

New Business Models for Data-Driven Services

Discussion paper 2023

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Last update: 24 November 2023

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ISBN: 978-92-78-43829-6

doi: 10.2830/034880

OA-02-23-227-EN-N

Executive summary

Over the last decade, data has risen to the top of national and global policy agendas, as nations seek to develop their economies, use data to address social challenges and respond to citizen concerns about the uses and abuses

of data ⁽¹⁾. Data has become the infrastructure on which modern economies are built. The growing ubiquity and abundance of data make it vital in every sector, and businesses of every size increasingly depend on it ⁽²⁾. Against this backdrop, open data has the potential to create significant value for society and the economy ⁽³⁾ when leveraged in partnership with the private sector. At the same time, the reuse of open data in Europe is still in its infancy and requires further research and implementation efforts to fully express its potential for public and private value creation. The content of this discussion paper goes in this direction and provides a review of the research conducted over the past two decades on how information generated by the public sector and released in an open data format may purposely be re-used by for-profit and not-for-profit private entities. The overarching intent is to identify relevant lessons learnt and principles that may be useful in promoting the flourishing of sustainable open data ecosystems across Europe.

The analysis shows how open data reuse may be regarded as a multi-billion and multi-dimensional opportunity for European corporations, small and medium-sized enterprises (SMEs) and start-ups, with the potential to unlock value-generation processes impacting the top and bottom lines of companies' balance sheets and the well-being of society at large. Businesses making use of open data in their activities can benefit from favourable economics that may exert a positive impact on their profitability once a sufficient level of competitive advantage is generated. Sources of competitive advantage may vary depending on the type of barriers encountered during the processes of data acquisition and analysis, and can come from the combination of open data with company-specific assets (skills, data, relationships, etc.) or the adoption of innovative business models relying on emerging technologies. Artificial intelligence (AI) and blockchain, in fact, represent useful technological evolutions in supporting the sharing, reuse and monetisation of open data, contributing to a smarter, more secure and automated data economy. The design of value propositions leveraging open data usually requires a resource-based approach where three strategic decisions need to be made in order to define a complete business model. Namely, the type of elaboration needed, the role of the knowledge generated in the final product or service and, finally, the pricing mechanism. The review of the literature conducted on business models for open data allowed us to identify 14 business models that may be clustered into five broad categories: freemium, premium, cost-saving, indirect benefit and razor-blade.

Finally, a new paradigm for open data management is proposed, entailing a shift in the way civil servants approach the release of data. The necessary change may be summarised through the following transitions:

- from legal obligation to operational necessity;
- from outward orientation to inward orientation;
- from cost to opportunity;
- from clerical function to strategic function;
- from requiring a leap of faith to generating evidence-based impact.

At an operational level, the implementation of such a paradigm requires the replacement of the 'data liberation' approach by an 'open-by-design' principle, allowing data to be open by default through a revision of their generation process. This would represent a valuable tool in facing the challenges of a steadily growing pressure on public budgets. In addition, it could contribute to making a further step towards the realisation of an outcome-based government whose actions demonstrate a clear link with the results generated (i.e. outcomes) in terms of value that, in turn, could be internalised by the governments (e.g. efficiency, effectiveness) without overlooking the quest for the creation of value for society at large ('public value').

⁽¹⁾ Global Data Barometer (2022), *First Edition Report – Global Data Barometer*, ILDA.

⁽²⁾ Fawcett, J., Chauvet, L. and Goodman, R. (2017), 'Data Entrepreneurship: Exploring successful business models with open data', *Open Data Institute*, ODINE programme.

⁽³⁾ See footnote 2

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1. Introduction

Over the last decade, data has risen to the top of national and global policy agendas, as nations seek to develop their economies, use data to address social challenges and respond to citizen concerns about the uses and abuses of data ⁽⁴⁾. Data has become the infrastructure on which modern economies are built. The growing ubiquity and abundance of data make it vital in every sector, and businesses of every size increasingly depend on it ⁽⁵⁾. Against this backdrop, open data has the potential to create significant value for society and the economy ⁽⁶⁾ when leveraged in partnership with the private sector. As a matter of fact, the ongoing processes of data generation and liberation within the public sector represent a remarkable opportunity for individual corporations, SMEs and start-ups. At the same time, the reuse of open data in Europe is still in its infancy and requires further research and implementation efforts to fully express its potential for public and private value creation.

