



Personal Data Markets: A Narrative Review on Influence Factors of the Price of Personal Data

Julia Busch-Casler^(✉)  and Marija Radic 

Fraunhofer IMW, Neumarkt 9-19, 04109 Leipzig, Germany
{julia.busch-casler,marija.radic}@imw.fraunhofer.de

Abstract. Personal data has been described as the “the new oil of the Internet.” The global data monetization market is projected to increase to USD 6.1bn by 2025, and the success of giants like Facebook or Google speaks for itself. Almost all companies create, store, share and/or use personal data i.e. information from or about individuals. While the current assumption is that data subjects voluntarily share their data in exchange for a “free” service, the awareness of the value of personal data and data sovereignty is growing amongst consumers, businesses, and regulators alike. However, there is currently no consensus on which factors influence the value of personal data and how personal data should be priced regarding self-determination and data sovereignty. With this narrative review, we answer the following research question: Which factors influence the pricing of personal data? We show that research on the subject is diverse and that there is no consensus on the optimal pricing mechanism. We identify individual privacy and risk preferences, informational self-determination, sensitivity of data and data volume and inferability as most prevalent influence factors. We underline the need to establish ways for data owners to exercise data sovereignty and informed consent about data usage.

Keywords: Pricing personal data · Value of personal data · Data products · Data markets · Data monetization

1 Introduction

Personal data has been described as the “the new oil of the Internet and the new currency for the digital world” [1] and is created, stored, shared, and used by almost all companies. Market studies expect the overall global data monetization market to increase from USD 2.3bn in 2020 to USD 6.1bn in 2025 [2]. A sharp increase of data creation and low cost of storage are main drivers. Companies such as Facebook and Google have created massive data environments and developed their business models around the voluntary sharing of personal data by individuals in exchange for using their services [3, 4].

The OECD defines personal data as “any information relating to an identified or identifiable individual (data subject)” [5]. It shows traits of a public good rather than a commercial good as it is difficult to exclude other parties from using it in an effective

way and usage by one party does not prevent other parties from using it as well [3, 5, 6]. Data owners on the other hand have a need for privacy [7]. With the collection of personal data happening continuously and through a multitude of interconnected devices and modalities, there is an abundance of data and it is challenging to introduce effective control mechanisms on who transfers and uses the data [3]. Additionally, at least in Europe, privacy and the right for information to remain private is of high value and are protected by complex laws and regulations such as the General Data Protection Regulation [8] or new regulations aiming to increase data sovereignty [9, 10]. The current business assumption is that users are willing to share their data in exchange for the (free) service they receive. However, studies such as Schwartz [11], have shown that users are often not fully aware that they are paying for the service with their data and that their data may be collected and sold to data brokers who in turn sell data bundles to different data users along a data value chain. Other studies such as Sindermann et al. [12] investigate whether this influences customers willingness to pay for Social Media and show that only a minority supports a monetary payment model. As consumers learn more about how their data is used, this duality will eventually have consequences for companies' business models [3, 12]. Thus, it will be necessary for companies to attach a monetary value to the personal data shared with them and allow data producers/owners to actively consent to the use of their personal data in return for monetary or non-monetary compensation and develop a data market [6]. This can be facilitated through a data broker who transfers data from data owner to data user and monetary or non-monetary compensation from data user to data owner. The price of data depends highly on a diverse range of factors, some inherent in the data and some based on data context and the data subject. Combined with the need to account for the value attributed to privacy by data subjects, this adds an extra layer of complexity to pricing models as the value of the privacy of the data owner may exceed the value companies are willing to pay. The question of how to price personal data remains open despite multiple calls for research concerning this topic [6, 13]. Literature reviews in this area focus on pricing models [14, 15] or on the value of privacy [7] and have been published some 5 years ago. A more current review was undertaken by Wdowin and Deepveen [16] as part of a research project and describes some factors related to the value of data. However, there is no detailed description of the search process and which criteria were chosen to define papers included in the review. There is currently no consensus in the literature on which factors influence the value of personal data. Given the omnipresence of personal data across divergent research fields and the regulatory efforts focusing on data sovereignty, a narrative synthesis of current findings is needed to provide a sound basis for research, model development and decision makers to answer the research question: Which factors influence the pricing of personal data?

We contribute to the discussion on pricing personal data in the following respects:

(1) we identify relevant influence factors for pricing personal data and (2) provide a structure and categories for further qualitative and quantitative analysis of the subject.

