the European Union,* hereinafter referred as FFDR.

These regulations introduce the main difference between personal and non-personal data, defining the rules for ensuring a proper data flow within the European borders and outside those borders. According to this framework, personal data is regulated by relying on a higher level of protection, while non-personal data can flow freely in the digital environment.

Therefore, ascertaining the nature of data is of paramount importance to determine the regulation and rules to apply: data taxonomy becomes crucial.

Art. 4(1) of the GDPR defines 'personal data' as "*any information relating to an identified or identifiable natural person ('data subject')* [...]".

In order to clarify this concept, the Working Party 29[23] stated that the contextual presence of 4 elements connotes personal data:

- *Any information*
- *Relating to*
- *An identified or Identifiable*
- *Natural Person*.

This specification certainly helps to determine the size of the concept but a broader view, in light of the risk of deanonymisation/re-identification as previously analysed, confirms the vulnerabilities which were originally highlighted in the Impact Assessment of the Regulation[99].

In fact, the difference between personal and non-personal data, as proposed in both regulations, seems to struggle if it takes into account data lifecycle and the physiological data attitude to be processed. Such processing modifies the status and nature of data, consequently, its definition and category.

In principle, the definition of personal data was coming from the centrepiece of EU legislation on data protection, Directive 95/46/EC adopted in 1995, with two main objectives: protecting the fundamental right to privacy and guaranteeing the free flow of personal data between Member States[24]. At that time, this definition of personal data had the advantage of providing a high degree of flexibility, and the possibility to adapt to various situations and future developments affecting fundamental rights. For this reason, the definition of "personal data" has been literally transposed into the GDPR, and by the majority of the Member States into their national laws.

However, since then, this broad, flexible definition has led to some diversity in the practical application of these provisions. For example, the issue of objects and items ("things" – referring to IoT systems) linked to individuals, such as IP addresses, unique RFID numbers, digital pictures, geo-location data and telephone numbers, has been dealt with differently by the various Member States.

[23] In detail: Article 29 Data Protection Working Party Opinion 4/2007 on the concept of personal data.

[24] The Directive was also complemented by several instruments providing specific data protection rules in the area of police and judicial cooperation in criminal matters (ex third pillar), including Framework Decision 2008/977/JHA

To this extent, the CJEU played, plays - and continues to play - an essential role in resolving these diversities, thus harmonising the legislation[25] and confirming that there is always room to shape the concept of personal data better.

Nevertheless, the core of the problem leading to legal uncertainty as a major area of divergence in the Member States, strictly linked to the data processing - and confirmed in the Impact Assessment of the Regulation (as mentioned above) - relates to the concept of *identifiability*. Specifically, it relates to the circumstances in which data subjects can be said to be "*identifiable*"; if data has been made "*anonymous*", so that data can no longer be related to the individual; if data has been "*pseudonymised*", where data can only be linked to the individual if one is in possession of a decoding "key".

Nowadays, the meaning and interpretation of *identifiability* still represents the main reason why the concept of personal data - and its interconnection with non-personal data - is widening and remaining problematic, especially in perspective of data processing, e.g. anonymisation, pseudonymisation.

Practically speaking, a person can be considered "identified" when she/he can be distinguished within a group of persons. In the case of identifiability this is not yet the case, however, it might be possible, e.g. by linking different data sets.

When transposed into the technological environment, as anticipated in the previous chapter, this perspective leads to the concept Personally Identifiable Information (hereinafter referred to as PII). Referring to the International Standards[26], ISO standard 27701[27] defines PII as "*any information that*

(1) *can be used to establish a link between the information and the natural person to whom such information relates, or*

(2) *is or can be directly or indirectly linked to a natural person*".

[25] To this aim, as an example, the judgment Case C-582/14: Patrick Breyer v Bundesrepublik Deutschland in which the Court ruled that dynamic IP addresses may constitute "personal data" even where only a third party has the additional data necessary to identify the individual.

[26] The European Commission's policy aims to align European Standards as much as possible with the international standards adopted by the recognised International Standardisation Organisations ISO, IEC and ITU. This process is called "primacy of international standardisation", meaning that European standards should be based on International standards (COM(2011)-311, point 7). For more info, cfr: https://ec.europa.eu/growth/single-market/european-standards/policy/international-activities_en

[27] ISO/IEC 27701:2019 (formerly known as ISO/IEC 27552 during the drafting period) is a privacy extension to ISO/IEC 27001. The design goal is to enhance the existing Information Security Management System (ISMS) with additional requirements in order to establish, implement, maintain, and continually improve a Privacy Information Management System (PIMS). The standard outlines a framework for Personally Identifiable Information (PII) Controllers and PII Processors to manage privacy controls to reduce the risk to the privacy rights of individuals.)

Contextualising these definitions in a dataset composed of different records, any kind of value can be a PII [100]. Consequently, it is possible to affirm that in the digital context based on big data, an "identity" [25] is any subset of attributed values of an individual person and, therefore, there is usually no such thing as "the identity", but several of them, as many as the number of the values combined with the same data-holder [101]. It goes without saying that the problem becomes greater if recalling the main premise of the data cycle, applied in the context of Big Data analysis systems in IoE environments, taking into account that any PII has a natural lifecycle [102] [103].

As specifically stated in the ISO standard "*from creation and origination through storage, processing, use and transmission to its eventual destruction or decay. The risks to PII can vary during its lifetime but protection of PII remains important to some extent at all stages. PII protection requirements need to be taken into account as existing and new information systems are managed through their lifecycle*."

To this extent, it can certainly be said that what is defined as personal data in *ex-ante* processing, cannot necessarily last and be confirmed at the moment of *ex-post* processing as non-personal and vice-versa, and also that there is certain clarity on the output data resulting from certain processing, e.g. anonymisation or pseudonymisation.

The investigation on the concept of personal data should be conducted while bearing in mind two different perspectives: the static, based on the reasoning of what can be literally considered as "personal data" and the dynamic one, thus what kind of status and nature modification data can have due to the processing, and the lifecycle.

After few years of the GDPR being in force, these vulnerabilities have been widely confirmed and discussed in academic debate [104] [37][105] [106] [94].

The importance in defining the concept of personal data is strengthened by the combined provisions of Art. 4 GDPR and Art. 2 FFDR, followed by Recital 26 of GDPR and Recital 8 of the FFDR.

With Article 4 GDPR and Art. 2 of FFDR, the legislator seems to acknowledge a mutually exclusive concept of personal and non-personal data. Moreover, Recital 26 of the GDPR and Recital 8 of the FFDR contains the acknowledgement that data processing can modify the nature of data, thus affecting the recognised protection and consequently placing on the shoulders of data processors and data controllers the responsibility of assessing the re-identification risk.

2.1.1. The GDPR and the FFDR in the perspective of the Data Governance Act (DGA)

The uncertainty linked to the two mutually exclusive definitions of personal and non-personal data impacts the development of future legislation. In fact, the GDPR and the FFDR settled the legislative ground for the European data flow before the definition of the data strategy presented by the European Commission in 2020[28]. However, despite the fact these pieces of legislation introduced the main difference on the *nature* of data, they did not provide a formal definition of data, which is only presented in the Data Governance Act[29]. Here, data is considered as *any digital representation of acts, facts or information and any compilation of such acts, facts or information, including in the form of sound, visual or audiovisual recording.* Even here, this definition seems extremely broad and includes not only individual data, but also data *compilations* [107]. As a consequence, the DGA imposes a changeover in the meaning of the data concept from the syntactic level to the semantic one, including the whole content of digital means. In this regard, especially recalling *compilation* and without specification of whether it refers to databases, datasets, or even aggregate data, it imposes an investigation of the interplay between the contents of the DGA, the GDPR and the FFDR, especially on a semantic level.

Semantically speaking, it seems that the definitions of the nature of data do not have the same relevance they used to have before this new piece of legislation entered into force.

[28] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en

[29] Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act) (Text with EEA relevance) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32022R0868

The DGA aims to set up a viable legal framework for data sharing, unleashing the potential of data flow. In this sense, the DGA seems to present a number of inconsistencies with the GDPR, most of which have also been investigated by the European Data Protection Board (EDPB) and the European Data Protection Supervisor (EDPS).

Specifically, in a Joint Opinion[30] the EDPB and the EDPS stress two main relevant points:

1. the blurring of the distinction between the processing of personal and non-personal data, and
2. the unclear relationship between the DGA and the FFDR.

Concerning the first point, the opinion confirms that the scenarios envisaged and desired by the *ratio* of the DGA increases the deanonymisation/re-identification risk for data subjects, as it proportionally increases the availability, re-uses and sharing of information, as well as the combination of personal data with non-personal data[31]. In this particular case, it is specified that different levels of safeguards can be deployed, even if it should be taken into account that with the increased availability of data and information, as well as the increase in its circulation, the risk naturally increases.

Concerning the second point of the relationship between the DGA and the FFDR, one of the main points of inconsistency emerged in relation to the *compilation* of data, namely in the combination of personal and non-personal data thus, the so-called *mixed datasets*.

[30] EDPB-EDPS Joint Opinion 03/2021 on the Proposal for a regulation of the European Parliament and of the Council on European data governance (Data Governance Act) https://edpb.europa.eu/system/files/2021-03/edpb-edps_joint_opinion_dga_en.pdf

[31] In this sense: Explanatory Memorandum, page 3.

2.1.2. Mixed data and the definition of data in the DGA

Art. 2(2) of the FFDR states that "*In the case of a data set composed of both personal and non-personal data, this Regulation applies to the non-personal data part of the data set. Where personal and non-personal data in a data set are inextricably linked, this Regulation shall not prejudice the application of Regulation (EU) 2016/679*".

To clarify the concept of inextricability, the European Commission released practical guidance for businesses on how to process mixed datasets [108], contextualising the case and confirming that in most real-life situations, a dataset is however very likely to be composed of both personal and non-personal data (mixed dataset). In this case it confirms that it would be challenging and impractical, if not impossible, to split such mixed datasets.

In this sense, it is then clearly evident that the main premise of conceiving two mutually exclusive concepts of personal and non-personal data sclerotised the whole system and, to a certain extent, as pointed out by some authors [109], became counterproductive to data innovation.

The legal uncertainty linked to the definition of personal and non-personal data, and to their interconnections, was also pointed out in the process of the FFDR Impact Assessment (see above), and especially in the feedback provided by the stakeholders, namely the academic ones and, in time, has been confirmed.

Academics are still stressing a more proper evaluation of the differential element between personal and non-personal data, given by identifiability, on whether - and if so - under which circumstances personal data can be processed to become non-personal data [106].

Others [110], referring to the *Breyer* case (as above), consider that characterising the data should be context-dependent, stressing the fact that the concept of personal data has some limits and the line between personal and non-personal data is fluid and evolves over time. This

reasoning also applies to anonymised data, meaning that, over time, non-personal data can become personal data again, because the context changes over time [104]. Specifically, authors consider that contextual controls have been conceived as complementary to anonymisation (e.g. *sanitisation techniques*) by the drafters of the GDPR. The GDPR is also considered compatible with a risk-based approach when contextual controls are combined with sanitisation techniques.). Hence, in order to mitigate the gross risk of re-identification, contextual checks become essential.

For others [23], the broad notion of personal data and the mutually exclusive concept of non-personal data is not problematic and even welcome, but this will change in future when everything will be or will contain personal data, leading to the application of data protection to everything. This will happen because technology is rapidly moving towards perfect identifiability of information, where datafication and data analytics will generate a lot of information. Therefore, "*the intensive compliance regime of the General Data Protection Regulation (GDPR) will become 'the law of everything', well-meant but impossible to maintain. [...] and by then we should abandon the distinction between personal and non-personal data*".

The FFDR complements the European legal framework on data processing, representing the natural continuation of the approach of the GDPR for personal data, introducing a smooth approach for the circulation of non-personal data. However, the semantic difference between personal and non-personal data seems to be remarkably difficult in practice, especially in the case of mixed big datasets. Moreover, apart from that, it must be stated that personal data can be generated from non-personal data as well, relying on deanonymisation techniques, as mentioned above.

In any case, personal data and non-personal data are often difficult to distinguish and a specific binding regulation on mixed dataset is lacking.

Moreover, in the above-mentioned guidance, the European Commission specifies that if non-personal data and personal data are inextricably linked, the GDPR prevails [111]. For the time being, the concept of inextricability has not yet been explored or investigated, opening up to a very broad concept of it.

In such a particular case, distinguishing only between personal and non-personal data may not necessarily grant proper protection to other types of data generally included in the main category of non-personal data, such as IP rights and namely trade secrets, copyrights, patent and confidential information.

To this extent, the Data Governance Act seems to confirm such an opening, unleashing the potential of many kinds of data. In defining the scope of application of the DGA, Article 3 refers to data held by public sector bodies which are protected on grounds of:

(a) *commercial confidentiality, including business, professional and company secrets*;

(b) *statistical confidentiality*;

(c) *the protection of intellectual property rights of third parties*; or

(d) *the protection of personal data, insofar as such data fall outside the scope of Directive (EU) 2019/1024*.

With such an approach, the DGA tends to go beyond the semantic dichotomy of personal and non-personal data as it extends the amount of data held by Public Sector Bodies that can be re-used, creating an ecosystem of trust [29], overcoming the main focus on the *nature* of data as in the GDPR and the FFDR.

It introduces new measures aimed at tacklng substantial issues posed by data reuses, such as *the lack of cross-sectoral interoperability, the limited ability to obtain reusable data, and the uncertainty about data quality*.[32]

In line with these premises, the questions posed by the concept of *inextricability* seems to represent an old perspective of and approach to data, outclassed by a new approach which relies on designing data stewardship entities for granting and advancing data access [112], on the assumption that technological development cannot be contained, thus it is better to deploy subjective solutions over the objective one. In this regard, some elements in the new DGA Regulation may eventually confirm this approach, such the prohibition of sharing data by default, the evaluation on the nature of data, the re-purpose of data and many more points that will be investigated in the following chapter.

[32] Commission Staff Working Document, Impact Assessment Report accompanying the DGA proposal, SWD (2020) 295 final https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020SC0295&from=EN

2.1.3. Processing and granting anonymity: certain grades of uncertainty

In spite of the mentioned different layers of legislations and their inconsistencies, there is one central point which seems to be granted in all them, in the GDPR, in the FFDR and in the DGA. These pieces of legislation recall anonymisation and pseudonymisation as the two main data models for implementing privacy by design and data protection, that are two different and independent models. Both impact on the identifiability of the natural persona to whom data refers.

However, in practice, there is often some confusion between the two models, their notions and application, especially on the perception of pseudonymised data as anonymous data [113].

In looking for a definition of anonymisation, the GDPR does not provide one, and neither does the FFDR or the DGA. The Working Party 29 Opinion 05/2014 on Anonymisation Techniques [114] explicitly considers this model as "*further processing*". As such, it must comply with the test of compatibility in accordance with the guidelines provided by the Working Party 29 Opinion 03/2013 on purpose limitation [115], and with the deanonymisation risk test as per the Working Party 29 Opinion 05/2014.

Differently, with regard to pseudonymisation, art. 4(5) of the GDPR defines pseudonymisation as "*the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organisational measures to ensure that the personal data are not attributed to an identified or identifiable natural person*".

This definition requests the presence of two main elements:

- the removal of the attribution link between the personal data and the data subject
- its replacement with new additional information.

When contextually considered by the legislation in force, these two elements make data always re-identifiable therefore, personal data.

In switching from the legal context to the technological one, namely recalling ISO 29100 for anonymisation[33] and ISO 25237 for pseudonymisation[34], the main difference between the two types of data processing is *irreversibility/reversibility*. Here, while anonymisation is considered an irreversible data model processing, pseudonymisation is considered a reversible data model processing. However, due to the available technology and the technological development, this dichotomy has eroded, at least regarding the irreversibility of anonymisation. This awareness can also be found in the legal framework, and namely in Recital 26 of GDPR[35] and Recital 9 of the FFDR.[36]

It is indeed generally recognised that, despite the investments and the different implementations by several interested communities (statistical, informatics, electrical engineering), in general, it is not possible to perform perfect anonymisation, and the span of the deanonymisation issue is rapidly increasing. This perception is confirmed by the academic debate which, at least regarding anonymisation seems to be polarised, focused on questioning whether anonymisation could - or could not - be a proper tool for protecting data. On one hand, some academics [15] [116] [117] [118] believe that it is not possible to grant proper, irreversible anonymisation while at the same time maintaining the data useful, or vice-versa. Others [16] [119] consider that, despite the awareness of the deanonymisation issue, a compromise between the commercial, social value of sharing data and some risks of identifying people should always be reached - even if producing consequences for personal privacy and data protection.

Thus, the traditional academic debate on anonymisation seems to be represented by a relation of *inverse proportionality* between data utility and data protection, as follows:

[33] International Standard Organisation (ISO/IEC) 29100:2011 Information technology – Security techniques – Privacy framework (*Technologies de l'information – Techniques de sécurité – Cadre privé*).

[34] International Standards Organisation (ISO/IEC) 25237:2017 Health informatics — Pseudonymisation. It contains principles and requirements for privacy protection using pseudonymisation services for the protection of personal health information.

[35] "*The principles of data protection should apply to any information concerning an identified or identifiable natural person.*
[...] The principles of data protection should therefore not apply to anonymous information, namely information which does not relate to an identified or identifiable natural person or to personal data rendered anonymous in such a manner that the data subject is not or no longer identifiable."

[36] "*The expanding Internet of Things, artificial intelligence and machine learning, represent major sources of non-personal data, for example as a result of their deployment in automated industrial production processes. Specific examples of non-personal data include aggregate and anonymised datasets used for big data analytics, data on precision farming that can help to monitor and optimise the use of pesticides and water, or data on maintenance needs for industrial machines. If technological developments make it possible to turn anonymised data into personal data, such data are to be treated as personal data, and Regulation (EU) 2016/679 is to apply accordingly".*

$$x \cdot y = k$$

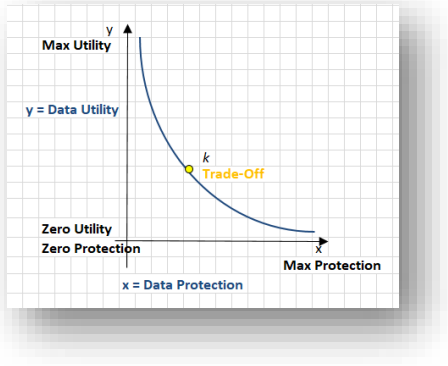

Fig. 2. Graph representing the inverse proportion between utility and protection in data anonymisation

Differently, with regard to pseudonymisation, research has increased in expanse and time, with an increasing interdisciplinary character, especially after being included in the GDPR as a data security measure.[37]

In the WP29 Opinion 04/2015 on the Anonymisation Techniques, pseudonymisation is defined by negation as "*not a method of anonymisation* [...]. *It merely reduces the linkability of a dataset with the original identity of a data subject and is accordingly a useful security measure*."

Some researchers have focused their attention on the risks linked with the choice of including it as a security measure [120], preparing the ground for an intense debate on the ambiguity surrounding the concept of pseudonymisation in the GDPR [121].

[37] GDPR - Article 32. Security of processing.
1. *Taking into account the state of the art, the costs of implementation and the nature, scope, context and purposes of processing as well as the risk of varying likelihood and severity for the rights and freedoms of natural persons, the controller and the processor shall implement appropriate technical and organisational measures to ensure a level of security appropriate to the risk, including inter alia as appropriate:*
a. the pseudonymisation and encryption of personal data; [...].

The choice made by the legislator, to include pseudonymisation among the data security tools to be improved and designed in line with the principles of privacy by design, the debate on pseudonymisation has even increased.