The content of this discussion paper goes in this direction and provides a review of the research conducted over the past two decades on how information generated by the public sector and released in an open data format may purposely be re-used by for-profit and not-for-profit private entities. The overarching intent is to identify relevant lessons learnt and principles that may be useful in promoting the flourishing of sustainable open data ecosystems across Europe.

The document is structured into five sections, including these introductory comments. Section 2 starts by providing a glimpse into the market opportunity relating to open data, its value chain and the economics that characterise it. Section 3 offers a deep dive into the studies that analysed business models adopted by private entities to reuse public sector information (PSI) released in an open data format. Section 4 looks into emerging technological trends in exponential technologies such as AI and blockchain, and discusses their potential impact on data reuse and valorisation. Finally, Section 5 offers some concluding remarks and recommendations on how to sustain the evolution of a vibrant open data ecosystem.

⁽⁴⁾ Global Data Barometer (2022), *First Edition Report – Global Data Barometer*, ILDA.

⁽⁵⁾ Fawcett, J., Chauvet, L. and Goodman, R. (2017), 'Data entrepreneurship: exploring successful business models with open data', *Open Data Institute*, ODINE programme.

⁽⁶⁾ See footnote 5

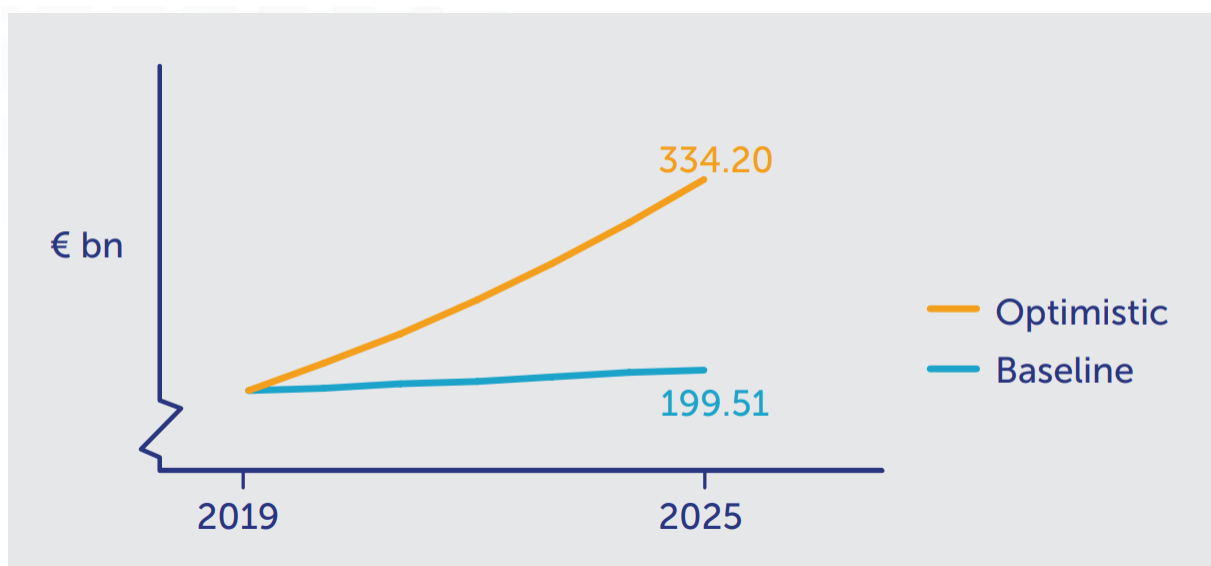
2. The open data opportunity

2.1. Market size and dynamics

One of the preconditions for the adoption of open data within existing or new business processes by corporate entities is the recognition of the opportunity lying behind the exploitation of such resources made available by the public sector in terms of value generation and capture.