2 Research Approach and Sample

2.1 Research Approach

We perform a narrative review [17] to conceptually integrate different fields of research on influence factors of the price of personal data. We use the following keywords: pricing of data, data markets, value of data, data valuation, data monetization, economics of personal data, pricing personal data and worth of privacy. We search EBSCO Business Source Complete as well as eLib, a specific directory which encompasses Web of Science, Scopus, Tema, Springer Link, Science Direct and other open access directories. We search for the keywords in TITLE/ABSTRACT of publications between 2001 and 2021. We find 1,535 papers in total. We screen the title and abstract based on (a) the topic of pricing privacy, pricing personal data or personal data markets and (b) peer review. We exclude papers that are out of scope, e.g. focusing on company data, pricing goods or services using personal data or using personal data for price discrimination. We exclude journal editorials or short summaries of conference papers. Overall, we exclude 1383 papers. We initially include 152 papers in our sample. We perform forward/backward referencing and include 8 additional in-scope papers respectively grey literature. Following the PRISMA [18] recommendations, we then perform a full text screening and exclude an additional 107 papers (1 duplicate, 106 papers out of scope based on the above mentioned criteria) from our final sample. Our overall sample consists of 54 papers. We extract relevant influence factors using an inductive content analysis [19] to identify the major themes in the literature. Two researchers perform the initial open coding independently and then perform multiple rounds of clustering and categorization to determine the main influence factors on the price of personal data. We derive a description for each factor and analyze the frequency of occurrence within our sample. We count each factor once per paper to determine the frequency.

2.2 Sample Description

The papers in the sample are published between 2005 and 2021 (see Fig. 1). The topic has become more frequently analyzed in the literature since 2014, highlighting its importance for current political and public discussion. There is a large spread of publications amongst different scientific outlets. About 60% of the analyzed papers were published in different scientific journals, while 30% were published in conference proceedings and the remaining 9% were published as grey literature reports. The topic of pricing personal data lies at an interface between business, economics, and information technology research. This is reflected in the publication outlets. The journals differed widely within the sample, with Electronic Markets being the most used outlet (3 publications), followed by Computer Law & Security Review (2 publications) and the IEEE Internet of Things Journal (2 publications). The remaining journals published one paper on the subject.

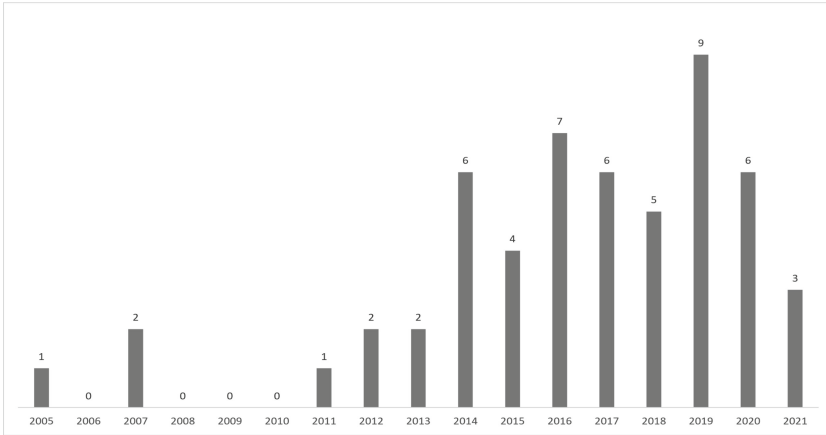


Fig. 1. Papers according to their year of publication

3 Results

3.1 General Results

Overall, the analyzed papers portrait a diverse stream of research. We classified them into eight categories: case study; commentary; data market model; data market model, technical¹; data pricing model; experiment; literature review and report. The results are provided in Fig. 2. The appendix provides an overview of the core topics covered.

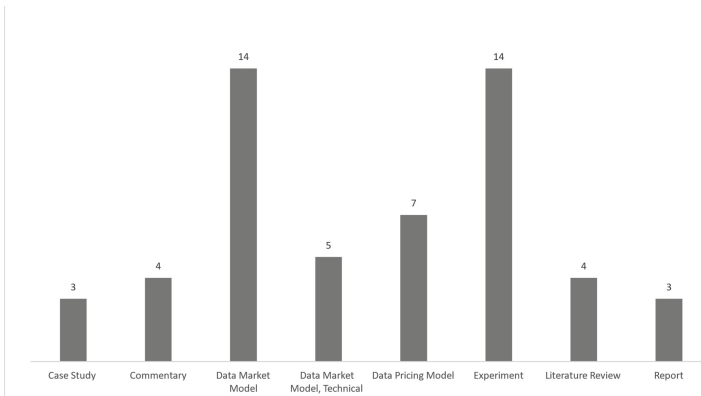


Fig. 2. Papers according to their content

The two most prevalent categories are theoretical data market models (14 papers + 5 papers on algorithm-based data markets) and experiments (14 papers). Data market

¹ The category “Data Market Model, Technical” refers to papers focusing on algorithms and technical solutions for data markets.

models focus on the development of different theoretical scenarios for establishing a personal data market. Most of the papers are theoretical in nature and deal with specific game-theoretical [20, 21] or auction-based [22] approaches for market creation. Some underline their findings with simulations based on real life data sets [23, 24]. Algorithm-based models show different ways to technologically facilitate data market settings and highlight the difficulties incorporating real-life influence factors such as anonymization and noise as well as profit-maximization calculations into an algorithm [25–27]. The experiments focus mainly on (a) eliciting willingness to pay for e.g. keeping personal data such as social media data [3, 28, 29] or preferences private [30] and (b) willingness to accept money for e.g. social media data [31] or location data [32, 33] from the participants². A notable finding is a gap between WPT and WTA-values with the average WTA-value being significantly higher than the WTP to protect one's privacy [35–37]. We further find several papers on what we call data pricing models, which focus on different pricing methods and ways to elicit prices for personal data. Literature reviews in this area focus on pricing models [14, 15] or on the value of privacy [7] and have been published some 5 years ago. A more current review was undertaken by Wdowin and Deepeven [16] as part of a research project and describes some factors related to the value of data. However, there is no detailed description of the search process and which criteria were chosen to define papers included in the review. The few case studies found in our research focus on the complexity of choice and value estimation for personal data.