Despite some contrasts in the definitions as anticipated, the growing potential of pseudonymisation now seems to have been recognised, and data utility and data protection seem to be in a relation of *direct proportionality*, as follows:

$$y / x = c$$

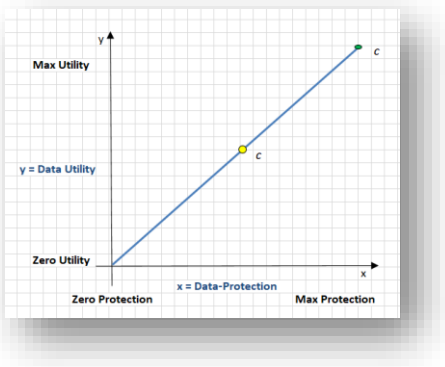

Fig. 3. Graph representing the direct proportion between utility and protection in data pseudonymisation

The remarkable importance given to these two models of processing data relies on the fact that both can be used to grant anonymity and protecting personal data. However, in line with the developments highlighted by the state of the art, anonymisation seems to be an obsolete model which was tailored for microdata (especially for the statistical needs of privacy preserving data publishing) and, as such, no longer suitable for big data analytics except for particular cases.

Differently, pseudonymisation seems to unfold its potential in big data analytics leading to overcoming the traditional objective approach (reversibility/irreversibility) and opening a new interpretation based on a subjective approach to data processing models, which involves all the stakeholders involved in the generation, collection and processing of data.

2.2. Anonymisation, deanonymisation and the trade-off between data utility and data protection

Anonymisation can be generally considered as the fact or process of rendering something anonymous; in this context, the main reference is to data, to rendering data anonymous thus not referring to a natural person. From a legal point of view, anonymous data should be considered non-personal data.

In providing specific examples of non-personal data, Recital 9 of the FFDR states *aggregate data* and *anonymised data* used for big data analytics. The Recital specifies, "*If technological developments make it possible to turn anonymised data into personal data, such data are to be treated as personal data, and Regulation (EU) 2016/679 is to apply accordingly*".

This specification clearly confirms the legislator's awareness of the deanonymisation issue the analysis of which is increased and completed in Recital 26 of the GDPR. Here, after stressing identification as an essential connoting element of personal data (personal data is only the one in which the data subject is *identified* or *identifiable*) the legislator determines the rules to assess whether anonymised data (thus, non-personal data) can be turned into personal data.

As anticipated, Recital 26 of GDPR clearly specifies that "*to determine whether a natural person is identifiable, account should be taken of all the means reasonably likely to be used, such as singling out, either by the controller or by another person to identify the natural person directly or indirectly*."

Thus for determining the nature of anonymised data, it becomes necessary to perform a case-by-case evaluation.

It is then clarified that "*to ascertain whether means are reasonably likely to be used to identify the natural person, account should be taken of all objective factors, such as the costs of and the amount of time required for identification, taking into consideration the available technology at the time of the processing and technological developments*."

In line with what is considered in the Recitals, the cost, the time, the available technology, and the technological developments represent objective factors in the analysis of the possibility to turn anonymised data into personal data. Only this assessment determines the level of protection granted to anonymised data, on the awareness that deanonymisation represents an issue and a risk.

Therefore, anonymised data cannot be considered by definition or by default as non-personal data: its nature has to be ascertained taking into account objective factors such as cost, time, available technology and technological development. The outcome of anonymisation does not determine *per se* the nature of data, as the identifiability of the natural personal to whom the data pertains can be anyway compromised.

2.2.1. Anonymisation in the soft-law: singling-out, linkability and inference

In the last two decades, the academic debate has registered a change from the past: rather than questioning whether anonymisation was a proper tool or not for protecting data and privacy, academics are currently demonstrating the possibility of reversing the process of anonymisation, exploring and studying its correlated techniques.

The attention is focused on the concrete possibility of deanonymising data that have undergone a process of anonymisation, relying on the available technology and technological development (no matter the anonymisation techniques used).

Concerning the legal framework in force, despite several mentions of anonymisation in the GDPR, FFDR and the DGA, the legal analysis confirms that European legislation does not provide an explicit regulation on anonymisation, nor a specific identification of the techniques, or how the process should be/could be performed. The legal focus is not on the tool *per se*, rather on its outcome, stressing the need to assess whether the outcome of anonymisation confirms the anonymity of data, impacting the re-identification of the natural person to whom the data pertains.

The only institutional reference stems from the Working Party 29 Opinion n. 05/2014 on Anonymisation Techniques (as mentioned above). Here the WP29 recommends that it is necessary to test the anonymisation techniques against the deanonymisation risk. To this extent, three declinations of this risk are mentioned:

- singling out an individual,
- linking different data

- inferring data.

Here, the WP29 considered solely the potential risks linked to this data processing, recalling the two main anonymisation techniques: randomisation and generalisation, which were the main anonymisation models used for structured data, thus becoming remarkably challenging with unstructured Big Data and increasing the risk of deanonymisation (Chapter 2).

Randomisation alters the veracity of data, weakening the links between values and objects (data subject), and introducing a casual element into the data. This result can be concretely accomplished using a few techniques: permutation, noise addition and differential privacy.

In permutation, the values are not modified: the unique association between the identifier and quasi-identifiers will be decoupled, to be associated with the quasi-identifiers of another identifier (object) randomly chosen. Lastly, the values of a person will be associated with another person. Permutation has the benefit of not modifying values, which are maintained as such, thus the analysis of aggregated data is still possible and useful.

In noise addition, noise refers to an automatic program called "*pseudorandom number generator*" also known as a "*deterministic random bit generator*" (DRBG), which introduces a random variable, perturbing the value and making it less accurate. For this reason, the database loses its utility and this technique, consequently, is considered vulnerable.

In the differential privacy, an algorithm analyses a dataset and computes statistics about it and "*it is said to be differentially private if by looking at the output, one cannot tell whether any individual's data was included in the original dataset or not*" [122][123]. This technique seems to make sure that information about participants in the database, is not leaked, even if academics from the statistical community have just pointed out its vulnerability [124].

Differently from randomisation, generalisation dilutes the attributes of a table, by modifying the respective scale or order of magnitude. Consequently, the scale of magnitude will be modified to the point in which more rows of the table will finally have the same combination of generalised attributes. All the records in the table with the same combination of generalised attributes are called equivalence class. The bigger the equivalence class, the smaller the possibility of re-attributing the value to the data subject.

Generalisation can be performed using the following techniques: aggregation and K-anonymity, L-diversity and T-closeness.

In aggregation and K-anonymity [125], all the equivalence classes have a cardinality higher than a certain K value and the generalisation scheme is called K-anonymity. In this case, the

attribute values are generalised to such an extent that each individual shares the same value. K-anonymity has been implemented with several algorithms [125][126][127].

L-diversity extends k-anonymity: it is ensured that in each equivalence class every attribute has at least L different values, thus relying on the fact that the deterministic inference attacks are no longer possible. However, L-diversity seems to be vulnerable and subject to probabilistic inference attacks [128].

T-closeness represents a refinement of L-diversity, and it creates equivalent classes that are very similar to the initial distribution of attributes in the table, thus it is mostly used when there is a need to keep the data as close as possible to the original one [129].

Certainly, the state of the art seems to confirm that anonymisation methods face big challenges with *real* data. Anonymisation methods, *such as k-anonymity, are highly dependent upon spatial locality to effectively implement the technique in a statistically robust way* [130].

To this extent, in light of the limits raised by different scientific communities on anonymisation models for structured data, new models of anonymisation are explored, with the aim of overcoming the limits of traditional anonymisation techniques with unstructured data. Among many, we can mention the model of "*functional anonymisation*" which is based on the relationship between data and environment within which the data exist, the so-called "*data environment*" [131] [17], relying on a pure statistical approach. Here, researchers provide a formulation for describing the relationship between the data and its environment that links the legal notion of personal data with the statistical notion of disclosure control [132][133][134][122].

Moreover, if perfect anonymisation has failed, others[135] remark that while the debate on deanonymisation remains vigorous and productive, "*there is no clear definition for policy*", arguing that the best way to move data release policy is focusing on the process of minimising risk of re-identification and sensitive attributes disclosure, rather than trying to prevent harm.

2.3. Pseudonymisation and Pseudonymity

Recalling the main premise, in pseudonymisation there are two main elements:

- the removal of the attribution link between the personal data and the data subject
- its replacement with new additional information.

As for anonymisation, the legal framework does not provide any detail on the techniques but provides orientation in terms of context. Specifically, the GDPR only recalls it in two different articles: in Art. 25 as an *appropriate technical and organisational measure designed to implement data-protection principles*, and in Art. 32 listing it, with the encryption, as a *security measure* that should be implemented by the data controller and the data processor.

These specific collocations explicitly confirm that data must undergo pseudonymisation processing in order to grant its security and, such processing can be adapted with other security measures to protect the dataset, implementing *privacy by design principles*.

A more precise description of pseudonymisation techniques stems from the European Agency for Cybersecurity (ENISA). It lists this data processing model among its priorities of the Programming Document 2018-2020 and provides recommendations on shaping technology according to GDPR provisions. Specifically, complete guidance can be found in four different recommendations[38]thus, as such, not legally binding, confirming the same approach followed by the WP29 Opinion 04/2015 on the Anonymisation Techniques.

[38] ENISA, Recommendations on shaping technology according to GDPR provisions. An overview on data pseudonymisation, November 2018, https://www.enisa.europa.eu/publications/recommendations-on-shaping-technology-according-to-gdpr-provisions ; ENISA, Pseudonymisation techniques and best practices. Recommendations on shaping technology according to data protection and privacy provisions, November 2019, https://www.enisa.europa.eu/publications/pseudonymisation-techniques-and-best-practices ; ENISA, Data

In the ENISA Recommendations, different techniques are described, on the assumption that pseudonymisation can relate to a single identifier, but also to more than one. The pseudonymisation can be performed with the following techniques: Counter, Random Number Generator (RNG), Cryptographic Hash Function (CHF), Message Authentication Code (MAC), and Encryption.

Counter represents the simplest pseudonymisation technique, wherein a number chosen by a monotonic counter substitutes the identifiers. Its simplicity makes it a proper technique for small datasets. The Random Number Generator (RNG) is like the counter, with the difference that a random number is assigned to the identifier, relying on a mechanism that produces values unpredictably selected.

The Cryptographic Hash Function is directly applied to the identifier obtaining the corresponding pseudonym, taking input strings, and mapping them to fixed length outputs. Similar, except for introducing a secret key to generate the pseudonym, is the Message Authentication Code (MAC), where the knowledge of the key is essential for mapping the identifiers and the pseudonyms.

Lastly, the encryption that relies on a symmetric encryption algorithm for generating the pseudonyms and for which the same secret key is needed as for the decryption. Asymmetric encryption algorithms can also be used in specific cases for pseudonymisation purposes.

However, as anticipated, not all the pseudonymisation techniques are equally effective and the possible practices vary. They can be based on the basic scrambling of identifiers, or to the advanced cryptographic mechanism. Their level of protection may vary accordingly.

In any case, especially for the hash function there is doubt as to the extent it represents an efficient pseudonymisation technique, especially under certain circumstances such as the case in which the original message has been deleted, thus granting irreversibility. In this case indeed, the hash value might even be considered as anonymised[39], based on the dichotomy of *reversible/irreversible* processing [106]. In line with this consideration, academics have started considering that anonymity can be granted not only with anonymisation models, but also with pseudonymisation, questioning the semantic approach imposed by the GDPR.

Pseudonymisation: Advanced Techniques and Use Cases, January 2021, https://www.enisa.europa.eu/publications/data-pseudonymisation-advanced-techniques-and-use-cases ; ENISA, Deploying pseudonymisation techniques, March 2022, https://www.enisa.europa.eu/publications/deploying-pseudonymisation-techniques

[39] In this sense, a first innovative approach came from the Spanish Data Protection Authority: AEPD, Introduction to the hash function as a personal data pseudonymisation technique, October 2019, https://edps.europa.eu/sites/edp/files/publication/19-10-30_aepd-edps_paper_hash_final_en.pdf

In fact, the GDPR considers that data that have undergone a process of pseudonymisation are still personal data, as its data processing is considered reversible as the additional information generated as pseudonyms can still be matched with the input data. In term of policy, this decision is of paramount importance to determine the compliance of rights recognised by the GDPR in certain types of processing (e.g., research, traffic data analysis, geolocation, blockchain and others).

However, in this regard, some authors consider that pseudonymisation can grant anonymity, as well as anonymisation, provided that some subjective conditions on the input data are met [121].

This vision confirms the reason the regulatory framework is still uncertain and that the zero-risk approach cannot certainly represent the final aim of any data processing, but can be the needed mind-set to navigate through the legal framework currently in force.

On the same note, some policy fragmentation in the Member States should be considered.

In some of them, Data Protection Authorities (hereinafter referred as DPAs) considered encoded or pseudonymised data as identifiable thus, as such, as personal data in relation to the actors who have means (the "key") for re-identifying the data, but not in relation to other persons or entities (e.g., Austria, Germany, Greece, Ireland, Luxembourg, Netherlands, Portugal, UK). In other Member States, all data linkable to an individual were regarded as "personal", even if the data were processed by parties who have no means for such re-identification (e.g., Denmark, Finland, France, Italy, Spain, and Sweden). DPAs in those Member States are “generally less demanding” regarding the processing of data that are not immediately identifiable, considering the likelihood of the data subject being identified as well as the nature of the data.[40]

Therefore, it should be noted that academics and DPA decisions are starting to break the traditional approach which tended to consider anonymisation as an irreversible approach and pseudonymisation as a reversible one. Consequently admitting that both impact on the identifiability of data, as well as, on anonymity.

[40] The extent of the issue is treated extensively in the Impact Assessment of the GDPR and confirmed by the first decisions of the DPAs, like the Spanish DPA referring to the ash function.

2.3.1. Granting anonymity relying on roles and responsibilities distribution among stakeholders

The state of the art concerning the two main data processing models recalled by the GDPR, anonymisation and pseudonymisation, shows that the objective perspective tends to be overcome. In fact, it is based on the data processing model *per se,* thus stressing on the fact that only anonymisation can grant data anonymity, while pseudonymisation cannot. Therefore, in the GDPR the traditional dichotomy of *anonymisation/irreversibility* and *pseudonymisation/reversibility* can be found.

However, the technological development helped to shape new interpretations of the GDPR that are able to question the above-mentioned semantic dichotomy.

Indeed, it is currently investigated and confirmed that as for anonymisation, even pseudonymisation can grant data anonymity if relying on the distribution of roles and responsibilities among stakeholders.

As anticipated, the first interpretation in this sense came from the academic debate, when scholars started questioning whether pseudonymised data were always personal data [121]. In this occasion, authors considered that *the definition of pseudonymisation given in Art.4(5) of the GDPR will not expand the category of personal data*. They believe that even pseudonymisation can render data anonymous, thus breaking the link between data and the natural person to whom the data pertain, using as a reference test Recital 26 of the GDPR.

Such an outcome can be achieved in a particular circumstance: if data that have undergone a process of pseudonymisation in one organisation are shared with a third party without the input data, thus rendered and remaining anonymous for such last third party.

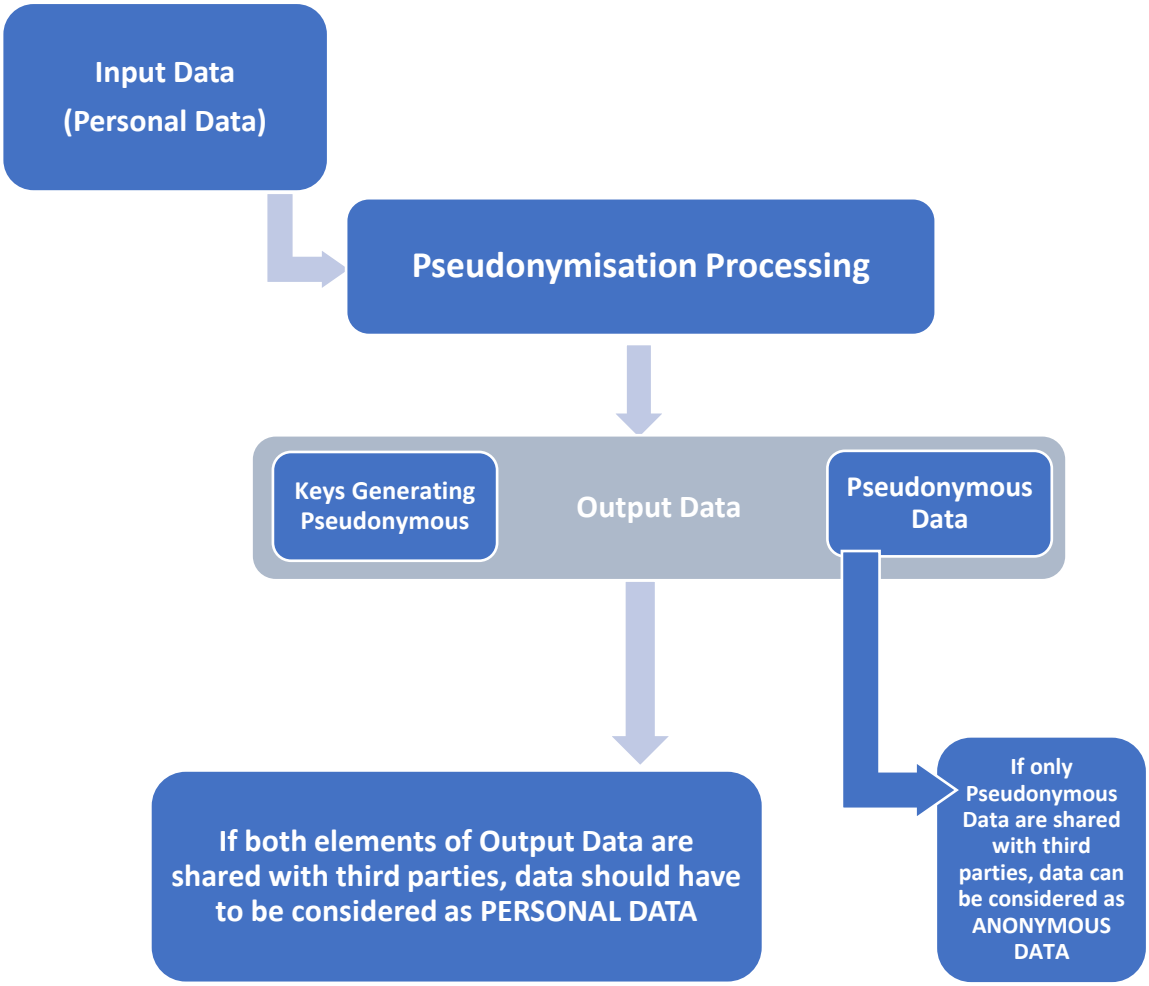

Fig. 4. Sharing pseudonymised output data with third parties

Therefore, in line with such reasoning, it can be considered that the sharing of pseudonymous data only should be subject to the deanonymisation/re-identification risk test based on Recital 26 of the GDPR. Moreover, if data are considered anonymous, the third party may process data at her/his best convenience as the link between the personal data and the natural person to whom the data pertain (data subjects) should be considered broken.

In this sense, the DGA can be considered as developing a new subjective approach on data semantics, overcoming the initial and traditional imprinting of the GDPR.

Chapter 3. *Big Data and IoE as Hybrid Human-based and Device-based Environment*

Index of the Chapter

Short Abstract of the Chapter

This chapter explains the main legal premises of the research, defining its technological context based on Big Data and the Internet of Everything. On one hand, it presents the main advantages of such technologies while, on the other hand, it also investigates the main risks and threats posed by such technologies in terms of privacy and data protection. Considering the datafication phenomena, this chapter discusses the feasibility of the right to be forgotten and how it can eventually be coordinated with the above-mentioned phenomena.