Over the last two decades, a number of scholars and professionals embarked on trying to provide an estimation of the potential value of open data, a challenging task given the cross-cutting nature and wide-ranging influence of the information released by the public sector. A preliminary attempt to systematise the literature was conducted by the Open Data Institute ⁽⁷⁾ in 2015, and a more recent and comprehensive effort was sponsored by the European Commission and carried out by Capgemini Invent in 2020 ⁽⁸⁾. According to the latter, findings show a narrow range of results on open data market size when converted in terms of share of gross domestic product. Applying the median share percentage (1.19 %) to the estimations present in the different studies, the open data market size for the EU-27 in 2019 was reported to be EUR 184.45 billion, with growth expectations for 2025 ranging from EUR 199.51 billion in a baseline scenario to EUR 334.2 billion in a more optimistic scenario (**Error! Reference source not found.**). Such projections represent an indication of the impact (EUR 134.69 billion) that policies and investments aimed at sustaining the expansion of open data reuse could attain in terms of growth potential. If compared to the data economy at large, the impact of open data plays a significant role. As a matter of fact, 12 % of the value creation in the data economy is directly created by open data, and about 45 % is indirectly impacted by open data, i.e. it is created by the contribution brought by open data in combination with other data sources.

Figure 1: Scenarios of EU open data market growth



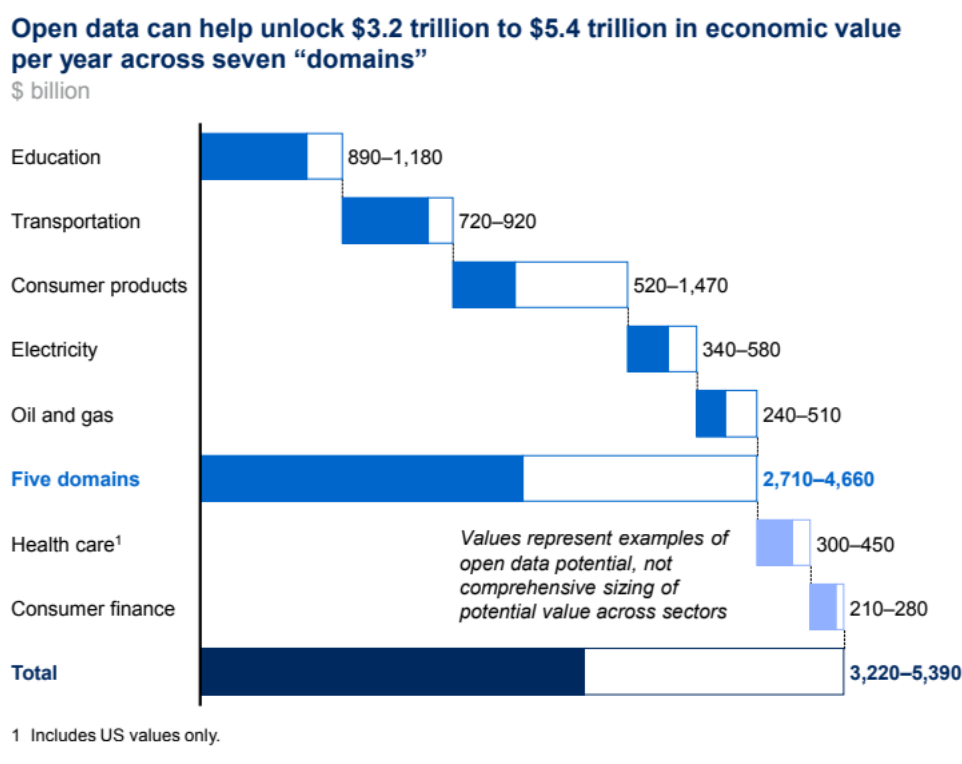
Moving down by one level of abstraction to look into the sector dynamics of open data, it is possible to observe a heterogeneous situation regarding growth and potential for impact among a selection of sectors identified as

⁽⁷⁾ Open Data Institute (2015), 'The economic impact of open data: what do we already know?', <https://medium.com/@ODIHQ/the-economic-impact-of-open-data-what-do-we-already-know-1a119c1958a0>.