3.2 Influence Factors on Pricing Personal Data

We find a multitude of influence factors on the price of personal data. We categorize them into four overarching categories: (1) data properties, (2) data context, (3) perceptions of data owner and (4) perceptions of data user. A detailed overview of the subsumed influence factors, their description and frequency of occurrence across the sample can be found in the respective Tables 1, 2, 3 and 4. “Data properties” refer to the inherent properties of a personal data dataset. This category represents general properties of data that are not limited to personal data, but apply to all types of data. We included this category as it lists important factors for pricing data. Within this category, sensitivity of data was found most frequently in the literature, followed by the data content, volume and coverage of data, quality data and level of data aggregation. The remaining factors were mentioned less frequently.

“Data context” refers to the environment and background of the personal data dataset. Within this category, data volume and inferability were found most often in the literature, often referring to arbitrage situations. Further, cost and length of data storage and cost of data gathering were discussed in the literature, while the remaining factors occurred less often.

The category “perceptions of data owner” focuses on the preferences and views of the data owner and the related willingness to consider selling personal data in general. Individual privacy and risk preferences and informational self-determination were found

² Willingness to pay (WTP) refers to the maximum amount of money an individual would be willing to pay to secure a specific change, while willingness to accept (WTA) refers to the minimum amount a person would be willing to accept to forego said change [34].

Table 1. Influence factors within the category “Data properties” and frequency of occurrence

Influence factor	Description	Frequency
Sensitivity of data	Refers to the level of identifiableness/anonymity and confidentiality and the associated loss of privacy in case of a data breach	18
Data content	Refers to the subject matter of the data	17
Level of data aggregation	Refers to the level of noise being added to a data set	12
Temporal coverage of data	Refers to the age and topicality of data	10
Volume and coverage of data	Refers to the amount and content of a specific dataset in terms of spatial coverage, granularity and generality of data	9
Uniqueness of data	Refers to the level of rarity/exclusivity of the data set	5
Data format	Refers to the data format and the linked interoperability, structure and resulting linkability of the data set with existing data	5
Intangibility of data	Refers to the inherent property that data is not a tangible asset	5
Completeness of data	Refers to the proportion of reality represented by the data (e.g. missing data points, biases in data collection)	4
Origin of data	Refers to the way the data was initially created	2
Filtering	Refers to the potential and level of filtering that is possible	1

Table 2. Influence factors within the category “Data context” and frequency of occurrence

Influence factor	Description	Frequency
Data volume and inferability	Refers to the amount of data available in general	17
Cost and length of data storage	Refers to the resources (e.g. hardware, financial, security and risk, time) used for data storage	12
Cost of data gathering	Refers to the resources (e.g. human, financial, time) used for data gathering	10

(continued)

Table 2. (continued)

Influence factor	Description	Frequency
Data gathering	Refers to the method (volunteered, surrendered, observed, inferred) and level of precision of data gathering	9
Level in the data value chain	Refers to the (commercial) potential and need for data refinement or aggregation for a specific purpose	9
Initial data owner	Refers to the profile and classification of the initial owner of the data	8
Frequency and type of usage	Refers to the delivery cadence of data and its usage	8
Data gatherer	Refers to the institution, person or device responsible for gathering data	5
Level of ownership	Refers to the accessibility and usage restrictions associated with the data	5
Culture	Refers to the societal context of data and the related cultural norms on e.g. sharing	5
Socio-economic impact	Refers to the social and economic consequences of data usage	4
Time of data access	Refers to the time and length of data access	1
Credibility	Refers to the level of verification of “correctness” of data	1

most frequently in the literature and are the most frequent influence factors mentioned overall.

Table 3. Influence factors within the category “Perceptions of data owner” and frequency of occurrence

Influence factor	Description	Frequency
Individual privacy and risk preferences	Refers to the individual’s rationales and preferences on privacy (loss) and associated risk taking	26
Informational self-determination	Refers to the awareness of the value and ownership of data and the ability to act accordingly	26
Trust in data market	Refers to the perceived transparency, fairness, quality and morality of a specific data market by the data owner	12

(continued)

Table 3. (continued)

Influence factor	Description	Frequency
Trust in data user	Refers to the perceived level of transparency, fairness and morality of the data user and the post-sale use of the data	9
Service level offered to data owner	Refers to the perceived service level of the data market place offered to the owner of the data	8

The category “perceptions of data user” focuses on the preferences and views of the data user. Within this category, the trust in the data market and the individual utility of the purchased data for the data user were most frequently mentioned.