The main perspective investigated is the further processing of data, as it is considered to be a higher stage of the first processing where poorly processed personal data can increase the risk of de-anonymisation/re-identification.

Lastly, the chapter presents an explorative literature review on the issue of de-anonymisation/re-identification.

3.1. Big Data and Internet of Everything for Cutting Out the Middleman

In recent decades, the evolution and development of technology has registered a remarkable growth, increasing the possibility of substituting the human intervention in the communication between machine-to-machine, people to people and people to machine [35]. Big Data [36] and Internet of Everything have played an essential role in this change, leading to the automation of many processes, *determining the inter-penetration of the 'real' and the so-called 'virtual'* [37].

Internet of Everything uses Big Data to empower the automation of electronic equipment in the surrounding environment. The vast collection of data is stored locally on devices (*things*), or possibly in the cloud, enabling data processing and data aggregation on a large scale. Data pertains to the digital environment, as well as to the users. Due to said technological process, machines can learn how to customise better services for the users, inferring information from data and, consequently, generating knowledge.

The combination of these technologies avoids human intercession in the process of collecting, storing and processing data, making human intercession superfluous.

As anticipated, in the IoE the public and the private sphere have merged [2], impacting the human space and generating a more globalised environment, which automatically collects analyses, and mines information about places, object and people. This environment constantly expands its perimeter, increasing its technological capacity.

The remarkable opportunities of Big Data and Internet of Everything have been comprehensively investigated by the scientific and business community, boosting the capacity of data analysis. The more information is multiplied and shared, the more concerns arise in terms of tracking, profiling, discrimination, exclusion; moreover, loss of control and surveillance risks.

Internet of Everything generates a remarkable amount of data and relies on data, processes, people and things connected in a network, including machine-to-machine (M2M), person-to-machine (P2M), and person-to-person (P2P) systems. Therefore, handling such amount of data requires more sophisticated techniques and tools, giving way to artificial intelligence (AI). In comparison to traditional data techniques and platforms, AI techniques provide more accurate, faster, and scalable results in big data analytics, and they can be used to transform big data into smart data, providing more accurate results [39][40]. Among these advanced techniques we can mention machine learning (ML), natural language processing (NLP), computational intelligence (CI), and data mining. These were designed to provide big data analytic solutions as they can be more accurate, more precise and faster for massive volumes of data, discovering information, hidden patterns, and unknown correlations.

The extraordinary societal benefits of big data—including breakthroughs in medicine, data security, and energy use—must be reconciled with increased risks to individuals' privacy. As is often the case, technological and business developments in big data analysis have far outpaced the existing legal frameworks, which date back from an era of mainframe computers, predating the Internet, mobile, and cloud computing.

These technological developments have also challenged the boundaries of fundamental rights, privacy and data protection. Despite efficiency in the process, the increase in the level of automation implies an increase in the vulnerability of such systems, thus impacting privacy and data subject protection.

Due to its volume, the amount of data generated is vulnerable to security breaches and, to this purpose, it became of paramount importance to secure the data at all levels from the initial source, transfer, storage and final output.

Many technologies have been implemented to secure big data analytics such as anonymisation, pseudonymisation, encryption, and others. In this sense, the European legislation keeps evolving, trying to provide guidance on the issue as well as trying to avoid suffocating the technological development.

In such intent, the European legislator dedicates specific attention to the evolution of the market, specifying in its Data Strategy its aim of *creating a single market for data that will ensure Europe's global competitiveness and data sovereignty. Common European data spaces will ensure that more data becomes available for use in the economy and society, while keeping the companies and individuals who generate the data in control* [41].

From a mere legal point of view, it appears particularly challenging to regulate the evolution of such technological capacity due to the clash with data subjects' fundamental rights and liberties. Mainly, the right to privacy is the first generally considered; not only considered in its first conception of the *right to be left alone*, but also the right to self-determination, avoiding any kind of interference in the private sphere. As such, the right to data protection is conceived as the empowerment of data subjects to exercise their control over the collection, use and disclosure of their personal information. These rights find an explicit recognition in the European Convention of Human Rights (ECHR), in Article 8 on the right to respect privacy and family life. The Charter of Fundamental Rights of the European Union reproduces - in Art. 7 - the content of Art. 8 of the ECHR, while Art. 8 raises the protection of personal data to the status of a fundamental right. Both of these rights interact in multiple ways, especially as the right to data protection represents the main tool by which the right to privacy is protected. The central importance of privacy and data protection in the digital environment is therefore not merely due to the fact that digital systems record what happens in 'real life'.

3.2. Datafication and the Right to be Forgotten in Streaming Structured, Semi-Structured and Non-Structured Data

The IoE accurately captures the environment to which it pertains, converting the outcome of such capture in data, thus in valuable information. In fact, digitalisation facilitates the datafication process, which is considered to be the representation of most aspects of our daily lives with data [42]. Digital technologies have accelerated such a process, automating the historical practice of databasing, analysing and generating knowledge and inferring information for creating value. Especially with IoE, data does not exclusively refer to humans

[43], but also to the environment to which technology pertains, recalling the broadest concept of environment.

The datafication process has been questioned since the 1960s and 1970s, especially in the United States [44] [45] [46] [47]. The increasing capabilities of technology to store information, give it a meaning and render it ready for subsequent uses has fuelled the first debate on privacy. Originally, such debate concerned only government and large private institutions as the only ones capable of collecting personal information in computerised databases: namely, citizens' tax, health, educational and social security benefits in the welfare state. This practice responded to the need for population management, developing into more modern forms of state bureaucratic administration[48]. Gradually, the debate expanded its focus, no longer limited to government and public institutions, but extending it to private companies running their major businesses on data [49].

On the same note, since the 1970s, the debate has also matured in Europe, confirming that datafication precedes digitalisation, using technology as an *instrument* for accelerating such a process [50].

In this sense, it can be argued that there is no shift of paradigm, rather a constant evolution of the one on which datafication is built: the collection of personal information represented by data.

Therefore, in some parts, the evolution of the legislation doesn't appear to take into account this expansion. Considering the current legislation on data, specifically the GDPR, it is unquestionable that some rights and freedoms mentioned here are unfeasible for enforcement in the digital environment and academics continue to debate their root and content [51] [52] [53] [53] [54] [55] [56]. In this regard, the right to erasure (*right to be forgotten*) is one of the most studied and questioned [57] [58]. As a matter of fact, the development and evolution of technology keeps challenging the implementation of the balancing test between competing rights of privacy and data protection, and free expression and access to information. However, the significant body of European jurisprudence on the matter provides a guideline for the implementation of the right to be forgotten. Indeed, almost a decade ago, the Court of Justice of the European Union recognised the individual's right to ask search engines (e.g. Google) to remove results for queries on a certain user's name (ECLI:EU:C:2014:317)[41]. As anticipated, scholars have long debated the right to be forgotten, its balancing test and the legitimacy and

[41] https://curia.europa.eu/juris/document/document.jsf?docid=152065&doclang=IT

transparency of search engines as private actors responsible for the implementation. These debates have confirmed that the right to be forgotten raises fundamental questions, not only in terms of personal data, but also in terms of media freedom, and on the impact of deletion. Specifically, technological development seems to confirm that the challenges in the implementation of the right to be forgotten increase the risk of de-anonymisation/re-identification [59] [60]. Such a right seems to be evolving towards being artificial, as it follows a technology-agnostic approach, as it does not allow laws to be coordinated with the state-of-the-art technologies in computer science and technology information.

In fact, big data comes in a variety of shapes and form, generating many difficulties in coordinating the protection and security of the information, and therefore increasing the unfeasibility of granting deletion (erasure, *forgetting*). Modern digital environments using big data struggle to handle the process of analysing and erasing [61]. Data is unable to be handled and processed by most current information system methods as *the most traditional data mining methods or data analytics developed for a centralised data analysis process may not be able to be applied directly to big data* [62]. Especially in IoE environments, the dataflow is constant, and the variety, diversity and volume of data are different. If, for example, considering only the structure of data, the fact of having structured, semi-structured and unstructured data poses many challenges for ensuring protection and security. Data can be made of only numerical or categorical attributes, or usually, as a mix of numerical and categorical attributes.

Preferable data is structured, but not necessarily. Unstructured data refers to data which does not adhere to conventional data models, thus not easily searchable. It comes with formats like audio, video, and social media postings, usually collected with powerful Artificial Intelligence applications. More than 80% of generated data are unstructured and this percentages grows by 55-60% every year[42]. Despite the structure, data can be organised into microdata or macrodata, it can be static or dynamic. The variety of data has a remarkable impact on the design of modern technologies from its embryonal phase, creating risks in terms of privacy and data protection, the reason that justified the integration of such rights in modern legislations[43].

[42] https://mitsloan.mit.edu/ideas-made-to-matter/tapping-power-unstructured-data

[43] In this sense, the statistics of the United Nations Conference on Trade and Development, showing that with the increase of the social and economic activities places online, the importance of privacy and data protection increases as well. Data confirms that 137 out of 194 countries had put in place legislation to secure the protection of data and privacy. Moreover, still according to data, Africa and Asia show different level of adoption with 61 and 57 per cent of countries having adopted such legislations. In detail: https://unctad.org/page/data-protection-and-privacy-legislation-worldwide

3.3. Privacy and Data Protection in Further Data Processing

The modern digital environments are implemented through big data, such as IoE, which imposes the integration of privacy and data protection principles from policy to engineering. The GDPR requests that *data controllers implement appropriate technical and organisational measures to protect personal data and avoid unlawful disclosure*, above all when the process involves the transmission of data over a network.

In determining the framework of these technical and organisational measures, it is essential to clearly define the concept of privacy and data protection, in order to better understand the extent of data controllers' responsibilities.

Data protection appeared as an *offspring of privacy* [50] and the two rights seem inextricably linked. Scholars tend to agree that data protection and privacy share a common characteristic: both are confronted with remarkable interferences in contemporary information society.

The debate among European scholars focused on whether data protection represents an autonomous fundamental right, thus separate from privacy, or whether it can be considered as a mere aspect of privacy [63]. Despite this aspect of the debate, data protection and privacy certainly interact and the European Constitution reserves separate roles to these distinct rights and considers data protection as a legal instrument adding something to privacy [64].

In Europe, the first legislations on data protection were issued in Germany[44] and Sweden.[45]

Since then, the concept of data protection has been distinct from the concept of privacy. The latter used to be considered as a *broad concept that embodies a range of rights and values, such as the right to be let alone, intimacy, seclusion, personhood, and so on according to the various definitions* [50]. Over time, it has emerged that such right cannot have strict boundaries and, due to the technological development, its concept keeps expanding. On the other hand, data protection emerged as a set of interests further to privacy, concerning the security of the information systems – data security – and its data quality [65]. Consequently, data protection emerged to serve fundamental rights other than the ones protected by privacy. As anticipated, such confirmation came from the Europe Constitution where data protection arises at the level of other fundamental rights, alongside privacy [66] [67]. Therefore, the inclusion of data protection in the European Charter of Fundamental Rights is a point of arrival in a process started almost fifty years ago, which culminates with this inclusion, as well as with the discussion, promulgation and entry into force of the General Data Protection Regulation [68].

Such pieces of legislation have imposed many principles and rules for granting the protection of data in the engineering of information systems, since its first design. Two requirements among the main instruments tailored by the legislator for protecting data subjects since the first collection of data, are particularly relevant in the context of IoE and big data: consent and purpose [69]. Both of these requirements have been analysed by the Working Party 29[46].

[44] Datenschutzgesetz, Oct. 7, 1970, § 6, 1 Gesetz- und Verordnungsblatt für das Land Hessen 625 (1970).
[45] Datalagen (Swedish Data Act) of May 11, 1973, entered into force July 1, 1973.
[46] The requirement of consent has been analysed in the Guidelines on consent under Regulation 2016/679, Adopted on 28 November 2017 and last revised and adopted on 10 April 2018 (17/ENWP259 rev.01); the

Defined and regulated from Article 6 to Article 8, consent has animated the scholars' debate since the first discussions of the GDPR. In time, the criticalities of such a requirement emerged and scholars remain sceptical on its efficiency if applied to big data [70], as most of the time consent forms are very difficult to navigate for data subjects [71], thus tending to legitimise dark patterns [72] and other issues, even in the event it is revoked [73]. Moreover, another essential requirement is purpose. In this regard, there still appears to be room to investigate the different declinations of purpose, especially in conjugation with consent for secondary uses of data, for further processing.

More issues seem to arise in further processing of data[74] (justifying secondary data uses): a typical case could be when data are legitimately collected but poorly processed. In principle, academics have long investigated this criticality in the context of research [75] and health data [76], trying to find certain benchmarks in ensuring data quality. However, this issue seems to be as difficult to handle as after the first processing. In application of the data minimisation principle [77], processed personal data, for which the purpose of collection has been reached, should be erased or anonymised. Therefore, it is outside the scope of application of the GDPR and the loss of its protection.

The notion of further processing is closely linked to the concept and scope of initial processing. The GDPR provides a broad concept of processing in Article 4.2 as "*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, adaption or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction*".

The European Court of Justice has further specified[47] that processing "*may consist in one or a number of operations, each of which relates to one of the different stages that the processing of personal data may involve*". This specification considers the various stages of the data lifecycle, even in secondary uses of personal data.

Moreover, the concept of further processing is strictly connected to the requirements and conditions under which the initial processing is undertaken. As anticipated, consent, as well as purpose, play an essential role in framing the legal basis for collection and processing personal

requirement of purpose has been analysed in Opinion 03/2013 on purpose limitation adopted on 2 April 2013 (00569/13/ENWP 203).

[47] Case C- 40/ 17, Fashion ID.

data. Consent and purpose of the first collection shape the boundaries of the secondary processing.

Recital 50 recalls further processing as processing of personal data *for purposes other than those for which the personal data were initially collected*.

The GDPR requests that any purpose for processing personal data should be clearly specified and accepted by the data subject. Personal data cannot be accumulated for secondary uses.

To allow recycling, repurposing and re-contextualisation [74], personal data should be further processed in compliance with specific principles and requirements, aimed at tackling the above-mentioned risks. As a general rule, according to art. art. 5(1)(b) GDPR, personal data cannot be processed for further purposes which are incompatible with the one justifying the first collection. The only exception is given by Art. 89 of the GDPR, introducing *safeguards and derogations relating to processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes*.[48]

3.3.1. Compatibility test *ex* art. 89 GDPR: data aggregation, statistical purposes and data sharing

Art. 89 recalls the reason of substantial public interest for implying certain derogations in the secondary processing of data. Among these, the case in which personal data are processed for

[48] In detail, Art. 89: Safeguards and derogations relating to processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes.

1. Processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes, shall be subject to appropriate safeguards, in accordance with this Regulation, for the rights and freedoms of the data subject. Those safeguards shall ensure that technical and organisational measures are in place in particular in order to ensure respect for the principle of data minimisation. Those measures may include pseudonymisation provided that those purposes can be fulfilled in that manner. Where those purposes can be fulfilled by further processing which does not permit or no longer permits the identification of data subjects, those purposes shall be fulfilled in that manner.

2. Where personal data are processed for scientific or historical research purposes or statistical purposes, Union or Member State law may provide for derogations from the rights referred to in Articles 15, 16, 18 and 21 subject to the conditions and safeguards referred to in paragraph 1 of this article in so far as such rights are likely to render impossible or seriously impair the achievement of the specific purposes, and such derogations are necessary for the fulfilment of those purposes.

3. Where personal data are processed for archiving purposes in the public interest, Union or Member State law may provide for derogations from the rights referred to in Articles 15, 16, 18, 19, 20 and 21 subject to the conditions and safeguards referred to in paragraph 1 of this article in so far as such rights are likely to render impossible or seriously impair the achievement of the specific purposes, and such derogations are necessary for the fulfilment of those purposes.

4. Where processing referred to in paragraphs 2 and 3 serves at the same time another purpose, the derogations shall apply only to processing for the purposes referred to in those paragraphs.

statistical purposes *ex* Art. 89. Union, or Member States' law may provide for derogations from the mandated disclosures, contained in Articles 13[49] and 14[50] of the GDPR.

[49] In detail: Article 13. Information to be provided where personal data are collected from the data subject
1. Where personal data relating to a data subject are collected from the data subject, the controller shall, at the time when personal data are obtained, provide the data subject with all of the following information:
(a) the identity and the contact details of the controller and, where applicable, of the controller's representative;
(b) the contact details of the data protection officer, where applicable;
(c) the purposes of the processing for which the personal data are intended as well as the legal basis for the processing;
(d) where the processing is based on point (f) of Article 6(1), the legitimate interests pursued by the controller or by a third party;
(e) the recipients or categories of recipients of the personal data, if any;
(f) where applicable, the fact that the controller intends to transfer personal data to a third country or international
organisation and the existence or absence of an adequacy decision by the Commission, or in the case of transfers referred to in Article 46 or 47, or the second subparagraph of Article 49(1), reference to the appropriate or suitable
safeguards and the means by which to obtain a copy of them or where they have been made available.
2. In addition to the information referred to in paragraph 1, the controller shall, at the time when personal data are obtained, provide the data subject with the following further information necessary to ensure fair and transparent processing:
(a) the period for which the personal data will be stored, or if that is not possible, the criteria used to determine that period;
(b) the existence of the right to request from the controller access to and rectification or erasure of personal data or restriction of processing concerning the data subject or to object to processing as well as the right to data portability;
(c) where the processing is based on point (a) of Article 6(1) or point (a) of Article 9(2), the existence of the right to withdraw consent at any time, without affecting the lawfulness of processing based on consent before its withdrawal;
(d) the right to lodge a complaint with a supervisory authority;
(e) whether the provision of personal data is a statutory or contractual requirement, or a requirement necessary to enter into a contract, as well as whether the data subject is obliged to provide the personal data and of the possible
consequences of failure to provide such data;
(f) the existence of automated decision-making, including profiling, referred to in Article 22(1) and (4) and, at least in those cases, meaningful information about the logic involved, as well as the significance and the envisaged consequences of such processing for the data subject.
3. Where the controller intends to further process the personal data for a purpose other than that for which the personal data were collected, the controller shall provide the data subject prior to that further processing with information on that other purpose and with any relevant further information as referred to in paragraph 2.
4. Paragraphs 1, 2 and 3 shall not apply where and insofar as the data subject already has the information.
[50] In detail: Article 14. Information to be provided where personal data have not been obtained from the data subject
1. Where personal data have not been obtained from the data subject, the controller shall provide the data subject with the following information:
(a) the identity and the contact details of the controller and, where applicable, of the controller's representative;
(b) the contact details of the data protection officer, where applicable;
(c) the purposes of the processing for which the personal data are intended as well as the legal basis for the processing;
(d) the categories of personal data concerned;
(e) the recipients or categories of recipients of the personal data, if any;
(f) where applicable, that the controller intends to transfer personal data to a recipient in a third country or international organisation and the existence or absence of an adequacy decision by the Commission, or in the case of transfers referred to in Article 46 or 47, or the second subparagraph of Article 49(1), reference to the appropriate or suitable safeguards and the means to obtain a copy of them or where they have been made available.

Statistics is included among these derogations. Statistics, namely, public statistics, is necessary for the performance of EU activities, as confirmed in the Treaty on the Functioning of the European Union (TFEU)[51].