⁽⁸⁾ Capgemini Invent (2020), 'The Economic Impact of Open Data – Opportunities for value creation in Europe', European Data Portal, Publications Office of the European Union, Luxembourg, <https://data.europa.eu/sites/default/files/the-economic-impact-of-open-data.pdf>.

promising. More specifically, Capgemini Invent ⁽⁹⁾ singled out two different clusters of sectors from which 15.7 % of the open data growth is supposed to originate. One is a high-impact cluster including public administration; professional, scientific and technical activities; information and communication and information and communication technology; and transportation and storage. The other is a high-potential cluster containing agriculture; financial services and insurance; health; education; wholesale, retail and trade; and real estate activities. In contrast, a study conducted by McKinsey & Company ⁽¹⁰⁾ identified a shortlist of seven domains with a high likelihood of being significantly impacted by open data. According to the estimations provided in the study, widespread use of open data within these domains may generate an economic impact ranging from USD 3.2 to USD 5.4 trillion (**Error! Reference source not found.**).

Figure 2: Domains in which open data can help unlock economic value ⁽¹¹⁾



Shifting the focus from the expected benefits of open data to the wider economy to the benefits it can bring to individual organisations, the main reasons for leveraging open data were found to be enhancing services, making informed decisions and increasing efficiency by optimising business operations ⁽¹²⁾. Depending on the levels of labour intensity, the total impact changed due to significant differences in value creation per employee across the sectors. When looking at open data value creation as a whole, opportunities might not lie only in growth due to an increase in the size of the workforce, but also in the way value is and will be created in the future by leveraging the opportunities offered by new exponential technologies such as blockchain and AI (see Section 4.2).

As summarised in **Error! Reference source not found.**, open data reuse may be regarded as a multi-billion and multi-dimensional opportunity for European corporations, SMEs and start-ups, with the potential to unlock value-

⁽⁹⁾ See footnote 8

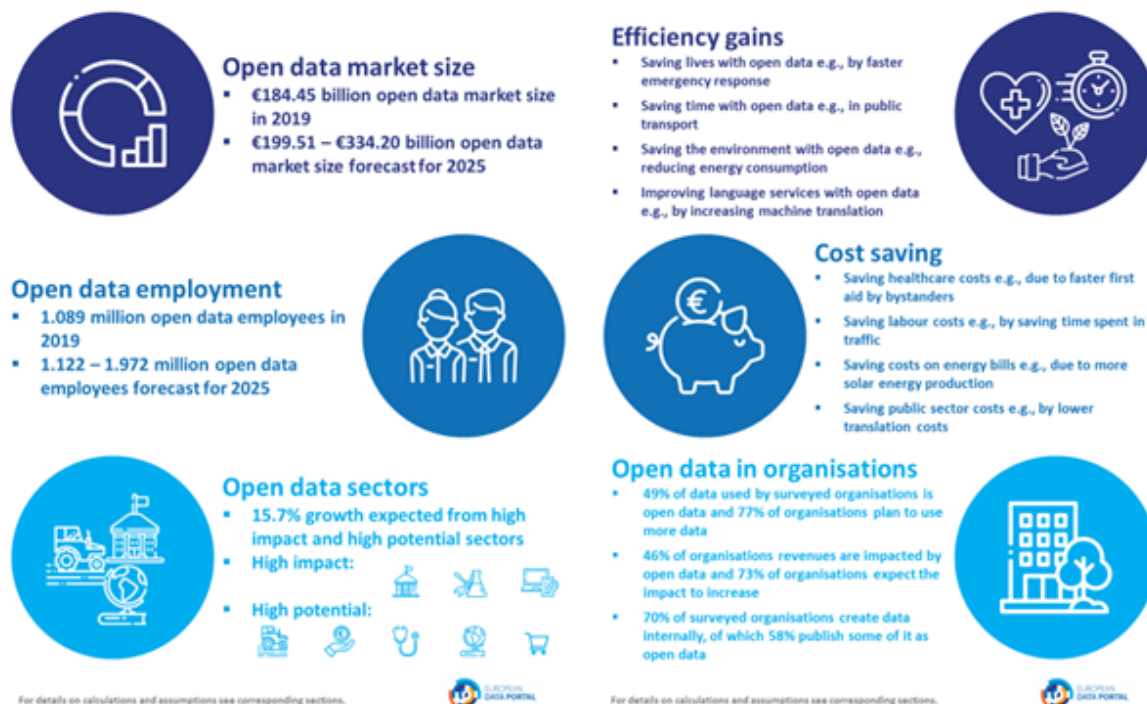
⁽¹⁰⁾ McKinsey & Company (2013), 'Open data: Unlocking innovation and performance with liquid information', p. 9.