Table 4. Influence factors within the category “Perceptions of data user” and frequency of occurrence

Influence factor	Description	Frequency
Trust in data market	Refers to the perceived transparency, fairness, quality and morality of a specific data market by the data user	12
Individual utility of purchased data	Refers to the perceived expected utility of the purchased data for the data user	10
Service level offered to data user	Refers to the perceived service level of the data market place offered to the user	8

Overall, individual preferences on risk and privacy, informational self-determination, sensitivity of data and data volume and inferability were identified as the most mentioned influence factors in the literature.

4 Synthesis of Findings

Our main finding is that while there already is a body of literature concerned with pricing personal data, the research base is heterogenous. Research is spread out amongst fields of science, journals, and research streams. It seems that there is not yet a consensus on key questions and a lack of overarching frameworks on the subject. This diverse research base, however, highlights the importance of the topic.

We have identified two main research aspects: (1) theoretical and what we call technical data market models and (2) experiments to elicit willingness to accept money/willingness to pay for privacy in exchange for data. Market models are focused on theoretical aspects of pricing personal data and are utilizing game theoretical and

profit maximization for developing narrow scope data market models. Technical data market models provide algorithms for different pricing mechanisms such as query-based pricing. While most papers try to validate their models with real life data sets, no paper provides insights from a real-life application of their model, which leads us to assume that data access is limited and that companies already operating data markets are unwilling to disclose their models as they are presumably core to their respective business models. Experiments focus on very narrow experimental settings, often with students as their subjects and are mainly focused on social media data (likes, shares, and general personal information) and a few using location data. To our knowledge, there are no experiments focusing on pricing more sensitive personal data such as electronic health records and very few studies with demographically diverse participants. Particularly when considering more sensitive personal data it would be interesting to gather information from a broad demographic including diverse age groups, educational backgrounds and levels of digital aptitude, as experiments show (1) irrationality concerning ones data (e.g. [35]) and (2) for parts of the participants a plain refusal to partake in data pricing (e.g. [38]). Additionally, there are some studies on data pricing models and very few case studies and literature reviews on the subject. While each of the streams has created a significant insight into the topic, it would be most useful to combine them to merge the aspects of (irrational) decision making of data subjects with more economical and algorithm-based thinking into a more practical data market model/algorithm, as has been attempted by e.g. Biswas et al. [39].

Looking at the factors that influence the price of personal data, we develop four categories of influence factors: (1) data properties, (2) data context, (3) perceptions of data owner and (4) perceptions of data user. All categories include several factors which we also rank by occurrence in the papers of the literature review. The most prevalent factors are individual privacy and risk preferences and informational self-determination. This is not surprising, as those factors are what differentiates personal data from e.g. company data and should thus have a strong impact on the price of personal data. Factors relating to trust, while still important, occur much less frequently, despite seemingly being a factor in increasing market participation by data owners. Market models thus may exclude an important factor in their setups if they exclude trust-creating mechanisms, Sensitivity, data content, and data volume and inferability are further factors that frequently appear in the literature. Those factors are rather generic and certainly applicable not only to the price of personal, but also data in general. Pricing also seems to be dependent on cost and length of data storage and cost of data gathering, which is not surprising since the utility derived from the data needs to outweigh the cost and since most data consumers operate within a restricted budget. Other factors such as culture, ownership level or origin of data appear infrequently and seem to be of less importance. Relating to culture, this is interesting since there are significant differences in how cultures approach the topic of privacy [40]. The most frequently used pricing method is market pricing. Other pricing concepts, such as option, per query or auction models appear much less frequently. This may be due to their perceived complexity in setup and operation.

5 Conclusion and Limitations

We conduct a narrative literature review and show a diverse array of research streams and questions that are related to the topic of pricing personal data and emphasize its importance. Due to the broad frame an aggregation of the results can only be done in a limited way. We believe that the resulting influence factors of our work are a valuable contribution to the scientific discussion and model development in future research. Our qualitative analysis of influence factors based on the underlying literature shows that the influence factors of the price of personal data can be classified into four categories. We provide a first description and ranking of the factors based on our literature review. These factors are only a starting point to researching the influence factors for pricing personal data and need further verification through empirical analyses such as a quantitative study or structured equation modelling. We aim to validate these factors empirically in future projects and to develop an operational model to quantify a price for personal data.

Acknowledgements. This research was partially funded by the German Federal Ministry of Education and Research (BMBF) within the scope of the research project DaWID (Platform for value determination and self-determined data release; funding reference number: 16SV8383).