Generally carried out in the public interest, this kind of processing is usually performed by public authorities. Their legal status makes them naturally trustworthy in tackling the risks. If we think, for example, of National Statistical Offices (NSOs), thirty years ago they were the only ones gathering data on citizens and they were naturally trusted as data controllers. For this

2. In addition to the information referred to in paragraph 1, the controller shall provide the data subject with the following information necessary to ensure fair and transparent processing in respect of the data subject:
(a) the period for which the personal data will be stored, or if that is not possible, the criteria used to determine that period;
(b) where the processing is based on point (f) of Article 6(1), the legitimate interests pursued by the controller or by a third party;
(c) the existence of the right to request from the controller access to and rectification or erasure of personal data or restriction of processing concerning the data subject and to object to processing as well as the right to data portability;
(d) where processing is based on point (a) of Article 6(1) or point (a) of Article 9(2), the existence of the right to withdraw consent at any time, without affecting the lawfulness of processing based on consent before its withdrawal;
(e) the right to lodge a complaint with a supervisory authority;
(f) from which source the personal data originate, and if applicable, whether it came from publicly accessible sources;
(g) the existence of automated decision-making, including profiling, referred to in Article 22(1) and (4) and, at least in those cases, meaningful information about the logic involved, as well as the significance and the envisaged consequences of such processing for the data subject.
3. The controller shall provide the information referred to in paragraphs 1 and 2:
(a) within a reasonable period after obtaining the personal data, but at the latest within one month, having regard to the specific circumstances in which the personal data are processed;
(b) if the personal data are to be used for communication with the data subject, at the latest at the time of the first communication to that data subject; or
(c) if a disclosure to another recipient is envisaged, at the latest when the personal data are first disclosed.
4. Where the controller intends to further process the personal data for a purpose other than that for which the personal data were obtained, the controller shall provide the data subject prior to that further processing with information on that other purpose and with any relevant further information as referred to in paragraph 2.
5. Paragraphs 1 to 4 shall not apply where and insofar as:
(a) the data subject already has the information;
(b) the provision of such information proves impossible or would involve a disproportionate effort, in particular for processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes, subject to the conditions and safeguards referred to in Article 89(1) or in so far as the obligation referred to in paragraph 1 of this article is likely to render impossible or seriously impair the achievement of the objectives of that processing. In such cases the controller shall take appropriate measures to protect the data subject's rights and freedoms and legitimate interests, including making the information publicly available;
(c) obtaining or disclosure is expressly laid down by Union or Member State law to which the controller is subject and which provides appropriate measures to protect the data subject's legitimate interests; or
(d) where the personal data must remain confidential subject to an obligation of professional secrecy regulated by Union or Member State law, including a statutory obligation of secrecy.

[51] To this purpose, Art. 338 clarifies that the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall adopt measures for the production of statistics where necessary for the performance of the activities of the Union.

reason, the statistical activity conducted by NSOs is even regulated with a specific legislation that represents the main legal framework for national statistics.[52]

Nowadays, however, business entities also perform data processing for statistical purposes. For example, economic actors focused on the development of Artificial Intelligence applications and Data Analytics models (including Machine Learning, Deep Learning and other techniques). They rely on statistical models built with a remarkable collection of statistical data. Due to its descriptive function, statistics reveals patterns and infers information observing data, granting a solid base for the development of the statistical models needed by this industry. Therefore, data controllers can be also private entities, therefore it appears more than reasonable to question the level of trust citizens should recognise, especially in light of the risks for privacy and data protection[78].

The implications for data controllers pursuing data processing for statistical purposes, dealing with aggregate data for the development of Artificial Intelligence applications, do not seem to be clear, exposing data subjects to the risk of deanonymisation/re-identification when data are poorly processed, thus impacting the quality. Therefore, it is reasonable to ask whether art. 89 of the GDPR applies to private companies as well, relying on statistical data for developing data analytics models [79].

To this extent, it can be noted that the taxonomy of the GDPR does not specifically define statistical data, but considers aggregate data as non-personal data, as the output of personal data processed for statistical purposes.

The Regulation defines processing for statistical purposes as "*any operation of collection and the processing of personal data necessary for statistical surveys or for the production of statistical results*". Moreover, the FFDR states that specific examples of non-personal data include aggregate and anonymised datasets used for big data analytics.[53]

[52] Regulation 223/2009 on European statistics. For microdata access: Regulation (EU) No 557/2013 on access to confidential data for scientific purposes. Separate laws in the EU/EEA/EFTA countries: https://ec.europa.eu/eurostat/web/ess/latest-news

[53] See extensively Recital 9 of the FFDR, literally: *The expanding Internet of Things, artificial intelligence and machine learning, represent major sources of non-personal data, for example as a result of their deployment in automated industrial production processes. Specific examples of non-personal data include aggregate and anonymised datasets used for big data analytics, data on precision farming that can help to monitor and optimise the use of pesticides and water, or data on maintenance needs for industrial machines. If technological developments make it possible to turn anonymised data into personal data, such data are to be treated as personal data, and Regulation (EU) 2016/679 is to apply accordingly*.

The literal and contextual interpretation introduces a presumption on the nature of aggregate data as non-personal data: as such, aggregate data do not fall under the scope of application of the GDPR.

However, while this approach may be effective for aggregate data resulting as the output of processing non-personal data (farm and agricultural data, for example), it is not the case for the output of processing personal data. A distinction should be made in terms of the nature of the input/output data. In this regard, the European Data Protection Supervisor (EDPS) specified that aggregate data is not the same as anonymised data, and not necessarily non-personal data[54], however recalling Recital 26 as a main tool for ascertaining the risks, but which is still not a certain method of assessment.

Apart from these critical points, which certainly deserve attention from the data controller perspective, the GDPR imposes a compatibility test to be carried out in order to evalute whether secondary processing can be considered compatible. In this sense, Art. 6(4) of the GDPR follows, providing a series of criteria to determine whether the processing for a purpose other than that for which the personal data have been collected, is to be considered compatible with this initial purpose.

The GDPR requires a compatibility test for further purposes to be carried out.

[54] European Data Protection Supervisor, Opinion 3/2020 on the European Strategy for Data.

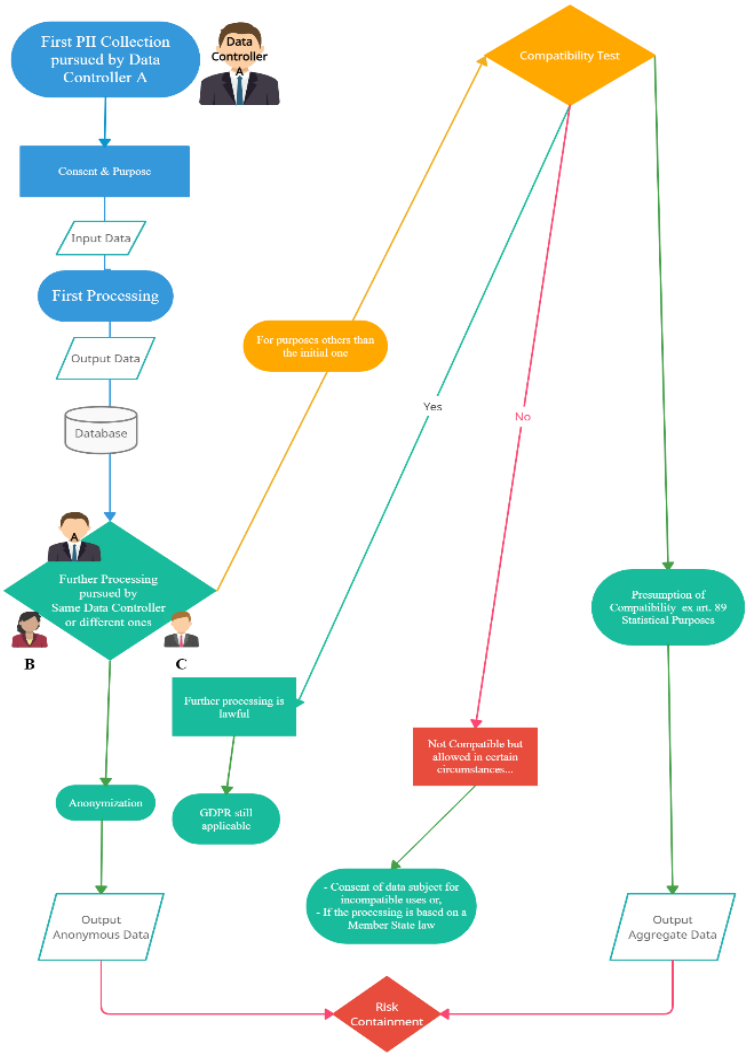

Fig. 5. Data processing in light of the GDPR perspective, with a particular focus on further processing and secondary uses of data

Two basic scenarios may occur with the compatibility test:

- The purpose is compatible; thus, the further processing is lawful and GDPR still applies to the further processing. In this case, recycling, repurposing, and re-contextualising is lawful.
- The purpose is not compatible; thus, the further processing is unlawful (unless consent has been obtained for incompatible uses, or the Member States law allows further processing).

Article 89 deserves a specific focus, as it lists other cases in which the compatibility test is not required, based on the presumption that the processing is considered compatible with the initial purpose. This is the case of *processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes*.

All these exemptions are somehow related to statistical processing, research included, for which scholars are currently exploring its boundary [80] [75][81], output which – as anticipated - is considered as non-personal data (aggregate data), thus outside the scope of application of the GDPR.

In this regard, especially from a legal-technological perspective, data aggregation is poorly investigated. Aggregation allowing secondary uses of data poses certain risks when poorly performed: disclosure, re-identification, and profiling.

The aggregation process has the advantage of transforming sets of microlevel data (thus PII referring to each single statistical unit) into macrolevel data [82] representing a summary of Personally Identifiable Information (PII) [83] .

From a purely legal point of view, the interaction between data protection, data aggregation and statistical purposes can be very controversial.

Data aggregation plays an essential role in data processing and data management. In the modern information systems, it allows information to be inferred from unusual patterns [84], bandwidth and energy costs to be reduced [85], and storage space to be saved [86]. Aggregate data is the main source of IoT systems, Cloud environments, Artificial Intelligence and Machine Learning applications and products. Within such systems, different aggregations may have various requirements to be satisfied by the design. For instance, while one aggregation receives data passively from a data source, another aggregation must actively collect data from a database which is shared concurrently by other processes [87].

This heterogeneity represents a challenge in designing a suitable solution with multiple aggregations, certainly increased when processing data of a different nature (considered from a legal point of view). Certain products and services built on aggregate data cannot even be developed without processing personal data, and data cannot always be directly acquired for individuals with informed consent[55].

When Article 89 recalls processing for statistical purposes, it lists such processing together with a broad range of processing activities: archiving, historical and scientific research. These are somehow related to the statistical processing which serves public interest.

However, there are many other types of activities that certainly cannot be considered as undertaken in the public interest, but they may also fall under this provision, especially if the

[55] This might eventually be the ratio behind Article 14 of the GDPR: Article 14 GDPR - *Information to be provided where personal data have not been obtained from the data subject*.

presumption of compatibility - as mentioned above, is considered. This has also been specified by the Working Party 29 Opinion 03/2013 on purpose limitation.[56]

The level of protection, between the public and the private sector, might be very different.

In the field of statistics performed in the public sector, the principles of statistical confidentiality and functional separation[57] impose certain measures to ensure that personal data processed for statistical purposes cannot be used for non-statistical purposes.

As already mentioned, some authors [79] have already pointed out that corporations might not have the same level of ethical and institutional safeguards in place as the public sector. Furthermore, corporate secrecy and opaque algorithms in AI research might create barriers to oversight. These are the limits faced by Article 22 of the GDPR on automated individual decision-making and right to explanation.

With this scenario, defining a proper risk assessment may be very difficult but the function of data protection should not be neglected, and an oversimplified approach should not be applied [88].

Therefore, aggregate data should require an appropriate risk test, which should be mandatory when performed by private entities.

As anticipated, the GDPR only imposes that such processing should be subject to appropriate safeguards for the rights and freedoms of the data subject. The application of these derogations implies that it must be "*likely to render impossible to or seriously impair the achievement of the specific purposes, and such derogations should be necessary for the fulfilment of those purposes*".

Member States should determine the scope of the derogations, however this creates fragmentation between policies, thus creating disparities within the Digital Single Market[58].

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[56] Working Party 29, Opinion 03/2013 on purpose limitation, adopted on 2 April 2013.

[57] Regulation (EC) No 223/2009 on European Statistics defines statistical confidentiality as "the protection of confidential data related to single statistical units which are obtained directly for statistical purposes or indirectly from administrative or other sources, implying the prohibition of use for non-statistical purposes of the data obtained and of their unlawful disclosure". See also Article 20(1) and (2) of the same regulation which sets out that "confidential data obtained exclusively for the production of European statistics shall be used by the [national statistical institutes] and other national authorities and by the Commission (Eurostat) exclusively for statistical purposes unless the statistical unit has unambiguously given its consent to the use for any other purposes". Further, see Article 338 of the Treaty on the Functioning of the European Union ('TFEU'), which requires that "the production of Union statistics shall conform to impartiality, reliability, objectivity, scientific independence, cost-effectiveness and statistical confidentiality".

[58] As an example, the case of the Italian Data Protection Authority (Garante per la Protezione dei Dati Personali) can be recalled, which has issued two notes introducing deontological rules regulating processing for statistical purposes, equalizing the rules to be applied when processing for statistical purposes in both the public and private sector, even if specifically determining the level of aggregation. Cfr: Regole deontologiche per trattamenti a fini statistici o di ricerca scientifica effettuati nell'ambito del Sistema Statistico nazionale pubblicate ai sensi dell'art. 20, comma 4, del d.lgs. 10 agosto 2018, n. 101 - 19 dicembre 2018 [9069677]; Regole deontologiche per

In addition, Article 89 requests that technical and organisational measures are in place to ensure respect for the principle of data minimisation. To this aim, the article seems to emphasise a kind of circular reasoning typical of the GDPR, where rules and principles are repeatedly recalled, posing uncountable doubts and challenges. Namely, Article 25 on Data Protection by Design and by Default, as well as Article 5 on Data Minimisation.

In both cases, data protection methodologies and rigorous PETs (Privacy Enhancing Technologies) should be created, while recalling a very broad view of these "*technical and organisational measures*". Certainly, there is no doubt that the legislator favoured broad statutory language, avoiding any specification on technologies and methodologies, in favour of technological neutrality. However, it actually becomes very difficult for companies to navigate through the principles of data protection. These open standards might represent a remarkable limit for small medium enterprises.

With regard to the part in which Article 89 overlaps with Art. 25 - in the technical and organisational measures - the legal uncertainties pertaining to Art. 25 spill over into Art. 89 [89].

Secondly, regarding minimisation techniques, academics [77] have already discussed the edges of the data minimisation principle in the current structure of the GDPR[59]. Again, the regulation is not providing a pragmatic view of data hygiene: determining how and where to start with data minimisation becomes very difficult.

How can the GDPR's core principles be translated into concrete design requirements and data protection methodologies? How can a compliant internal policy, for small-medium enterprises, be technologically designed?

With regard to aggregation, can all these questions possibly be solved determining ex-ante how large the aggregate should be, before the data cease to be personal? Is it feasible to determine such a benchmark? Or, somehow, does it appear to be impossible to determine it, due to the available technology and the technological development in the digital context?

It should be clearly specified how data protection principles relating to data minimisation and purpose limitation should apply to processing for statistical purposes. The main need is

trattamenti a fini statistici o di ricerca scientifica pubblicate ai sensi dell'art. 20, comma 4, del d.lgs. 10 agosto 2018, n. 101 - 19 dicembre 2018 [9069637].

[59] Literally, the authors confirm that *purpose limitation and data minimisation remain feasible albeit challenging in the context of data-driven personalisation, profiling and decision-making systems. While the longer-term research problems await their solutions, practitioners might employ a variety of organisational best practices and off-the-shelf tools that minimise data even if not explicitly developed for minimisation purposes.*

overcoming the legal uncertainty which surrounds the GDPR and its further application of rules and principles, which appear as open standards.

Theoretical solutions and explanations are required, especially in the light of the growing phenomena of data deanonymisation/re-identification.

Recent developments and legal initiatives, namely the new Data Governance Act or the new proposal on Artificial Intelligence (AI ACT proposal), have demonstrated that several AI-related questions do not find an explicit answer in the GDPR. In the Data Governance Act, the European legislator proposes data altruism processing with supervision by data sharing services. In the AI Act proposal, the data management supporting AI applications and products should be documented and archived with particular regard to training, validation and testing data aimed at demonstrating that the AI tools remain within the limitation of the purposes defined *ex-ante*. This situation of legal uncertainty, and imperfect integration with different legislation initiatives probably led by different industrial market interests, creates an overburden for data controllers applying indeterminate concepts, vague clauses and open standards, particularly challenging for small-medium enterprises, which can be penalised. In addition, it increases the risk of deanonymisation/re-identification for data subjects.

It appears noticeable that, if data controllers cannot determine and quantify the residual risk linked to a data lifecycle, the GDPR may be reduced to a mere bureaucratic procedure based on a checklist, performed with automatic tools, from which big corporations can take advantage, as evidently more resourceful. In this situation data subjects would appear to be penalised.

To this extent, determining the clear boundaries of the risks seems to be the most practical solution for tackling it.

3.4. An explorative literature review on data deanonymisation

While the collection of personal data provides for a better definition of personal profiles, improving efficiency, on the other hand profiles can be used not only for granting access to certain services, but also to refuse it. The same data collected for tailoring a 100% satisfactory customised service can be used for decisions based on opacity.

One of the main risks linked to secondary uses of poorly processed personal data relies on the possibility of reverse-engineering the process of data protection and re-identifying the subject to whom the data refer.

In this regard, the European Union and the Member States has implemented many policies aimed at containing these risks. The evolution of the legislation in the last decade shows that, as a first step, the legislator blazed the path for approaching the issue from an objective perspective thus, recalling certain safeguards on the data processing *per se*. In this sense, with the GDPR having imposed the basic principles of data processing (art. GDPR) such as minimisation and erasure, or introducing certain guidelines aimed at countering the dark side of data protection: deanonymisation and re-identification. Finally, in recent years, the European legislator implemented new policies focused on a subjective perspective, aimed at empowering and instilling responsibility in actors involved in the data processing. The Data Governance Act represents a step towards data circulation and data sharing aimed at granting data reuses, while protecting data and data subject's privacy.

Therefore, in a digital ecosystem where data subjects generate data, data collectors use data, the ideal situation would be:

- allowing data subjects to limit the information collected about them
- granting the maximal potential on the reuse of data collected and processed to data users.

This paragraph aims to frame the technological development of the deanonymisation/re-identification risk, querying *Arxiv* (https://arxiv.org/), an Open Access archive for scholar pre-prints in the fields of physics, mathematics, computer science, quantitative biology, quantitative finance, statistics, electrical engineering and systems science, and economics, thus merely referring to the technical field and not to the legal one. Containing pre-prints, Arxiv is considered to provide a better representation of the topic development, establishing the main trends in the topic.

The exploratory literature review on the topic outlines the technological development on the topic, identifying the state of the art. A literature analysis leads to a better definition of the gaps in the body of the in-force legislation, understanding whether the legal framework is in line with the technological development.

In scientific literature the keywords deanonymisation and re-identification are used in an undifferentiated way (at least from an etymology perspective) [90], for referring to the practice of reverse-engineering the processing of personal data anonymisation [17, 91], identifying the natural person whose personal data have been processed aiming at reaching anonymity. Therefore, if such a process is reversed, the process of reaching data anonymity is impacted, producing effects on privacy and data protection of data subjects.