⁽¹¹⁾ See footnote 10

⁽¹²⁾ Capgemini Invent (2020), 'The Economic Impact of Open Data – Opportunities for value creation in Europe', <https://data.europa.eu/sites/default/files/the-economic-impact-of-open-data.pdf>.

generation processes impacting the top and bottom lines of the companies' balance sheets, along with the wellbeing of society at large.

Figure 3: Dimensions of the open data opportunity ⁽¹³⁾



2.2. Open data economics and value chain

In order to design financially sustainable and strategically cunning business models for data-driven services, it is important to have a clear and deep understanding of the economics of digitised information in the form of data and its impact on potential exploitation strategies. In this respect, a seminal and authoritative contribution on the topic was offered by Shapiro and Varian in *Information Rules: A Strategic Guide to the Network Economy*, published by Harvard Business Review Press ⁽¹⁴⁾. In their bestselling book, the two authors provide a clear and detailed account of the cost structure of information in terms of production, reproduction and distribution.

One of the most fundamental features of information goods is that their cost of production is dominated by 'first-copy costs'. Once the first copy of any information asset has been generated, the cost of producing additional units is very low. In addition, the cost of distributing information is falling, causing first-copy costs to comprise an even greater fraction of the total costs to get information goods into the hands of potential consumers. In the language of economics, the fixed costs of production are large, but the variable costs of reproduction are small. This cost structure leads to substantial economies of scale: the more you produce, the lower your average cost of production. But there's more to it than just economies of scale: the fixed costs and the variable costs of producing information each have a special structure. The dominant component of the fixed costs of producing information are sunk costs, i.e. costs that are not recoverable if production is halted. Sunk costs generally have to be paid upfront, before commencing production. In addition to the first-copy sunk costs, marketing and promotion costs loom large for most information goods, especially for services targeted at retail consumers. The variable costs of information production also have an unusual structure: the cost of producing an additional copy typically does not increase, even if a great many copies are made. Normally there are no natural limits to the production of additional copies of information: if you can serve one customer, you can serve a million customers at roughly the same unit cost. The

⁽¹³⁾ See footnote 12

⁽¹⁴⁾ Shapiro, C. and Varian, H. R. (1998), *Information Rules: A Strategic Guide to the Network Economy*, Harvard Business Review Press.

low variable cost of information goods offers great marketing opportunities. Just as sellers of new brands of physical products (e.g. toothpastes, perfumes, beauty creams) may distribute free samples via direct mail campaigns, sellers of information goods can distribute free samples via the internet at a cost per unit close to zero.

The first-copy costs common to information goods are merely the extreme version of what we see in other industries where scale economies are powerful, which includes many high-technology industries like chip fabrication. To summarise the brief overview of the economics of digitised information, we may say that:

- information is costly to produce but cheap to reproduce;
- once the first copy of an information good has been produced, most costs are sunk and cannot be recovered;
- multiple copies can be produced at roughly constant per-unit costs;
- there are no natural capacity limits for additional copies.