Appendix - Overview of Included Papers

#	Paper	Classification	Key issue explored
13	Feijóo et al. [4]	Case Study	Case study on estimation of personal data
18	Hacker & Petkova [41]	Case Study	Case study on active choice of using data as currency
20	Holt et al. [42]	Case Study	Case study on value of data in stolen data markets
21	Jentsch [43]	Commentary	Commentary on the difficulties of valuing personal data
37	Perera et al. [44]	Commentary	Commentary on the challenges of privacy protection in IoT
39	Raskar et al. [45]	Commentary	Commentary on challenges of data pricing and data markets
44	Sidgman & Crompton [6]	Commentary	Theoretical commentary on current challenges and research opportunities
4	Bataineh et al. [23]	Data Market Model	Two-sided data market model with experimental comparison based on real life data set
8	Choi et al. [46]	Data Market Model	Theoretical data market model with consumer consent for data collection

(continued)

(continued)

#	Paper	Classification	Key issue explored
12	Dimakopoulos & Sudaric [47]	Data Market Model	Theoretical data market with platform competition
16	Gkatzelis et al. [48]	Data Market Model	Theoretical data market model for unbiased data samples
22	Jiao et al. [22]	Data Market Model	Data market model with Bayesian profit maximization auction
23	Lei Xu et al. [24]	Data Market Model	Theoretical data market model with privacy and learning policies in a multi-armed bandit model
24	Li & Raghunathan [49]	Data Market Model	Data market model when purpose of data use is unclear
34	Niyato et al. [20]	Data Market Model	Theoretical data market model for optimal big data pricing with simulation
36	Oh et al. [50]	Data Market Model	Theoretical data market model between broker and service provider under profit maximization and respect for privacy protection and valuation
38	Radhakrishnan & Das [51]	Data Market Model	Theoretical data market model for smart grid data
45	Spiekermann et al. [52]	Data Market Model	Theoretical data market model focusing on challenges of personal data markets
46	Spiekermann & Novotny [53]	Data Market Model	Theoretical data market model focusing on operating principles
49	Tian et al. [54]	Data Market Model	Theoretical data market model based on optimal contract-based mechanisms
50	Wang et al. [21]	Data Market Model	Theoretical data market model with data owners exhibiting informed consent in a Nash equilibrium with a non-trusted data collector
3	Balazinska et al. [55]	Data Market Model, Technical	Technical data market model with query-based pricing

(continued)

(continued)

#	Paper	Classification	Key issue explored
11	De Capitani Di Vimercati et al. [27]	Data Market Model, Technical	Technical data market model focusing on including privacy issues in a cloud setting
25	Li et al. [56]	Data Market Model, Technical	Technical data market model with query-based pricing
30	Nget et al. [25]	Data Market Model, Technical	Technical market model and simulation of query-based pricing mechanism
53	Yang & Xing [26]	Data Market Model, Technical	Algorithm for personal data pricing with multi-level privacy division
7	Biswas et al. [39]	Data Pricing Model	Theoretical model to induce data provider to accurately report privacy price within differential privacy
29	Mehta et al. [57]	Data Pricing Model	Theoretical data pricing model with price-quantity schedule and approximation scheme for data seller
32	Niu et al. [58]	Data Pricing Model	Technical pricing model for trading aggregate statistics over private correlated data
33	Niu et al. [59]	Data Pricing Model	Algorithm for personal data pricing with reverse price constraint
42	Shen et al. [60]	Data Pricing Model	Data pricing model for Big Personal Data based on tuple granularity
43	Shen et al. [61]	Data Pricing Model	Data pricing model based on data provenance
54	Zhang et al. [62]	Data Pricing Model	Data pricing with privacy concern introducing privacy cost concept
1	Acquisti et al. [35]	Experiment	Experiment on WTP/WTA money for private data and privacy
5	Bauer et al. [29]	Experiment	Survey-based experiment on value of Facebook user information from user perspective

(continued)

(continued)

#	Paper	Classification	Key issue explored
6	Benndorf & Normann [31]	Experiment	Experiment to extract WTA money with take-it-or-leave-it offers
10	Danezis et al. [33]	Experiment	Experiment on WTA money for location tracking
15	Frik & Gaudeul [30]	Experiment	Method and experimental validation for eliciting the implicit value of privacy under risk
17	Grossklags & Acquisti [37]	Experiment	Experiment on WTP/WTA money for private data and privacy
19	Hann et al. [63]	Experiment	Conjoint analysis to estimate individual's utility of mitigate privacy concerns
26	Lim et al. [64]	Experiment	Discrete choice experiment to estimate value of types of personal information leakage
27	Mahmoodi et al. [28]	Experiment	Experiment quantifying WTP for different levels of privacy on social media platforms & analysis of psychological factors (ongoing)
31	Nielsen [38]	Experiment	Experiment showing lay peoples reaction to data markets is diverse and shows unwillingness to participate in data market
41	Schomakers et al. [65]	Experiment	Mixed-method study on data sharing and privacy preferences in data markets
47	Spiekermann & Korunovska [3]	Experiment	Experiment on WTP/WTA money for private data and privacy
48	Staiano et al. [32]	Experiment	Living lab experiment focusing on pricing and correlated behaviour patterns
52	Winegar & Sunstein [36]	Experiment	Survey-based experiment on the disparity of WTP and WTA money to give up privacy
2	Acquisti et al. [7]	Literature Review	Literature review on privacy

(continued)

(continued)