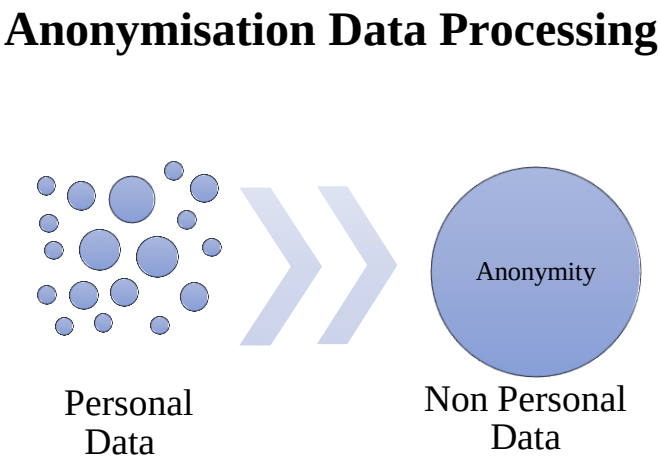


Fig. 6. The legal semantic process from personal data to non personal data

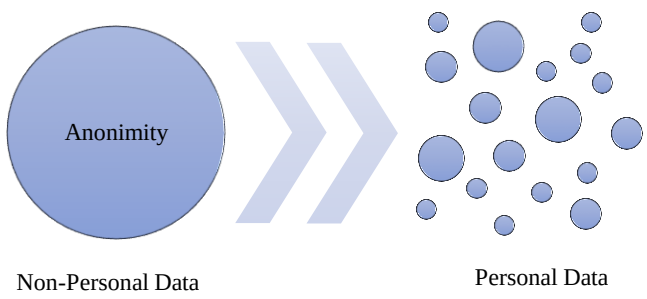


Fig. 7. The legal semantic process from non-personal data to non-personal data

Moreover, still considering the terminology, some scholars [17] highlighted that in some jurisdictions (such as US, Canada, and Australia), deanonymisation is used to mean what anonymisation means in the EU context. A literature review shows that the same approach is used for the two words re-identification (US, Canada, and Australia) and deanonymisation in the EU context.

First of all, it must be clarified that the technical literature on the topic does not refer to *personal data* solely in name – as usually referred in legal terminology. Specifically, it refers to Personally Identifiable Information (PII), with the same meaning as personal data. As anticipated, the concept of PII is particularly relevant in the context of data processing and data protection, as there is no unique definition [92] [93–95][94] [96][97].

In taking into account the GDPR, the definition of personal data contained in Art. 4 recalls *any information related to an identified or identifiable natural person*[60], in line with the previous definition recalled in Directive 95/46/EC of the European Parliament and Council of 24 October 1995, on the protection of individuals with regard to the processing of personal data and on the free movement of such data[61], as the in-force legislation for data protection prior to the GDPR.

Both of these definitions of personal data have their roots in the 1980 OECD Recommendation of the Council concerning Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data[62] which has played a pivotal role in the development of policies for the protection of personal data, and remains an essential benchmark.

[60] Art. 4(1) specifies that, *for the purposes of this Regulation: 'personal data' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person*; […].
Moreover, in detail: Article 2, Article 4(1) and (5) and Recitals (14), (15), (26), (27), (29) and (30) of the GDPR; Article 29 Working Party Opinion 4/2007 on the concept of personal data; Article 29 Working Party Opinion 05/2014 on Anonymisation Techniques.

[61] Article 2 specifies that, *for the purposes of this Directive: (a) 'personal data' shall mean any information relating to an identified or identifiable natural person ('data subject'); an identifiable person is one who can be identified, directly or indirectly, in particular by reference to an identification number or to one or more factors specific to his physical, physiological, mental, economic, cultural or social identity*; […].

[61] https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0188

Since the OECD Recommendation, PII has not been defined *per se* by a list, but rather accounts for the possibility of deductive disclosure. Therefore, if taken into account the in-force legislation, PII can be considered as any *identifier* such as a

- *name*
- *identification number*
- *location data*
- *an online identifier*
- *one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity*

of a natural person.

In general, a common misconception on data anonymisation exists: removing all explicit identifiers from a dataset makes data anonymous. If this approach was considered to be true in the 70s, when Statistical Agencies used to apply anonymisation to microdata, with the advent of Big Data and its continuously increasing availability, anonymisation becomes a remarkable challenge to address, while rendering deanonymisation/re-identification easier.

According to these premises, the explorative literature review aims to determine the extent of the deanonymisation/re-identification risk.

The first outcome to be analysed is the number of publications per year, with a total of 1467 papers from 2016 to 2022.

	2016	2017	2018	2019	2020	2021	2022
Tot	70	109	189	259	324	345	171

Fig. 8. Total number of publications per year concerning the topic of deanonymisation/re-identification

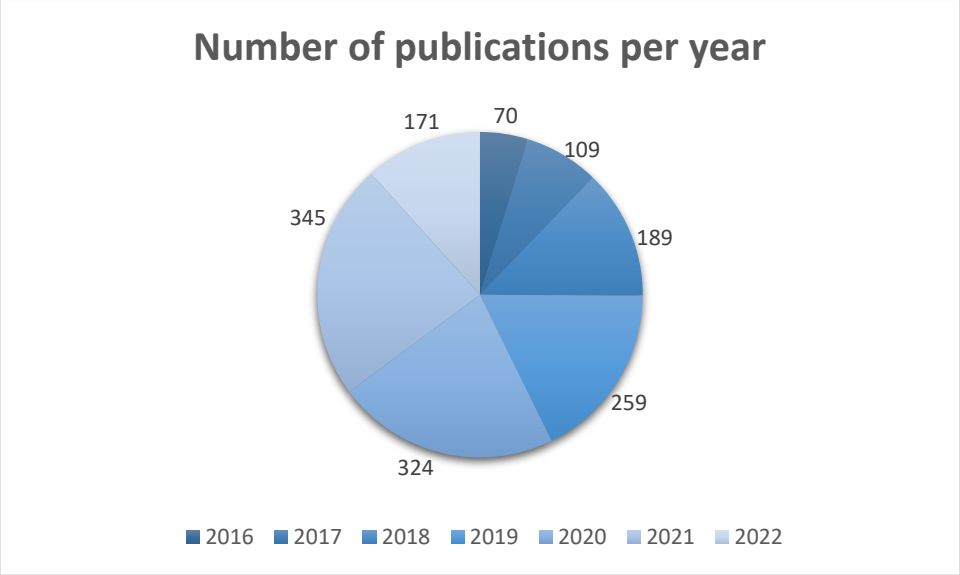


Fig. 8.a. Pie chart of the total number of publications per year concerning the topic of deanonymisation/re-identification

The pie chart shows that in the transition from the previous Data Protection Directive to the GDPR, from 2016 to 2018 – the year in which the GDPR entered into force – the technological development in deanonymisation/re-identification increased. Despite the GDPR introducing new and stricter rules for the protection of personal data, the majority of papers on the topic were published in between 2019 and 2022.

Concerning the keywords (deanonymisation/re-identification) used in the exploratory review, despite being used, as anticipated, in an undifferentiated way for referring to the same concept, scholars tend to prefer the use of the word re-identification.

	2016	2017	2018	2019	2020	2021	2022	TOT
de-anonymization	11	8	13	20	17	16	9	94
re-identification	59	101	176	239	307	329	162	1373
tot	70	109	189	259	324	345	171	1467

Fig. 8.b. Chart of the total number of publications per year based on keywords

As anticipated, in the technical domain, the words deanonymisation and re-identification tend to be used with the same meaning, even if a preference for the latter is registered.

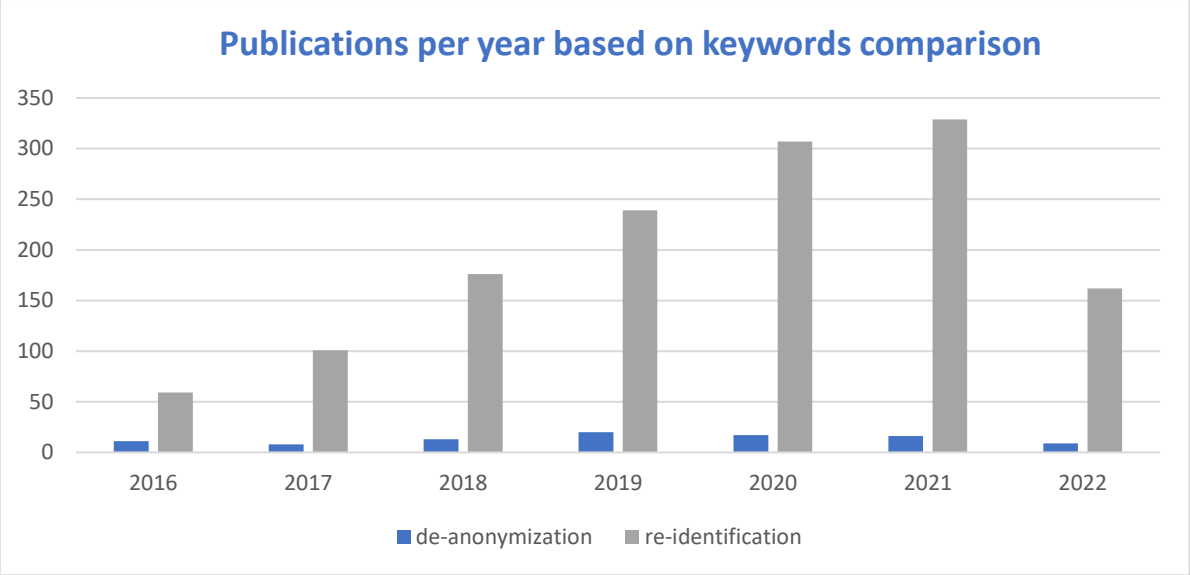


Fig. 9. Bar chart of the number of publications per year, based on keywords comparison

The content of the explorative literature review shows that deanonymisation/re-identification can be performed not only using auxiliary data (*seed-based deanonymisation*), thus data gathered in any kind of contexts private or public, but also with no auxiliary data (*seed-free deanonymisation*). Therefore, this consideration makes the semantic difference introduced by the European legislator between personal and non-personal data totally irrelevant.

Moreover, it shows that even in the case of sophisticated anonymisation techniques[63], the strength of protection is impacted more in structured data (such as microdata contained in databases and other repository) than in unstructured data. Rich auxiliary information, also called *background information*, is mainly available for structured data. Therefore, the state-of-the-art shows that most papers are focused on the deanonymisation/re-identification of structured data, therefore in these cases the techniques are more consolidated. However, it also shows several limitations such as the imprecision of the background knowledge used to deanonymise or the a possible lack of accuracy as they rely on limited structural data.

Such limitations and constraints represented the main background used to develop new deanonymisation/re-identification techniques without auxiliary knowledge (*seed-free or blind deanonymisation/re-identification*)[98], mostly tailored for unstructured data, between the early 2000s and 2022, most probably due to the increase in the Big Data technologies.

[63] In this regard, the main reference is to differential privacy which is currently considered one of the main data protection models, even if academics have already begun to question its efficiency. See in detail in Chapter 3.

Lastly, the technological literature analysis aimed to highlight the difference in the perception of the topic among technicians (IT, data scientist, statisticians etc.) and jurists.

The aim is to analyse the technological development provided with the articles using a legal lens, thus recalling the three main deanonymisation/re-identification technique mentioned in the unique institutional guideline (WP29 05/2014):

- singling-out
- linkability
- inference

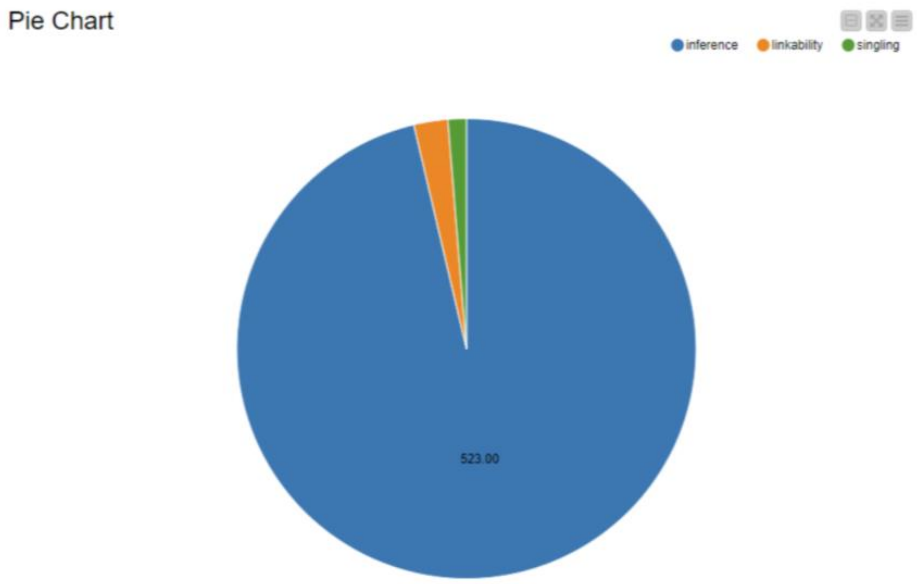


Fig. 9.a. Pie chart of recurrence recalled by the institutional guideline on anonymisation and consequent issue of deanonymisation/re-identification

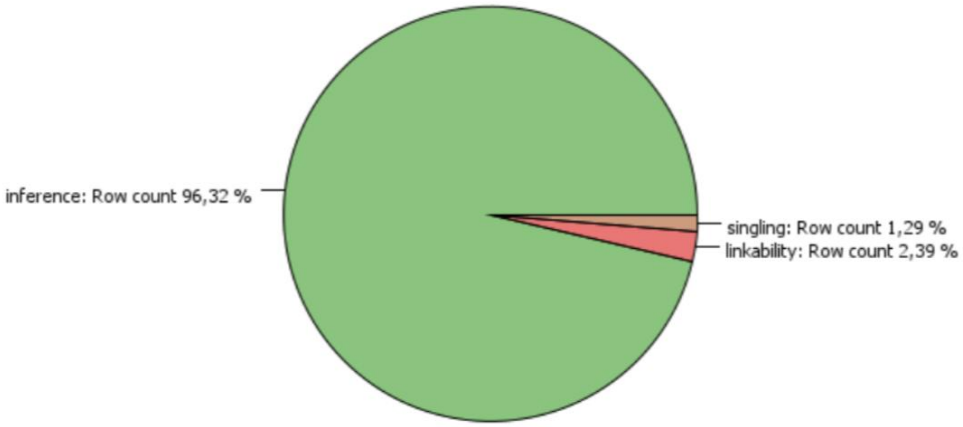


Fig. 9.b. Pie chart of the percentage of recurrence (singling out, linkability, inference)

As shown in Fig. 9.a. and Fig. 9.b. the word recurrence presents the highest percentage for inference, thus most likely the technique of singling out and linkability may be combined with inference to deanonymise personal data.

Chapter 4. *An Empirical Observation of Data Deanonymisation Spectrum in Further Data Processing: Forgetting by Reusing?*

Index of the Chapter

Short Abstract of the Chapter

This chapter provides a sample of the empirical legal research on the technological development of the deanonymisation issue, from 2016 to 2022, with a statistical analysis and a visual representation of the outcome by continental jurisdictions. The statistical analysis shows which continental jurisdictions invest more in researching the deanonymisation issue, and thus have a greater technological development. Moreover, it investigates the correlation between such trends and different continental approaches to data, namely centralised and de-centralised, demonstrating to what extent the right to be forgotten ex Art. 17 of the GDPR can

be granted. Moreover, the analysis investigates the evolution of the technological development before and after the entry into force of the GDPR.

The papers collected for the empirical legal research provided in this chapter are indexed and annexed to this chapter.

Based on the grounds of the explorative literature review on data deanonymisation presented in Chapter 2, this chapter analyses the deanonymisation issue in light of the sole institutional guidance on deanonymisation: the Working Party Opinion 05/2014 on anonymisation techniques. As such, papers are grouped into three main deanonymisation techniques: singling-out, linkability, inference.

As the European institutions consider presenting a new guidance on the issue in the forthcoming months, this chapter will integrate it with a comparative analysis.

4.1. Statistical Analysis of the Deanonymisation Spectrum Risk

As anticipated, the main institutional reference to the risk of deanonymisation/re-identification comes from the Working Party 29 Opinion 05/2014 on anonymisation techniques. Many things have changed the publication of this opinion, but, for the time being, this opinion still represents a guideline in the evaluation of the level of data anonymity granted using the anonymisation model in processing data.

Referring to Chapter 3 with regard to the specificity of each technique, this chapter focuses on the main declinations of the risk, as specifically recalled in the Opinion.

In fact, the WP29 request the testing of the robustness of the chosen technique against three declinations of the de-identification/re-identification risk, therefore whether:

- it is still possible to single out an individual
- it is still possible to link records relating an individual
- information concerning an individual can be inferred.

The anonymisation technique should prevent the risk of singling-out an individual, the risk of linking records and the risk of inference, thus respectively singling out an individual, or linking her/his data, or inferring knowledge from an individual with or without auxiliary knowledge.

In line with this premise, this paragraph aims to frame the technological development in these three declinations of deanonymisation/re-identification, as well as showing the spread of it among continental jurisdictions. Moreover, it pictures the trend in technological development in the transition from the previous legislation to the entry into force of the GDPR.

	2016	2017	2018	2019	2020	2021	2022	TOT.
Singling-out	7	5	11	9	21	22	15	90
Linking	38	42	58	58	94	91	62	443
Inference	19	31	64	105	204	312	208	943

Fig. 10. Table representing the number of publications per year

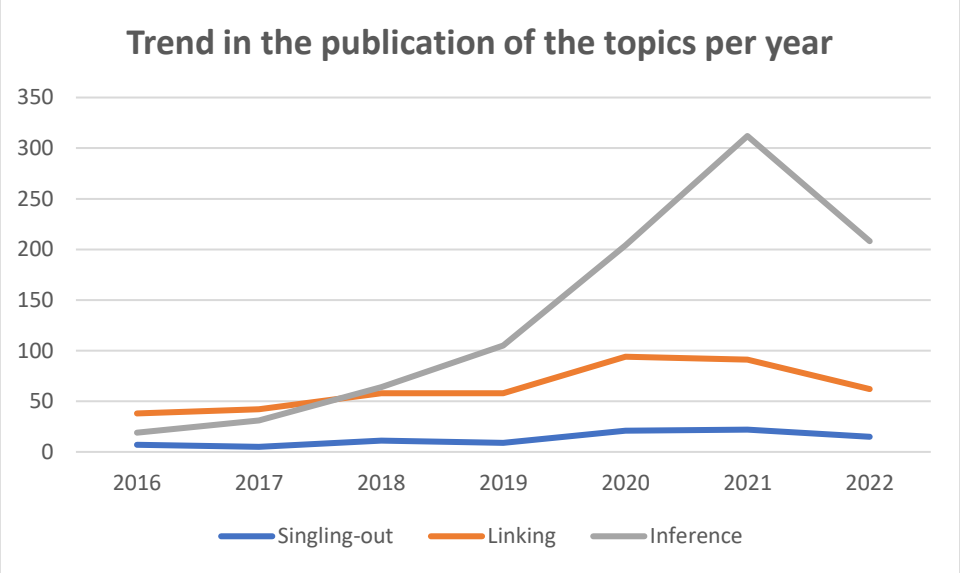


Fig. 11. Trend in the publication of topics per year

Figures 10 and 11 show the evolution of the topic in the number of publications.
The technological development of the techniques seems to be impacted differently in the transition from the previous legislation on data protection and the GDPR.
The technological development of singling out seems constant in time, registering a small increase between 2019 and 2022 but overall remaining constant. The same considerations are valid for the technique of linking multiple records relating an individual.
The technological development of the inference technique is remarkably different, which registered a notable increase, especially from 2019 to 2021.
Therefore, data shows that despite the GDPR becoming directly applicable in 2018, the technological development of deanonymisation/re-identification has not been impacted and the number of publications has continued to grow by year. The only exception is represented by the technological development of the inference technique, which registered a remarkable growth from 2019 to 2021.
Lastly, it should be considered that data was collected until August, thus the decreases registered from 2021 to 2022 may be linked to the incomplete representation of data.