The cost structure of information goods is a key aspect to remember when designing economically sustainable products or services leveraging open data as a strategic resource.

When moving from generic information assets to data released by the public sector in an open format, there are a few important specificities to consider. Firstly, data is generated for internal purposes connected to the provision of a service or in compliance with a legal requirement and released to the public in order to generate economies of scope. Thus, the publication of data is not the primary goal of the data generation process. Secondly, open data is often not the result of a one-off activity constrained within a limited time frame, but requires a continuous stream of data generation, storage and curation. As a consequence, maintenance and upgrading costs should not be disregarded ⁽¹⁵⁾. Finally, the returns generated in terms of taxable gross domestic product linked to the reuse of specific datasets may not be enjoyed by the agencies who need to shoulder the extra costs of making open data available to the wider public in a suitable format and with an adequate level of quality. In summary, the economics of open data are influenced by the following aspects:

- the reuse of open data is a second-order effect and not the main goal behind the generation of data;
- the presence of non-negligible maintenance and upgrading costs should be considered;
- the lack of direct, clear and quantifiable returns may represent a disincentive to information sharing.

As far as the open data value chain is concerned, the process that spans from the generation of a data asset to its consumption is far from being linear and subject to diverse interpretations. Many studies have embarked on providing a high-level representation of how PSI comes to fruition ⁽¹⁶⁾. The various attempts provided representations at different levels of granularity and units of analysis. For the purposes of this discussion paper, a recent version proposed in 2018 within the book *The Open Data World* ⁽¹⁷⁾ will be used, as it provides a helicopter view of three relevant aspects pertaining to the open data value chain: activities conducted, relevant actors and outputs generated in each step of the value chain (

). The main added-value activities carried out along the chain are data generation, dissemination, retrieval, storage, categorisation, exposure, re-use and consumption, while the outputs of the different steps are raw data, refined data, and ‘fit-for-purpose’ products and services. Finally, a number of archetypal actors operating along the value chain have been presented to highlight the concurrent presence of government agencies, for-profit and not-for-profit entities with no expectation of exhaustivity. The intent was to show the need for a cooperative approach ⁽¹⁸⁾

⁽¹⁵⁾ Kitchen, R. (2014), *The data revolution: big data, open data, data infrastructures & their consequences*, Sage, London, p. 57.

⁽¹⁶⁾ European Commission, Directorate-General for the Information Society and Media (2000), *Commercial exploitation of Europe's public sector information – Executive summary*, Publications Office of the European Union, Luxembourg.

Ferro, E. and Osella, M. (2013), ‘Eight business model archetypes for PSI re-use’, Open Data on the Web Workshop, Google Campus, London.