#	Paper	Classification	Key issue explored
14	Fricker & Maksimov [15]	Literature Review	Literature review on pricing of data products
28	Malgieri & Custers [14]	Literature Review	Literature review on pricing of personal data
51	Wdowin & Diepeveen[16]	Literature Review	Literature review on value of personal data
9	Coyle et al. [66]	Report	Policy Recommendation for capturing data value
35	OECD [5]	Report	Overarching report on pricing personal data
40	Rose et al. [67]	Report	Report on value of digital identity based on EU survey

References

1. Kuneva, M.: Keynote speech. Roundtable on online data collection, targeting and profiling, 31 March 2009
2. MarketsandMarkets: Data Monetization Market (2020). <https://www.marketsandmarkets.com/Market-Reports/data-monetization-market-127405959.html>. Accessed 23 Sep 2020
3. Spiekermann, S., Korunovska, J.: Towards a value theory for personal data. *J. Inf. Technol.* (2017). <https://doi.org/10.1057/jit.2016.4>
4. Feijóo, C., Gómez-Barroso, J.L., Voigt, P.: Exploring the economic value of personal information from firms' financial statements. *Int. J. Inf. Manag.* (2014). <https://doi.org/10.1016/j.ijinfomgt.2013.12.005>
5. OECD: Exploring the Economics of Personal Data: A Survey of Methodologies for Measuring Monetary Value (2013). <https://doi.org/10.1787/5k486qtxldmq-en>
6. Sidgman, J., Crompton, M.: Valuing personal data to foster privacy: a thought experiment and opportunities for research. *J. Inf. Syst.* (2016). <https://doi.org/10.2308/isys-51429>
7. Acquisti, A., Taylor, C., Wagman, L.: The economics of privacy. *J. Econ. Lite.* (2016). <https://doi.org/10.1257/jel.54.2.442>
8. European Commission: EU data protection rules (2020). https://ec.europa.eu/info/law/law-topic/data-protection/eu-data-protection-rules_en. Accessed 27 July 2020
9. Madiega, T.: Digital sovereignty for Europe. European Union (2020)
10. European Commission: A European Strategy for data (2021). <https://digital-strategy.ec.europa.eu/en/policies/strategy-data>. Accessed 13 Jan 2022
11. Schwartz, P.M.: Property, privacy, and personal data. *Harv. Law Rev.* (2004). <https://doi.org/10.2307/4093335>
12. Sindermann, C., Kuss, D.J., Throuvala, M.A., Griffiths, M.D., Montag, C.: Should we pay for our social media/messenger applications? Preliminary data on the acceptance of an alternative to the current prevailing data business model. *Front. Psychol.* (2020). <https://doi.org/10.3389/fpsyg.2020.01415>
13. Currie, C.S.M., Dokka, T., Harvey, J., Strauss, A.K.: Future research directions in demand management. *J. Revenue Pricing Manag.* (2018). <https://doi.org/10.1057/s41272-018-0139-z>