The following charts and graphs represent the technological development of the deanonymisation/re-identification techniques as listed in the WP29 Opinion on Anonymisation Techniques no. 05/2014, namely singling out, linkage and inference.
The study is conducted collecting and analysing the number of publications by year and by continental jurisdictions.

	Africa	America	Asia	Europe	Multiple C	UK
2016	0	1	1	3	0	2
2017	0	0	1	4	0	0
2018	0	3	3	2	2	1
2019	0	5	4	0	0	0
2020	0	7	5	8	0	1
2021	0	8	7	7	0	0
2022	0	7	3	4	0	1

Fig. 12. Chart of singling out technological development values

This first chart collects the number of publications per year and continental jurisdiction, from 2016 to 2022. It is easily noticeable at a glance that such techniques are not common, and its technological development is lower compared to the other techniques.

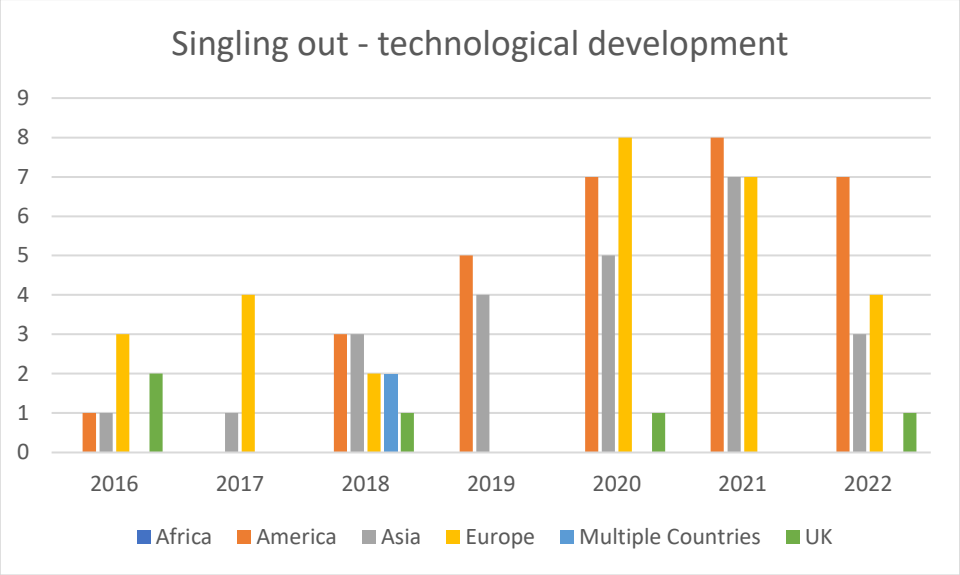


Fig. 13. Graph of singling out technological development by year and continental jurisdictions

The graph shows the comparison of continental jurisdictions per year, from which it emerges that America holds the highest number of publications, thus can be considered as the leading country in technological development and represents a trend setter. Asia and Europe follow the lead, while a lesser contribution is provided by UK and lastly, by Africa which seems not to take part to the academic debate.

	Africa	America	Asia	Europe	Multiple C	UK
2016	0	9	11	15	1	2
2017	1	18	8	11	0	4
2018	1	26	21	8	0	2
2019	0	25	16	12	2	3
2020	1	33	27	27	1	5
2021	0	27	34	25	0	5
2022	0	21	16	19	0	6

Fig. 14. Chart of linkage technological development values

Figure 14 shows the number of publications by year and continental jurisdictions of the linkage deanonymisation/re-identification techniques.

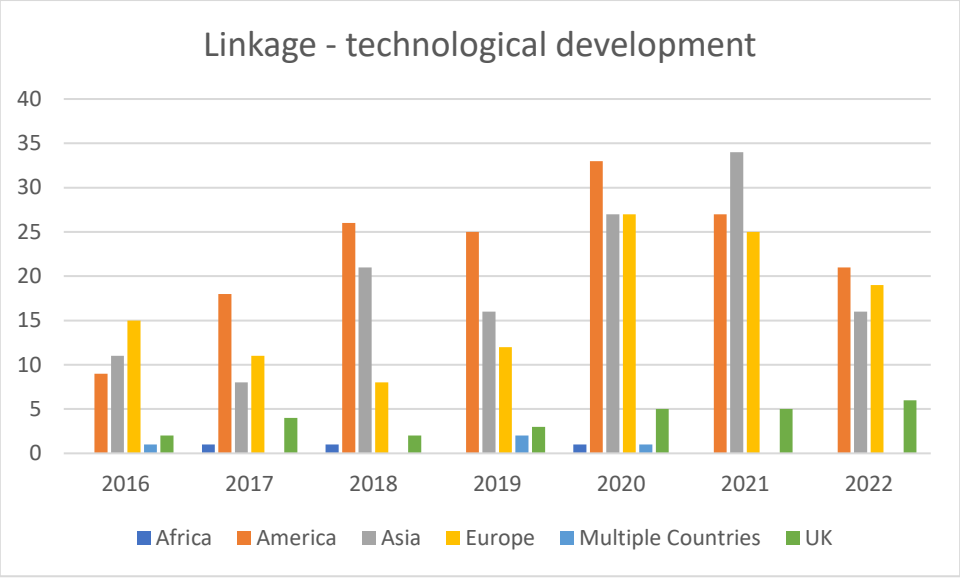


Fig. 15. Graph of technological development by year and continental jurisdictions

Figure 15 shows the comparison of continental jurisdictions by year, from which it emerges that Asia and America are the trendsetters in the technological development of data linkage. Especially from 2021, Asia has led the academic debate on this deanonymisation technique, followed by America and Europe which have almost proportional values. UK and multiple other countries are also participating in the debate, while Africa only has a small "voice" with only few publications.

	Africa	America	Asia	Europe	Multiple C	UK
2016	0	6	3	5	0	5
2017	0	18	2	5	1	5
2018	0	38	4	9	2	11
2019	0	52	18	21	3	11
2020	0	97	56	35	3	13
2021	0	150	83	60	3	16
2022	0	97	57	36	3	15

Fig. 16. Chart of inference technological development values

Figure 26 presents a chart on the technological development values on data inference from 2016 to 2022, among continental jurisdictions, from which it is evident that Africa is not taking part in the academic debate.

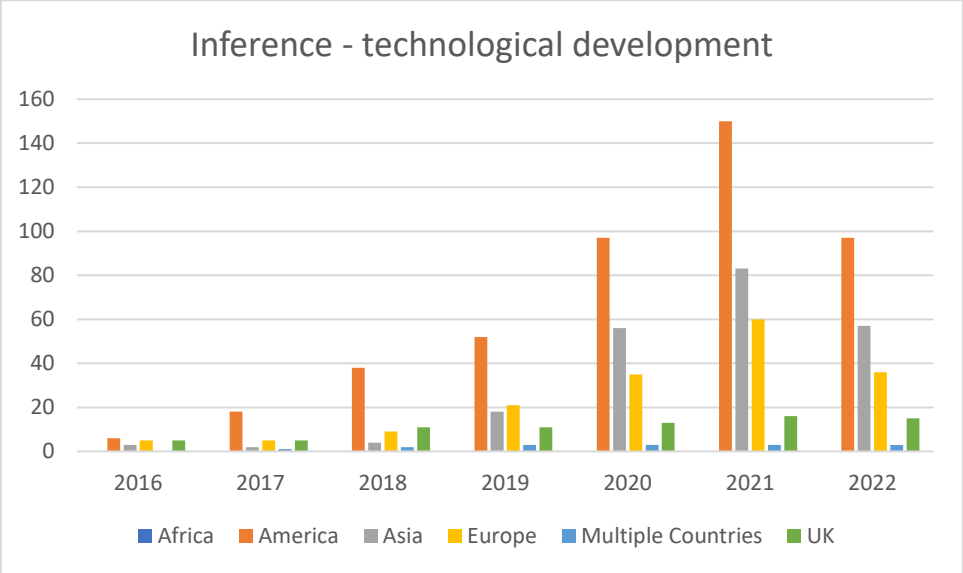


Fig. 17. Graph of inference technological development by year and continental jurisdictions

Figure 17 shows the comparative values between continental jurisdictions by year, from which it emerges that America is leading the technological debate, thus the technological development, on data inference for deanonymise data. It is followed by Asia and Europe, while UK and other countries give a smaller contribution. Again, Africa is not participating to the academic debate.

From the comparative analysis of the previous figures (in this paragraph) it can be inferred that America and Asia are leading the debate on data deanonymisation/re-identification, providing

the advance in the technological development of such techniques. Considering this evidence, it could certainly be beneficial to outlaw such techniques in Europe, especially considering the fact that Europe doesn't seem to have a central role in the debate. The know-how developed by the leading countries can make data of other countries vulnerable and almost everything can lead to difficulties in granting data subjects' rights protection due to misuses.

As a last note, the scientific literature gathered on the topic allowed an analysis on the term recurrence to be performed, recalling 3 (three) terms that represent personal data *ex* art. 4 of the GDPR: name, IP, location. The following pie chart shows the main words recalled:

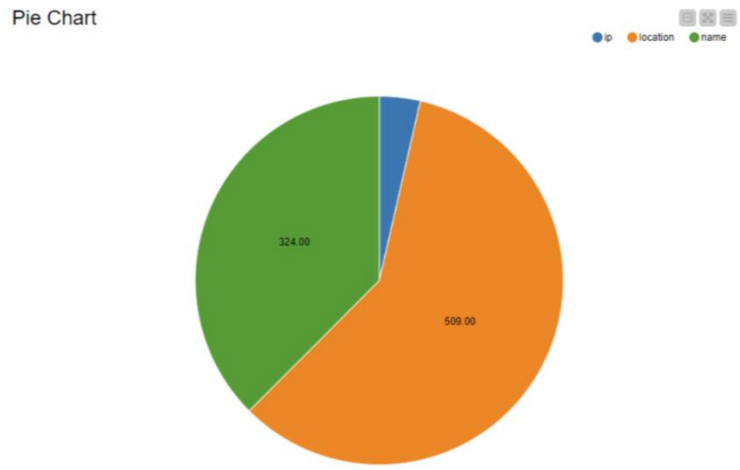


Fig 18. Pie Chart of term recurrence

In the following figure the related percentages are provided:

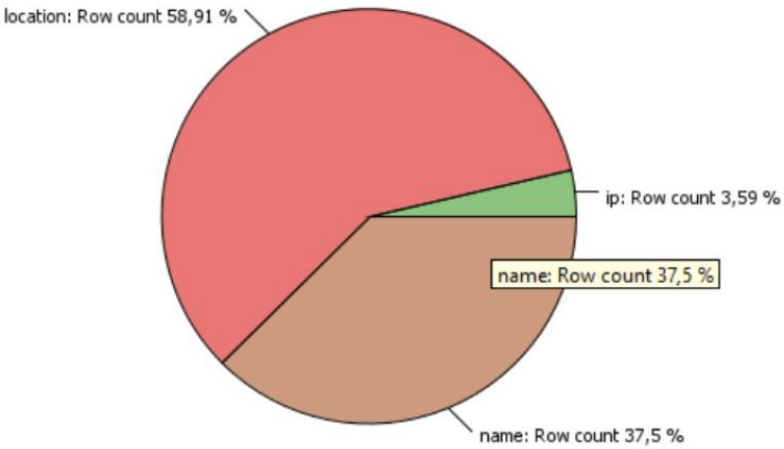


Fig. 18.a. Pie chart of percentage term recurrence (name, location, IP)

Figures 18. and 18.a. show that the major development of the deanonymisation/re-identification techniques pertains to location data with a percentage of 58.91%. The deanonymisation techniques used to deanonymise names recur less than the ones on location. Last are the ones used for the IP with 3.59%.

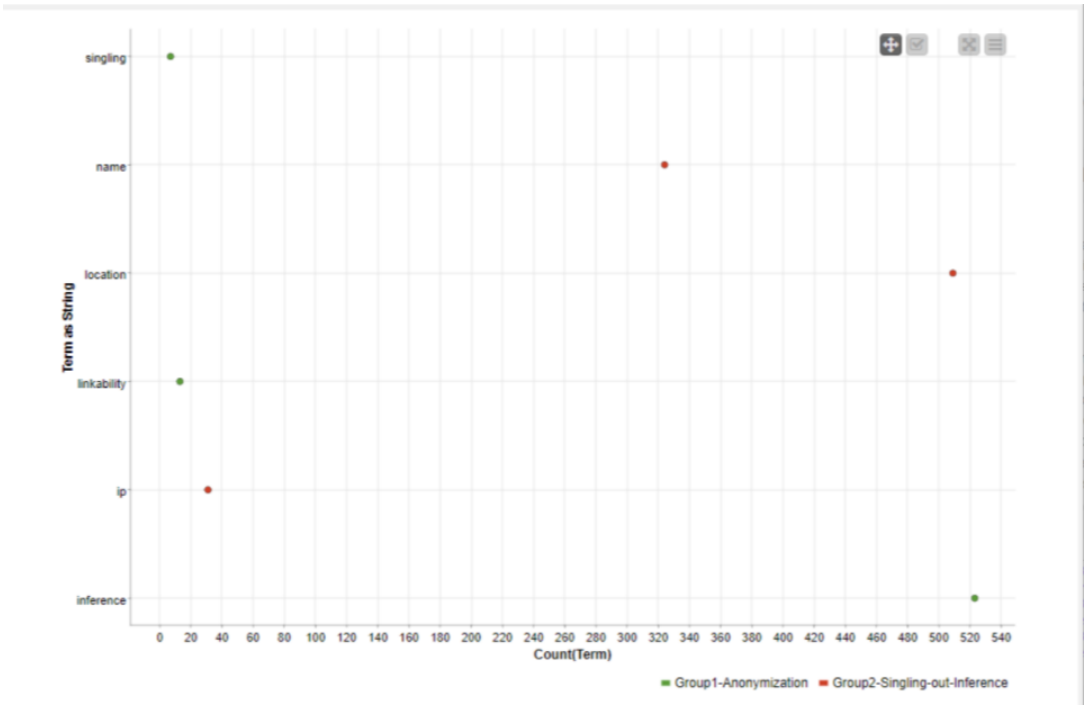


Fig. 19. Term recurrence comparison in the literature recalled in Annex I, II, III, IV and V.

4.2. Further Data Processing and Sharing: Forgetting or Not Forgetting? An Old Problem Under a New Guise

Data misuse certainly has an impact on the values introduced by the GDPR. The right to erasure (right to be forgotten) has been widelyanalysed and investigated in literature, as it raised interest not only in Europe but all around the world. Traditionally the right to be forgotten has been studied and investigated as the right recognised for data subjects to erase their information appearing online (personal data), that is considered harmful, therefore solely limited to personal data. This right must overcome many balance tests with other fundamental rights in trials, and still nowadays it seems that there is still room for this right to take shape. In fact, of the main problems of the right to be forgotten lies in the existing lack of hierarchy of the respected fundamental rights concerned [160]. In this regard, the Courts are certainly involved in defining the presumption of supremacy among fundamental rights[64] but, for the time being, there is no evidence of trials concerning the impact of the deanonymisation/re-identification risk on the right to be forgotten, and the risk of that becoming a dead letter in the GDPR.

There is no empirical evidence that data can be deanonymised thus, data subjects are not potentially able to ascertain any violation in this sense. From the opposite perspective, there is effective legislation punishing such practices.

Only a more efficient and clear legislation can help tackle such a risk, as non-personal data may be as harmful as personal data and the safeguards tools implemented in light of the GDPR have proved not to be sufficient.

In fact, is clear that the continuing technological development that allows non-personal data (processed personal data) to be turned into personal data represents a risk not properly addressed by the legislator. First, it must be said that the only institutional reference considering the risk and tackling it is limited to the Working Party Opinion 05 on anonymisation techniques

[64] In this sense, please refer to the following list of the European Court of Justice handling cases on the Right to be Forgotten: https://curia.europa.eu/juris/documents.jsf?nat=or&mat=or&pcs=Oor&jur=C%2CT%2CF&for=&jge=&dates=&language=en&pro=&cit=none%252CC%252CCJ%252CR%252C2008E%252C%252C%252C%252C%252C%252C%252C%252C%252C%252Ctrue%252Cfalse%252Cfalse&oqp=&td=%3BALL&avg=&page=1&text=right%2Bto%2Bbe%2Bforgotten%2B&lg=&cid=1172581 or to the list provided in the database of the European Court of Human Rights: https://hudoc.echr.coe.int/eng#{%22fulltext%22:[%22right%20to%20be%20forgotten%22],%22documentcollectionid2%22:[%22GRANDCHAMBER%22,%22CHAMBER%22]}

from 2014. Since then, technological development has evolved and the semantic difference between personal and non-personal data seems to be no longer sufficient to grant data protection. Consequently, rights granted by the GDPR, such as the right to be forgotten, risks becoming a dead letter.

Especially in the forthcoming implementation on data ecosystems allowing reuses of data, the remarkable availability of data in the infosphere may have an impact on the personal management of data subject representation in the infosphere. This may potentially lead to obscure decisions, discriminations, and inequality.

Therefore, it is deemed essential to continue investigating the technological development of the deanonymisation/re-identification risk as it provides a real perspective on data processing and further uses. As such, it allows a better understanding of the concrete feasibility of many principles set out in the General Data Protection Regulation, avoiding those practices violating data subjects' rights that risk falling beyond human control, from remaining unnoticed.

Lastly, it could certainly be beneficial to outlaw practices of turning non personal data into personal data, with fines and proper enforcement mechanisms able to *concretely* grant data subjects' protection.

Chapter 5. *Unlocking Data Re-uses through Proliferation of Roles and Responsibilities: a Subjective Perspective*

Index of the Chapter

Short Abstract of the Chapter

This chapter aims to provide a subjective perspective on the issue of deanonymisation. Specifically, it investigates whether a certain degree of anonymity can eventually be granted relying on the proliferation of roles and responsibilities among stakeholders, analysing data governance models and especially in Government to Business (G2B) data sharing. In such investigation, the focus is on the Regulation on European Data Governance COM/2020/7679 - the Data Governance Act - conceived as a natural evolution of the data policies in data flow.
In fact, since 2018, confident of having settled the main grounds for the protection of citizens' rights with the GDPR, the European Commission has begun brainstorming on new models of data. In 2020 the Data Strategy stresses a main subjective point, stating that "*Citizens will trust and embrace data-driven innovations only if they are confident that any personal data sharing in the EU will be subject to full compliance with the EU's strict data protection rules*".

5.1. Trusting the Middleman in the DGA: Data Stewardship and its Role in respect of the GDPR and the FFDR

After acknowledging the main strength of big data analysis systems in IoE (the possibility of cutting out the middleman in the dataflow and automating the process) scholars highlighted the issues linked to this strength as the vulnerability of such systems in terms of privacy and data protection [3] [136] [4][2].

Moreover, from a purely legal point of view, as investigated in the previous chapters, the objective perspective introduced by the GDPR on data anonymity and relying on anonymisation has been proven to emphasise such problems.

Therefore, a new interpretation has been proposed and new regulatory frameworks seem to offer new approaches to the above-mentioned risk, opening up to a new interpretation of the issue based on a subjective approach. In this sense, data intermediation and data stewardship represent a solution for integrating new leading figures in the analysis process, provided that some conditions and requirements are met.

Data stewardship is considered as the existence of mechanisms for responsibly acquiring, storing, safeguarding, and using data [112]. This concept is closely linked to data governance and intends to convey a trust (or fiduciary) level of responsibility toward the data [137].

As uncontrolled data access may have a detrimental impact, data governance conceptualises and frames data stewardship responsibilities, allowing secondary data uses and repurposing to be unlocked. The concept of data stewardship has its roots in the practice and science of data collection, sharing and analysis, recalling a typical approach to data management aimed at protecting data that can identify individuals [112].

Therefore, the main aim of the DGA is to introduce a scheme of trust which finds a balance between the legitimate interest of collecting data and the safe and secure data handling for secondary data uses.

Data stewardship represents the main approach of the DGA where the role of intermediaries is neutral, aimed at coordinating the interest of data subjects – who generate data – and data users – who create services and goods based on data.

The European framework designed in the DGA represents a hybrid model, as it lies in between the one based on data ownership and the one based on data access[26, 27][27].

The first incentivises data access through payment for information, thus recognising data ownership rights, while the second treats the information as a public good. In doing so, the information is available for use by entities structured and operated in accordance with the principle of data stewardship, imposing important limits on the use of data and transparent policy standards.

The DGA can therefore be considered as a hybrid model in between the ones mentioned above because it aims to

- make public sector data available for re-use, when such a right is subject to rights of others, granting access to data
- share data among business, even allowing data use on altruistic ground.

Moreover, according to the forthcoming legislation on data spaces[65], data is expected to be naturally reused, relying on secured processing environments supervised by the public sector.

Therefore, one of the main needs posed by the DGA is to supervise the purpose of reuses, define responsibility and liability exposure of public sector bodies, and define a formal approach to stewardship activities that support compliance and verification reporting to grant transparency.

Some academics [138] [139] stress the fact that, when considering the DGA interacting with other regulatory instruments, and especially with the GDPR, creates some legal uncertainty. The two regimes present several areas of inconsistency, on the distinction between personal and non-personal data as a key element of the data sharing practice.

In fact, even before the Data Governance Act proposal, academics [140] highlighted the tension between the principles set out in the GDPR and the FFDR, especially concerning data sharing for secondary and further purposes. However, now the DGA has been adopted, it seems that the same criticalities [141] [142] [138] [143] [144] persist, even being exacerbated by the new regulation.

In fact, the DGA seems to be built on the main semantic concepts of the GDPR and the FFDR (as investigated in Chapter 3) and, to some extent propagating the legal uncertainty and interpretation issues. Even the issue of a mixed dataset based on the semantic meaning of

[65] In this sense, please see the Staff Working Document of the European Commission, introducing the framework on Data Spaces: https://digital-strategy.ec.europa.eu/en/library/staff-working-document-data-spaces in which it is clarified that *The creation of EU-wide common, interoperable data spaces in strategic sectors aims at overcoming legal and technical barriers to data sharing by combining the necessary tools and infrastructures and addressing issues of trust by way of common rules. A common European data space brings together relevant data infrastructures and governance frameworks in order to facilitate data pooling and sharing.*

personal and non-personal data remains open, exacerbating the problem of having two mutually exclusive definitions of personal and non-personal data [145]. In addition, recalling the *compilation of data*, the DGA seems to leave room for *strategic behaviour of firms exploiting this regulatory rivalry* regarding the uncertainty on mixed datasets [145]. Therefore, we may consider the possibility that the European legislator deliberately avoided the issue, aiming to open the market and allowing dataflow in the Digital Single Market, relying on data stewardships. In this sense, it can also be added that the problem raised by the inextricability of datasets composed by both personal and non-personal data, being not technically feasible to be solved, could be overcome with the introduction of an additional actor in the dataflow.

Some authors [138] consider the fact that due to the inconsistencies in the regulatory framework, the ambitions and goals of the DGA will not be able to materialise.

On the same note, the joint Opinion of the EDPB-EDPS confirmed the risk of collision between the DGA, the GDPR, and the FFDR, mainly based on the concepts of personal data and non-personal data. This consideration led to consider the GDPR, upon which the DGA has been built, as *the elephant in the room of data economy* [146].

Some authors consider that instead of sorting it out, it builds upon it [138], therefore applying to any kind of data, personal and non-personal.

Apart from the objective perspective based on data semantics and investigated in the previous chapter, the DGA seems to rely on the introduction of new roles and responsibilities for the stakeholders involved in the dataflow, introducing trusted third parties that provide data sharing services, as represented in the following figure.

(1) Data Subjects

(2) Data Controller
& Data Processor

(3) Collection &
Primary Use(s) of Data

(4.a) Data Minimisation

(4.b.1.) Data Stewardship

(4.b) Secondary Uses of Data
Data Repository

(4.b.2) Data Sharing with third parties

Fig. 20. Introduction of trusted third parties in the data sharing flow

With data stewardship intended to convey a fiduciary (or trust) level of responsibility towards the data, the DGA introduces a new trusted thread in the data flow with the aim of ensuring re-uses in a common European data space, creating an Internal Market for Data[66].

In this sense, it creates two different cycles of reuse, based on the entrustment to competent bodies establishing them as data utilities or as data intermediaries acting in the general interest.[67]

These two cycles are respectively organised:

- relying on public sector bodies designated as competent under national law to grant or refuse access for re-use
- relying on neutral intermediaries as data intermediation service providers (which can be public or private).

Actually, both are required to further bridge the gap between the initial use of data and its re-uses as they licence the data for further and subsequent uses and covering an instrumental role in granting data re-uses for further purposes. They are entitled to establish the infrastructure for connecting data holders and data users, as well as creating data repositories enabling the exchange and exploitation of data[68].

Specifically, in relation to the first cycle which relies on public sector bodies, their role is instrumental to the opening to public sector data that does not fall under the scope of application of the Directive on Open Data and the Re-use of Public Sector Information[69]. These last ones are indeed pertaining to data held by public sector bodies, data that is not subject to rights of others.

[66] In this sense, Recital 3 of the Regulation species that it is necessary to improve the conditions for data sharing in the internal market, creating a harmonised framework for data exchange.

[67] This point is further investigated in the Explanatory Memorandum of the DGA at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52020PC0767

[68] Article 9 of the DGA further specifies that

[69] Directive (EU) 2019/1024 of the European Parliament and Council of 20 June 2019 on open data and the re-use of public sector information (recast) at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019L1024

The DGA, conversely and as anticipated, opens the flow to data held by the public administration but subject to rights of others, like personal data.

In this case, the DGA requests that with the data flow opening, public sector bodies control the and monitor further data processing incentivising data access through the payment of information. Therefore, such a scheme seems to represent the recognition of data ownership rights by the public sector, conversely to the cycle which relies on data intermediation service providers, on neutral intermediators which can be private or public. In that context, the DGA confirms that the information is treated as public good, available for secondary uses in accordance with the principle of data stewardship and relying on transparent policy standards. According to these premises, we can agree with some academics who considered that the DGA opted for a hybrid data governance approach recalling the principles of data ownership, as well as the principle of data access [26][27].

5.2. Secure Processing Environments for Overcoming the Spectrum of Deanonymisation

Both cycles allow the data re-uses under different circumstances. Apart from the respective peculiarities, they seem to cope differently with the spectrum of deanonymisation, ensuring different safeguards for protecting personal data.

According to the Regulation, public sector bodies holding data that are subject to rights of others are the only ones providing secure processing environments. More specifically, Art. 5 clarifies that public sector bodies will ensure the protected nature of data is preserved, providing the following requirements:

a) to grant access for the re-use of data only where the public sector body or the competent body, following the request for re-use, has ensured that data has been:

> *i) anonymised, in the case of personal data; and*
>
> *(ii) modified, aggregated, or treated by any other method of disclosure control, in the case of commercially confidential information, including trade secrets or content protected by intellectual property rights;*

(b) to access and re-use the data remotely within a secure processing environment that is provided or controlled by the public sector body;

(c) to access and re-use the data within the physical premises in which the secure processing environment is located in accordance with high security standards, provided that remote access cannot be allowed without jeopardising the rights and interests of third parties.

Therefore, with regard to personal data, public sector bodies (or competent bodies) should ensure data access if data have been anonymised and, in the event of remote access or access to the physical premises, a secure processing environment should be provided.

In this regard, Art. 2 specifies that a secure processing environment is the *physical or virtual environment and organisational means to ensure compliance with Union law*, referring to the

GDPR.[70] A more detailed explanation of the point is provided in the Recitals. Specifically, Recital 7 clarifies that anonymisation, differential privacy, generalisation, suppression and randomisation, the use of synthetic data, or similar methods or other state-of-the-art privacy-preserving methods can contribute to a more privacy-friendly processing of data. It furthers specifies that these techniques, in combination with comprehensive data protection impact assessments and other safeguards, can grant safe reuses of data. However, it is explicitly mentioned that *in many cases the combination of such techniques, the impact assessment and other safeguards implies that data can be used only in a secure processing environment provided or controlled by public sector bodies*. In this case, as confirmed in the closing formula of the recital[71], the main recall is to the statistical context where the SDC has been proved as no longer being safe and secure for releasing statistical microdata, raising new approaches in Europe, contrarily to other extra -European countries [147]. Namely, regarding the European approach, national Statistical Agencies and Eurostat acknowledged that confidentiality and data protection in Official Statistics are evolving towards more dynamic solutions of SDC. To this aim, new approaches are developed, combined SDC with complementary solutions, especially the Secure Multi-party Computation techniques that are based on a cryptographic technique where multiple parties perform a joint computation without revealing the input provided by each party [148][149][150].

With the combination of such techniques and more advanced solutions of SDC, the public sector is making advances in providing services of data sharing and shaping new data ecosystems. As expressly recalled in the DGA, the main insight comes from the traditional scenario of data monopoly used in the National Statistical Offices (NSO)[151]. In fact, according to Regulation 557/2013 on European Statistics with regard to access to confidential data for scientific purposes[72] and expressly recalled in the DGA (Recital 7), apart from the data

[70] Art. 2(20) literally specifies that: *'secure processing environment' means the physical or virtual environment and organisational means to ensure compliance with Union law, such as Regulation (EU) 2016/679, in particular with regard to data subjects' rights, intellectual property rights, and commercial and statistical confidentiality, integrity and accessibility, as well as with applicable national law, and to allow the entity providing the secure processing environment to determine and supervise all data processing actions, including the display, storage, download and export of data and the calculation of derivative data through computational algorithms*; […].

[71] In this sense, Recital 7 states that "*There is experience at Union level with such secure processing environments that are used for research on statistical microdata on the basis of Commission Regulation (EU) No 557/2013(25). In general, insofar as personal data are concerned, the processing of personal data should be based upon one or more of the legal bases for processing provided in Articles 6 and 9 of Regulation (EU) 2016/679*".

[72] See Commission Regulation (EU) No 557/2013 of 17 June 2013 implementing Regulation (EC) No 223/2009 of the European Parliament and of the Council on European Statistics as regards access to confidential data for scientific purposes and repealing Commission Regulation (EC) No 831/2002 Text with EEA relevance at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R0557

processing used for the output checking and aimed at data publication of National Statistical Data, National Statistical Offices provide a secure processing environment (in-premises) used for research on statistical microdata. The scenario is the following:

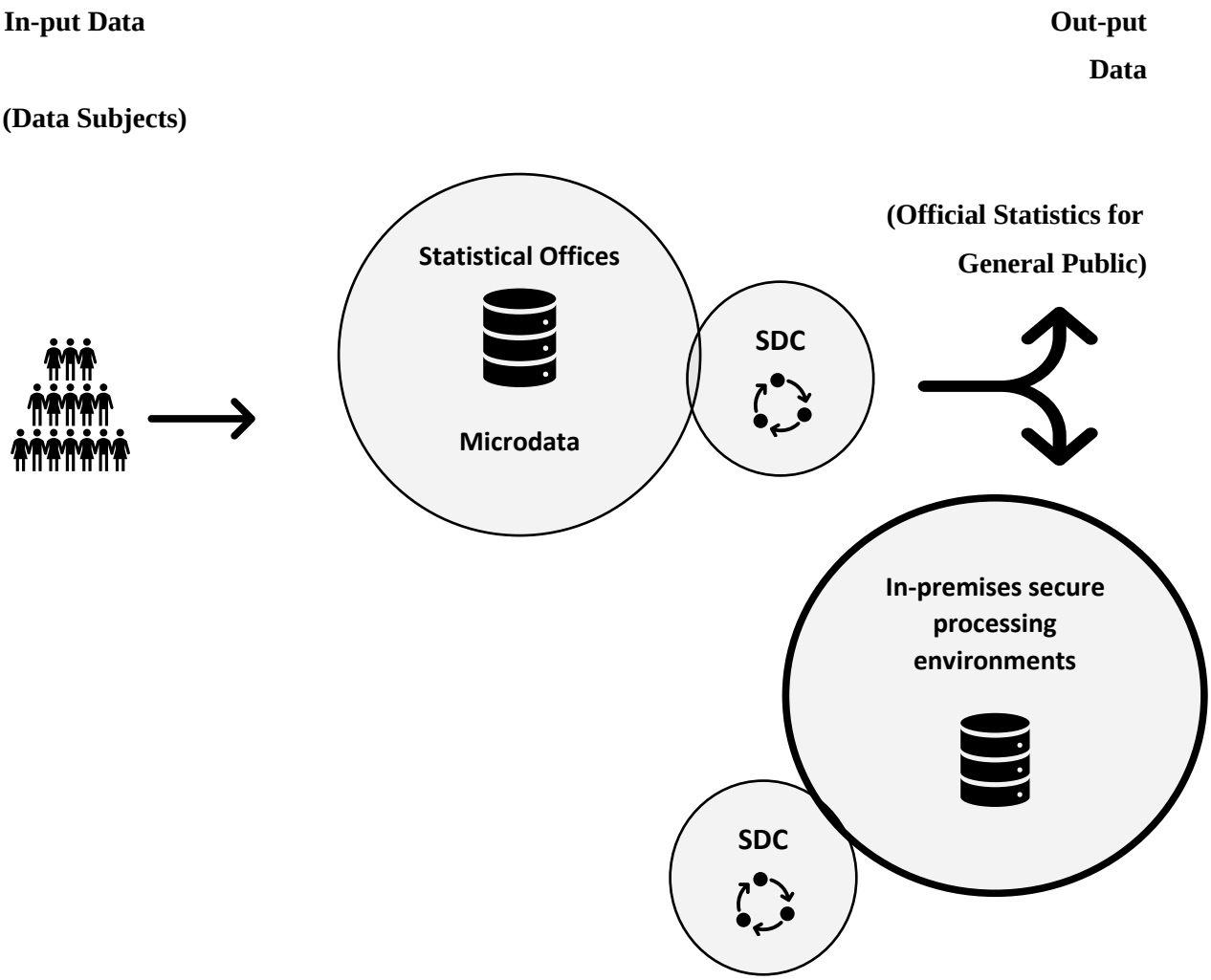


Fig. 21. Traditional Data Monopoly of National Statistical Agencies used for research on statistical microdata based on Commission Regulation (EU) n. 557/2013

Therefore, in light of the Regulation on National Statistics as regards access to confidential data for scientific purposes applied to Statistical Offices, the DGA recalls the same models for public entities holding data that are subject to rights of others, unleashing the potential of data held by public entities and allowing reuses.

In line with these premises, the scenario introduced by the DGA for data that is subject to rights of others and held by public entities relies on the creation of a data ecosystem provided and/or controlled by public entities, as shown in the figure below.