14. Malgieri, G., Custers, B.: Pricing privacy—the right to know the value of your personal data. *Comput. Law Secur. Rev.* (2018). <https://doi.org/10.1016/j.clsr.2017.08.006>
15. Fricker, S.A., Maksimov, Y.V.: Pricing of data products in data marketplaces. In: Ojala, A., Holmström Olsson, H., Werder, K. (eds.) *ICSOB 2017. LNBIP*, vol. 304, pp. 49–66. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-69191-6_4
16. Wdowin, J., Diepeveen, S.: *The value of data: literature review*, Cambridge, UK (2020)
17. Cook, D.J., Mulrow, C.D., Haynes, R.B.: Systematic reviews: synthesis of best evidence for clinical decisions. *Ann. Intern. Med.* (1997). <https://doi.org/10.7326/0003-4819-126-5-199703010-00006>
18. Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G.: Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ (Clin. Res. Ed.)* (2009). <https://doi.org/10.1136/bmj.b2535>
19. Elo, S., Kyngäs, H.: The qualitative content analysis process. *J. Adv. Nurs.* **62**, 107–115 (2008)
20. Niyato, D., Alsheikh, M.A., Wang, P., Kim, D.I., Han, Z.: Market model and optimal pricing scheme of big data and Internet of Things (IoT). In: 2016 IEEE International Conference on Communications (ICC). 2016 IEEE International Conference on Communications (ICC), pp. 1–6 (2016). <https://doi.org/10.1109/ICC.2016.7510922>
21. Wang, W., Ying, L., Zhang, J.: The value of privacy: strategic data subjects, incentive mechanisms and fundamental limits. In: *Proceedings of the SIGMETRICS 2016: Proceedings of the 2016 ACM SIGMETRICS International Conference on Measurement and Modeling of Computer Science* (2016)
22. Jiao, Y., Wang, P., Niyato, D., Abu Alsheikh, M., Feng, S.: Profit maximization auction and data management in big data markets. In: 2017 IEEE Wireless Communications and Networking Conference (WCNC). 2017 IEEE Wireless Communications and Networking Conference (WCNC), pp. 1–6 (2017). <https://doi.org/10.1109/WCNC.2017.7925760>
23. Bataineh, A.S., Mizouni, R., Barachi, M.E., Bentahar, J.: Monetizing personal data: a two-sided market approach. *Procedia Comput. Sci.* (2016). <https://doi.org/10.1016/j.procs.2016.04.211>
24. Xu, L., Jiang, C., Qian, Y., Zhao, Y., Li, J., Ren, Y.: Dynamic privacy pricing: a multi-armed bandit approach with time-variant rewards. *IEEE Trans. Inf. Forensics Secur.* (2017). <https://doi.org/10.1109/TIFS.2016.2611487>
25. Nget, R., Cao, Y., Yoshikawa, M.: How to balance privacy and money through pricing mechanism in personal data market (2017)
26. Yang, J., Xing, C.: Personal data market optimization pricing model based on privacy level. *Information* **10**, 123 (2019)
27. Di Vimercati, S.D.C., Foresti, S., Livraga, G., Samarati, P.: Toward owners’ control in digital data markets. *IEEE Syst. J.* 1–8 (2020). <https://doi.org/10.1109/JSYST.2020.2970456>
28. Mahmoodi, J., et al.: Internet users’ valuation of enhanced data protection on social media: which aspects of privacy are worth the most? *Front. Psychol.* (2018). <https://doi.org/10.3389/fpsyg.2018.01516>
29. Bauer, M., et al.: Using crash outcome data evaluation system (CODES) to examine injury in front vs. rear-seated infants and children involved in a motor vehicle crash in New York State. *Inj. Epidemiol.* **8**, 1–10 (2021)
30. Frik, A., Gaudeul, A.: A measure of the implicit value of privacy under risk. *J. Consum. Mark.* (2020). <https://doi.org/10.1108/JCM-06-2019-3286>
31. Benndorf, V., Normann, H.-T.: The willingness to sell personal data. DICE discussion paper, vol. 143. DICE, Düsseldorf (2014)
32. Staiano, J., Oliver, N., Lepri, B., de Oliveira, R., Caraviello, M., Sebe, N.: Money walks: a human-centric study on the economics of personal mobile data. In: *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, 13 September 2014, pp. 583–594 (2014). <https://doi.org/10.1145/2632048.2632074>

33. Danezis, G., Lewis, S., Anderson, R.J.: How much is location privacy worth? In: WEIS
34. Hanemann, W.M.: Willingness to pay and willingness to accept: how much can they differ? *Am. Econ. Rev.* **81**, 635–647 (1991)
35. Acquisti, A., John, L.K., Loewenstein, G.: What is privacy worth? *J. Leg. Stud.* (2013). <https://doi.org/10.1086/671754>
36. Winegar, A.G., Sunstein, C.R.: How much is data privacy worth? A preliminary investigation. *SSRN J.* (2019). <https://doi.org/10.2139/ssrn.3413277>
37. Grossklags, J., Acquisti, A.: When 25 cents is too much: an experiment on willingness-to-sell and willingness-to-protect personal information. In: *Proceedings of the Workshop on the Economics of Information Security Proceedings 2007* (2007)
38. Nielsen, A.: Measuring lay reactions to personal data markets. In: *Proceedings of the 2021 AAAI/ACM Conference on AI, Ethics, and Society (AIES 2021)* (2021). <https://doi.org/10.1145/3461702.3462582>
39. Biswas, S., Jung, K., Palamidessi, C.: An incentive mechanism for trading personal data in data markets. In: Cerone, A., Ölveczky, P.C. (eds.) *ICTAC 2021*. LNCS, vol. 12819, pp. 197–213. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-85315-0_12
40. Cockcroft, S., Rekker, S.: The relationship between culture and information privacy policy. *Electron. Mark.* **26**(1), 55–72 (2015). <https://doi.org/10.1007/s12525-015-0195-9>
41. Hacker, P., Petkova, B.: Reining in the big promise of big data: transparency, inequality, and new regulatory frontiers. *Northwestern J. Technol. Intellect. Prop.* **15**(1), 6–42 (2017)
42. Holt, T.J., Smirnova, O., Chua, Y.T.: Exploring and estimating the revenues and profits of participants in stolen data markets. *Deviant Behav.* (2016). <https://doi.org/10.1080/01639625.2015.1026766>
43. Jentzsch, N.: Monetarisierung der privatsphäre: welchen preis haben persönliche daten? *DIW Wochenbericht* (2014)
44. Perera, C., Ranjan, R., Wang, L.: End-to-end privacy for open big data markets. *IEEE Cloud Comput.* **2**(4), 44–53 (2015). <https://doi.org/10.1109/MCC.2015.78>
45. Raskar, R., Vepakomma, P., Swedish, T., Sharan, A.: Data markets to support AI for all: pricing, valuation and governance (2019)
46. Choi, J.P., Jeon, D.-S., Kim, B.-C.: Privacy and personal data collection with information externalities. *J. Public Econ.* (2019). <https://doi.org/10.1016/j.jpubeco.2019.02.001>
47. Dimakopoulos, P.D., Sudaric, S.: Privacy and platform competition. *Int. J. Ind. Organ.* (2018). <https://doi.org/10.1016/j.ijindorg.2018.01.003>
48. Gkatzelis, V., Aperjis, C., Huberman, B.A.: Pricing private data. *Electron. Mark.* **25**(2), 109–123 (2015). <https://doi.org/10.1007/s12525-015-0188-8>
49. Li, X.-B., Raghunathan, S.: Pricing and disseminating customer data with privacy awareness. *Decis. Support Syst.* (2014). <https://doi.org/10.1016/j.dss.2013.10.006>
50. Oh, H., Park, S., Lee, G.M., Choi, J.K., Noh, S.: Competitive data trading model with privacy valuation for multiple stakeholders in IoT data markets. *IEEE Internet Things J.* **7**(4), 3623–3639 (2020). <https://doi.org/10.1109/JIOT.2020.2973662>
51. Radhakrishnan, A., Das, S.: Data markets for smart grids: an introduction. In: *2018 IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia)*. 2018 IEEE Innovative Smart Grid Technologies–Asia (ISGT Asia), pp. 1010–1015 (2018). <https://doi.org/10.1109/ISGT-Asia.2018.8467818>
52. Spiekermann, S., Acquisti, A., Böhme, R., Hui, K.-L.: The challenges of personal data markets and privacy. *Electron. Mark.* **25**(2), 161–167 (2015). <https://doi.org/10.1007/s12525-015-0191-0>
53. Spiekermann, S., Novotny, A.: A vision for global privacy bridges: technical and legal measures for international data markets *Comput. Law Secur. Rev.* (2015). <https://doi.org/10.1016/j.clsr.2015.01.009>