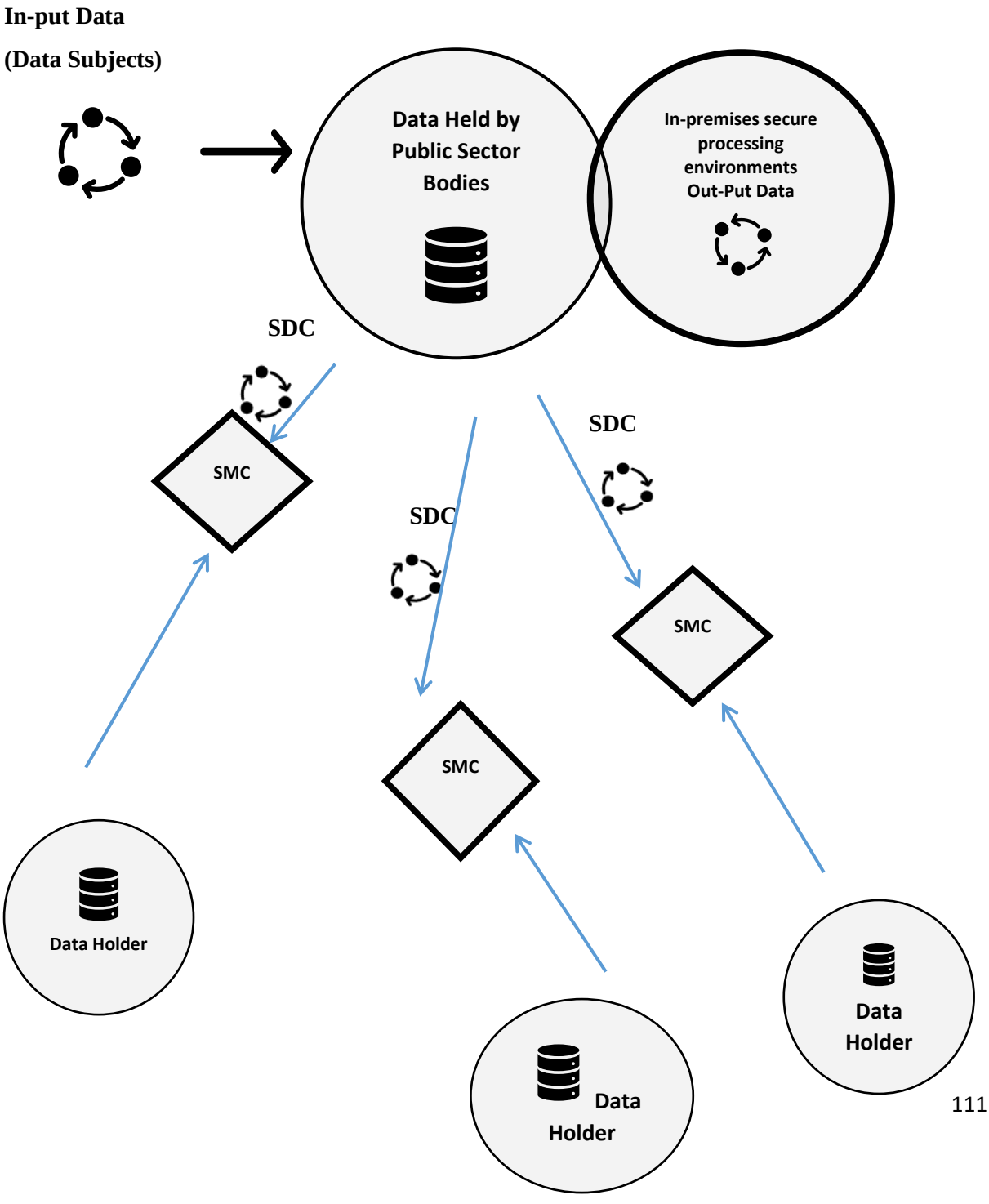


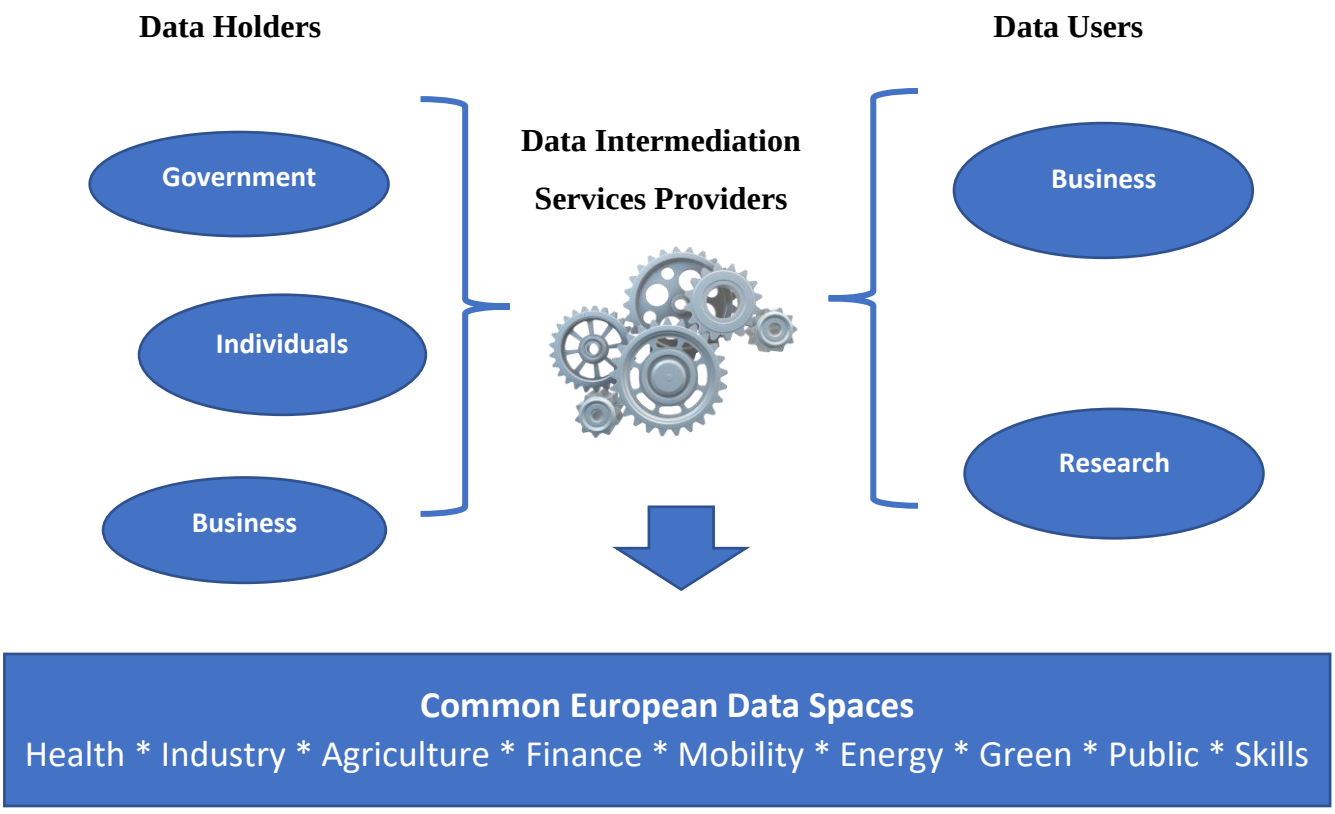
Fig. 22. New scenario introduced by DGA inspired by the traditional scenario (Fig.22) and based on public sector data ecosystem specifically applied for data listed in Art. 3.1(a)(b)(c)(d)

This scenario is better designed in Art. 5, Art. 6 and Art. 7 of the DGA, highlighting that the secure processing environment should be provided or controlled by public sector bodies.
However, it can be noted that the DGA does not provide theoretical solutions for the cases in which the re-uses can be granted *only* in secure processing environment, confirming that data processing models such as anonymisation, SDC, and other techniques combined with impact assessment are not sufficient against the risk of deanonymisation. Recital 15 only recalls the procedure of the GDPR (Articles 35 and 36 – consult the supervisory authority) in the event the provision of anonymised or modified data did not respond to the needs of the re-user, giving way to the secure processing environment, or eventually to the use of pseudonymous data.
In this sense, it introduces the design of new secure processing environments, but it leaves open the determination of the specific conditions under which this solution should be used.
In any case, the approach followed for data held by public entities is different from the one designed by the DGA for data intermediation service providers (which can be private or public). In this case indeed, as represented in fig. 13, the role of intermediator is key as it relies on data stewardship through the proliferation of roles and responsibilities among stakeholders, with the awareness that they cannot afford the cost of secure processing environments.

5.3. The role of Data Intermediation Services Providers in the DGA

In light of the Data Strategy[73], the forthcoming Data Act[74], and the initiatives proposed by the European Commission for the establishment of Common European Data Spaces[75], the DGA outlines the role played by Data Intermediation Services Providers.

In fact, they are demanded to play a neutral role in the evolving scenario, where new data ecosystems will naturally arise.



[73] https://ec.europa.eu/commission/presscorner/detail/en/ip_20_273
[74] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0068&qid=1667038718753
[75] https://digital-strategy.ec.europa.eu/en/library/staff-working-document-data-spaces

Fig. 23. Role of intermediation service providers in pooling data in Data Spaces (DGA)

According to the DGA, data intermediation services providers are expected to play a key role in the data economy, especially in supporting and promoting voluntary data sharing practices. Therefore, their main scope is to create data pooling for facilitating bilateral and multilateral data sharing[76]. In this sense, academics [152] emphasise the fact that this natural intermediation creates an ecosystem of trust, allowing the issues linked to disruptive technologies to be overcome.

Therefore, simultaneously applying to personal and non-personal data, data intermediation services providers are made accountable and responsible for data processing in the interest of third parties. They are independent from any player with a significant degree of market power. In fact, according to the regulation, they are not allowed to use data they transact in the interest of third parties (cross-usage data prohibition), for any other purpose (Recital 33), imposing a separation between the data intermediation service and other services [153] [154] [141].

In this regard it is essential to highlight that, contrary to the objective perspective, the subjective perspective on data processing models seems to allow the risk of deanonymisation to be addressed in a better manner. In fact, data intermediation services providers are the only ones responsible for processing data and take care of roles, duties, and responsibilities in granting an acceptable level of anonymity for ensuring data reuses, offering temporary storage, curation, conversion, anonymisation and pseudonymisation. Therefore, the level of data anonymity seems to no longer pertain to data holders in the event they wish to reuse their data and, to some extent creating legal uncertainty even if concentrated on the figures of data intermediation services providers [138].

This approach is also confirmed when they are, for example, required to take all reasonable measures to prevent access to the systems where non personal data (e.g. processed personal data) are stored.[77]

[76] In this sense, Recital 27 specifies that data intermediation services providers have a facilitating role in the emergence of new data-driven ecosystems, and that this will be particularly important in the context of establishment of European Data Spaces.

[77] In this sense, Recital 23 states that data *intermediation services providers adhere to all relevant technical standards, codes of conduct and certifications at Union level*, confirming a certain interest in aligning their roles and duties within the Union, avoiding fragmentations.

The activity performed by data intermediation services providers is therefore subject to oversight by competent authorities[78] for ensuring compliance and they are concretely facilitating the exchange of data, especially in the light of the implementation of Data Spaces, where they play a key role in pooling data. The DGA clearly tailors a specific role for data intermediation services providers aimed at establishing commercial relationships among third parties, but also at ensuring standards in the processing of data and generating interoperability, even if their liability must be addressed based on national liability regimes.

Moreover, in providing such intermediation services for data subjects, in line with what is anticipated in Recital 30 of the DGA, they should be considered as a specific category, as they seek to enhance the agency of data subjects, or rather individual control over their data. To this aim, the DGA imposes that the business model of such providers should ensure there are no misaligned incentives to make individual data more available than is necessary in their interest, thus allowing any kind of business model in line with such condition. A specific recall is to data cooperatives, whose aim should be to strengthen individual positions and make them aware of better choices about their data. In this sense, academics [155] consider that data cooperatives certainly act as the fiduciary of their account holders' data, thus ensuring fair data access. However, they face two main challenges. The first pertains to participatory democratic governance as the *delegative democracy,* or *proxy democracy* [156] which require both elements of direct and representative democracy. The second challenge is linked to their funding, as they are self-representative entities thus, especially at the beginning of their activity, there is a consistent need of financial support.

In this regard, it seems that data altruism organisations, as introduced in the DGA, should aim to overcome such a challenge, as they might provide a governance and trust framework for data sharing and data donation in the primary interest of data subjects. However, some uncertainties remain.

[78] Recital 44.

5.4. Data Altruism Organisations for Allowing Re-uses on Altruistic Grounds

In the framework provided by the DGA, data altruism organisations seem to serve a different purpose from data intermediation services providers and, therefore, represent a different category.

In fact, they are not required to offer data intermediation services, nor to establish a commercial relationship between potential data users, data subjects and data holders.

Art. 2(16) of the DGA clarifies the concept of data altruism as the voluntary sharing of data based on data subjects' consent to process their personal data, or the permission of data holders to allow the use of their non-personal data (e.g., processed personal data), without seeking or receiving a reward going beyond compensation aimed at covering the cost they incur where they make data available for objective of general interest.

With this introduction, the EU legislator grants a strong potential to the use of data voluntarily made available and, even in this case – as in the case of intermediation services providers, there is a clear aim to contribute to pooling data in the Data Spaces, eventually allowing and enabling data analytics and machine learning, as expressively mentioned in Recital 35.

In this regard, the creation of data altruism organisations may be decisive in allowing a fairer use of data, especially in light of avoiding many practices based on the reward of data subjects for their data donation, which have been criticised [157].

A central role is played by Member States that are encouraged to facilitate data altruism through national policies and the implementation of a system of public registers.

The key element of such organisations is indeed their non-profit status, thus leading to the consideration that they are supposed to receive public funds for the pursuit of their purpose and, in such cases eventually generating conflict of interests among Member States, even if they may function as independent bodies.

Moreover, it seems that the data altruism organisation roles and duties may overlap with the data intermediation services providers offering their services to data subjects, especially because implementation of the Regulation may vary among Member States.
However, to a certain extent, as the DGA has only just entered into force and many amendments have been made to its first proposal, academic literature is lacking, and Member States are currently proceeding with implementation.
However, a single element keeps attracting major interest in academic literature: the general interest justifying the activity of data altruism organisations.

5.4.1. General interest in the DGA & public interest in the GDPR: a dialectic tension

Art. 15 of the DGA stresses the fact that the requirements applicable to data intermediation services shall not apply to *recognised data altruism organisations or other non-profit entities insofar as their activities consist of seeking to collect data for objectives of general interest, made available by natural or legal persons on the basis of data altruism, unless those organisations and entities aim to establish commercial relationships between an undetermined number of data subjects and data holders on the one hand and data users on the other*.
With this premise, the DGA sets out an exceptional framework for the above-mentioned activities, encouraging individuals and companies to make data voluntarily available for the common good, e.g., for a particular research project.
The main reference for this kind of entities is the pursuit of general interest activities. This concept seems to create a dialect tension with the public interest as recalled in the GDPR.
In this last case, academic literature shows there are different approaches to the notion of public interest, especially when investigated with reference to biobanking and scientific research [158]. Moreover, it emerged that in the GDPR, the concept is recalled roughly 70 times, but a specific and concrete definition is not provided. In this regard, the main reference to public interest may be the one relating to the lawful processing of personal data - Article 6(2) and Article 6(3) – or, for secondary purposes carried out in the public interest, the prohibition of processing personal data can be lifted – Art. 89 of the GDPR.
Therefore, the GDPR opted for an open formula for defining the public interest, even allowing Member States to define it on their own, determining their own policies, as anticipated in

Chapter 2. This approach has been heavily criticised in the Impact Assessment of the Regulation which used to recall the concept of "*high public interest*"[79], maintaining that with such a formula, the Commission could have had the opportunity to centralise control over Member States regarding exceptions in processing and, more generally, on the exception to the GDPR. However, despite such an expression was not retained in the final draft of the approved GDPR, some critics persist [159], the situation on secondary purposes of processing the situation may be problematic, as already investigated.

Specifically, the GDPR recalls cases of necessary processing for reason of public interest in art. Art. 9(2)(i) […] *in the area of public health, such as protecting against serious cross-border threats to health or ensuring high standards of quality and safety of health care and of medicinal products or medical devices, on the basis of Union or Member State law which provides for suitable and specific measures to safeguard the rights and freedoms of the data subject, in particular professional secrecy*;

9(2)(j) […] *for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes in accordance with Article 89(1) based on Union or Member State law which shall be proportionate to the aim pursued, respect the essence of the right to data protection and provide for suitable and specific measures to safeguard the fundamental rights and the interests of the data subject*.

Rather than presenting a definition, the DGA provides examples and contextualisation. For example, Recital 16 recalls *objectives of general interest as provided for in national law, where applicable, such as healthcare, combating climate change, improving mobility, facilitating the development, production and dissemination of official statistics, improving the provision of public services, public policy making or scientific research purposes in the general interest*.

Even in this case, it is not clear what the legislator intended by general interest. However, differently from the GDPR, the DGA imposes that entities seeking to collect data for objective of general interest based on data altruism should be registered in an *ad hoc* register kept by *competent public authorities*.

In this sense, DGA seems overcoming the legal uncertainty linked to the concept of public interest in the GDPR, recalling similar example but centralising the control on the hand of the public sector. The implementation of the DGA would reveal the evolution of the imprinting

[79] In this sense, please refer to the impact assessment of the GDPR, also extensively recalled in Chapter 3.

given by the DGA being certain, so far, that the evolution of the legislation seems propending towards a centralised approach over data processing.

In conclusion, three main points represent the pillars of the DGA:

- The introduction of rules aimed to ensure the widest availability of data held by public sector bodies thus granting re-uses
- A notification system and defined requirements for data intermediation services
- A registration system for data altruism.

Irrespectively on how the DGA will be implemented in the Member States, it is unquestionable that all of them are strictly anchored to public sector supervision, exposing data to public centralisation.

Chapter 6. *Conclusion*

This research investigated the foundations on which the whole European system is built, namely the GDPR and the FFDR, which introduced the main semantic difference between personal data and non-personal data. Specifically focusing on *further processing* in Big Data analysis systems in IoE environments, its aim was to question the semantic nature of data in the further uses of data and the consequent protection recognised for data subjects' rights. The investigation was carried out referring to two points of view that are considered to challenge the process of conciliate law with reality: the risk of deanonymisation/re-identification (allowing the turning of non-personal data - processed personal data - into personal data) and the right to erasure (*right to be forgotten*).

Scientific literature shows that the technological development of deanonymisation/re-identification techniques is growing remarkably, especially in some geographical areas which tend to invest more in such research.

Therefore, despite the fact that the GDPR is considered to be a gold standard in protecting data subjects, technological development certainly impacts on data subjects' rights, especially on the right to erasure *ex* art. 17 of the GDPR (*right to be forgotten*).

The two different perspectives, objective and subjective, investigated in the thesis confirm the above-mentioned impact. The objective one, questioning the extent of the protection granted by the two main data processing models recalled by the GDPR, namely, anonymisation and pseudonymisation, led to framing the limits of these models. Therefore, it demonstrates that anonymisation may represent a sufficient data protection model only in a few cases, but not necessarily for Big Data. Here, the diversity of the data consistently challenges the model and contextual evaluations are needed, in addition to a Data Protection Impact Assessment (DPIA),

aimed at better empowering data processors and data controllers in the processing of anonymised data.

Contrarily, pseudonymisation seems to satisfy the need to grant better data protection, ensuring a better level of data anonymity compared to anonymisation. Such an approach seems to be validated and endorsed in the evolution of the legislation, namely the DGA. In line with this point, the subjective perspective confirmed the potential of granting better protection by relying on the proliferation of stakeholders' roles and responsibilities, also with the introduction of new neutral intermediaries.

However, considering the fact that the DGA pins specific roles and duties on these new public entity figures, this type of approach is limited to generating a data ecosystem solely dependent on the public sector orientations, thus it may represent a challenge for democracy. This situation may be exacerbated by the lack of specification concerning general interest in the DGA and public interest in the GDPR, eventually leading to the concentration of data in the public sector challenging privacy and data protection of citizens. In this scenario, the right to erasure may evolve to a dead letter.

Moreover, the implementation of the DGA expected in the following months and implemented by Member States may generate the data subjection of some Member States in favour of others, in pooling data into the Data Spaces, thus justified by general interest and/or public interest.

In line with these considerations, it is considered that more work is required to control this possible drift. On one hand, improving the empirical research approach aimed at framing the new trends in the creation and evolution of data ecosystems. On the other hand, incentivising the establishment of legal entities aiming to represent data subject rights solely and uniquely, conjugate legal and technological knowledge in line with the technological development.

Annexes

Annex I. Deanonymisation

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Annex II. Re_Identification

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Annex III: Singling out

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Annex IV: Linkage

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Annex V: Inference

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Chapter 6. *Conclusion*

This research investigated the foundations on which the whole European system is built, namely the GDPR and the FFDR, which introduced the main semantic difference between personal data and non-personal data. Specifically focusing on *further processing* in Big Data analysis systems in IoE environments, its aim was to question the semantic nature of data in the further uses of data and the consequent protection recognised for data subjects' rights. The investigation was carried out referring to two points of view that are considered to challenge the process of conciliate law with reality: the risk of deanonymisation/re-identification (allowing the turning of non-personal data - processed personal data - into personal data) and the right to erasure (*right to be forgotten*).

Scientific literature shows that the technological development of deanonymisation/re-identification techniques is growing remarkably, especially in some geographical areas which tend to invest more in such research.

Therefore, despite the fact that the GDPR is considered to be a gold standard in protecting data subjects, technological development certainly impacts on data subjects' rights, especially on the right to erasure *ex* art. 17 of the GDPR (*right to be forgotten*).

The two different perspectives, objective and subjective, investigated in the thesis confirm the above-mentioned impact. The objective one, questioning the extent of the protection granted by the two main data processing models recalled by the GDPR, namely, anonymisation and pseudonymisation, led to framing the limits of these models. Therefore, it demonstrates that anonymisation may represent a sufficient data protection model only in a few cases, but not necessarily for Big Data. Here, the diversity of the data consistently challenges the model and contextual evaluations are needed, in addition to a Data Protection Impact Assessment (DPIA), aimed at better empowering data processors and data controllers in the processing of anonymised data.

Contrarily, pseudonymisation seems to satisfy the need to grant better data protection, ensuring a better level of data anonymity compared to anonymisation. Such an approach seems to be validated and endorsed in the evolution of the legislation, namely the DGA. In line with this point, the subjective perspective confirmed the potential of granting better protection by relying on the proliferation of stakeholders' roles and responsibilities, also with the introduction of new neutral intermediaries.

However, considering the fact that the DGA pins specific roles and duties on these new public entity figures, this type of approach is limited to generating a data ecosystem solely dependent on the public sector orientations, thus it may represent a challenge for democracy. This situation may be exacerbated by the lack of specification concerning general interest in the

DGA and public interest in the GDPR, eventually leading to the concentration of data in the public sector challenging privacy and data protection of citizens. In this scenario, the right to erasure may evolve to a dead letter.

Moreover, the implementation of the DGA expected in the following months and implemented by Member States may generate the data subjection of some Member States in favour of others, in pooling data into the Data Spaces, thus justified by general interest and/or public interest.

In line with these considerations, it is considered that more work is required to control this possible drift. On one hand, improving the empirical research approach aimed at framing the new trends in the creation and evolution of data ecosystems. On the other hand, incentivising the establishment of legal entities aiming to represent data subject rights solely and uniquely, conjugate legal and technological knowledge in line with the technological development.

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