54. Tian, L., Li, J., Li, W., Ramesh, B., Cai, Z.: Optimal contract-based mechanisms for online data trading markets. *IEEE Internet Things J.* **6**(5), 7800–7810 (2019). <https://doi.org/10.1109/JIOT.2019.2902528>
55. Balazinska, M., Howe, B., Suci, D.: Data markets in the cloud: an opportunity for the database community. *Proc. VLDB Endow.* **5**(12), 1962–1965 (2011)
56. Li, C., Li, D.Y., Miklau, G., Suci, D.: A theory of pricing private data. *ACM Trans. Database Syst.* (2014). <https://doi.org/10.1145/2691190.2691191>
57. Mehta, S., Dawande, M., Janakiraman, G., Mookerjee, V.: How to sell a dataset? Pricing policies for data monetization. *SSRN J.* (2019). <https://doi.org/10.2139/ssrn.3333296>
58. Niu, C., Zheng, Z., Wu, F., Tang, S., Gao, X., Chen, G.: Online pricing with reserve price constraint for personal data markets (2019)
59. Niu, C., Zheng, Z., Wu, F., Tang, S., Gao, X., Chen, G.: ERATO: trading noisy aggregate statistics over private correlated data. *IEEE Trans. Knowl. Data Eng.* (2019). <https://doi.org/10.1109/TKDE.2019.2934100>
60. Shen, Y., Guo, B., Duan, X., Dong, X., Zhang, H.: A pricing model for big personal data. *Tsinghua Sci. Technol.* **21**(5), 482–490 (2016). <https://doi.org/10.1109/TST.2016.7590317>
61. Shen, Y., et al.: Pricing personal data based on data provenance. *Appl. Sci. Basel* **9**(12) (2019). <https://doi.org/10.3390/app9163388>
62. Zhang, Z., Song, W., Shen, Y.: A reasonable data pricing mechanism for personal data transactions with privacy concern. In: U, L.H., Spaniol, M., Sakurai, Y., Chen, J. (eds.) *APWeb-WAIM 2021*. LNCS, vol. 12859, pp. 64–71. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-85899-5_5
63. Hann, I.-H., Hui, K.-L., Lee, S.-Y.T., Png, I.P.L.: Overcoming online information privacy concerns: an information-processing theory approach. *J. Manag. Inf. Syst.* (2007). <https://doi.org/10.2753/MIS0742-1222240202>
64. Lim, S., Woo, J., Lee, J., Huh, S.-Y.: Consumer valuation of personal information in the age of big data. *J. Assoc. Inf. Sci. Technol.* (2018). <https://doi.org/10.1002/asi.23915>
65. Schomakers, E.-M., Lidynia, C., Ziefle, M.: All of me? Users’ preferences for privacy-preserving data markets and the importance of anonymity. *Electron. Mark.* **30**(3), 649–665 (2020). <https://doi.org/10.1007/s12525-020-00404-9>
66. Coyle, D., Diepeveen, S., Wdowin, J., Kay, L., Tennison, J.: *The value of data: policy implications*, Cambridge, UK (February 2020). <https://www.nuffieldfoundation.org/project/valuing-data-foundations-for-data-policy>
67. Rose, J., Rehse, O., Robe, B.: *The value of our digital identity* (2012). <https://www.bcg.com/publications/2012/digital-economy-consumer-insight-value-of-our-digital-identity.aspx>. Accessed 29 Apr 2020