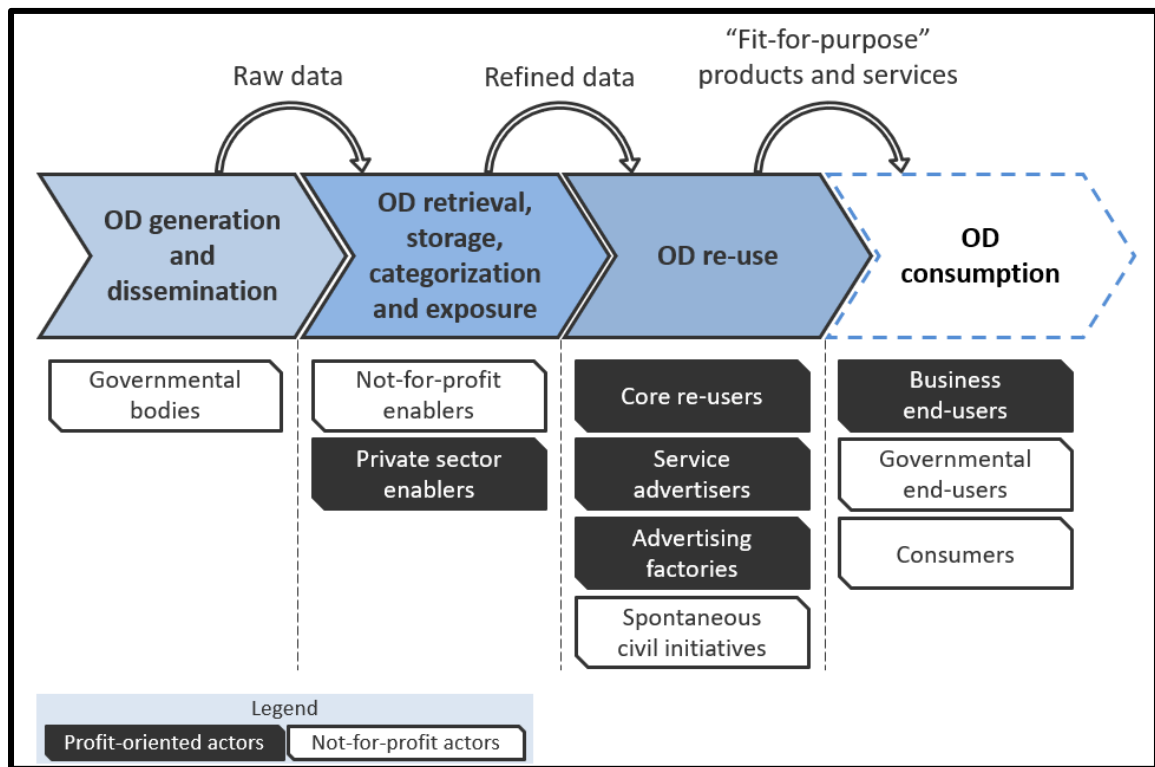
European Commission, Directorate-General for Communications Networks, Content and Technology (2013), ‘A European strategy on the data value chain’. European Commission, Directorate-General for the Information Society and Media (2015), Carrara, W., Fischer, S., Steenbergen, E. et al., *Creating value through open data – Study on the impact of re-use of public data resources*, Publications Office of the European Union, Luxembourg.

⁽¹⁷⁾ Charalabidis, Y., Zuiderwijk, A., Alexopoulos, C., Janssen, M., Lampoltshammer, T. and Ferro, E. (2018), *The World of Open Data: Concepts, Methods, Tools and Experiences*, Public Administration and Information Technology, Vol. 28, Springer International Publishing.

⁽¹⁸⁾ Janssen, M. and Zuiderwijk, A. (2014), ‘Infomediary business models for connecting open data providers and users’, *Social Science Computer Review*, Vol. 32, No 5, p. 707.

to build the foundations for successful open data ecosystems capable of realising the potential briefly described in the previous section.

Figure 4: Open data value chain ⁽¹⁹⁾



As previously expounded in this section, private stakeholders interested in providing data-driven services or products based on government open data may leverage favourable cost structures in the creation and delivery of value for any market segment. While this represents a great opportunity, a number of challenges are still present, having to do with creating the technical, legal and procedural preconditions and identifying appropriate business models that may guarantee the long-term financial viability of such activities. As a matter of fact, while data sharing is widely recognised as a value multiplier, the release of information in an open data format through Creative Commons licenses generates information-based common goods characterised by non-rivalry and non-excludability in fruition. This aspect poses significant challenges for the pursuit of sustainable competitive advantages ⁽²⁰⁾. The following section will shed light on some of the challenges highlighted above, with particular reference to the business models that may be adopted for bringing data-driven services to the market.

⁽¹⁹⁾ Charalabidis, Y., Zuiderwijk, A., Alexopoulos, C., Janssen, M., Lampoltshammer and T., Ferro, E. (2018), *The World of Open Data: Concepts, Methods, Tools and Experiences*, Public Administration and Information Technology, Vol. 28, Springer International Publishing, p. 119.

⁽²⁰⁾ See footnote 22

3. The open data business models

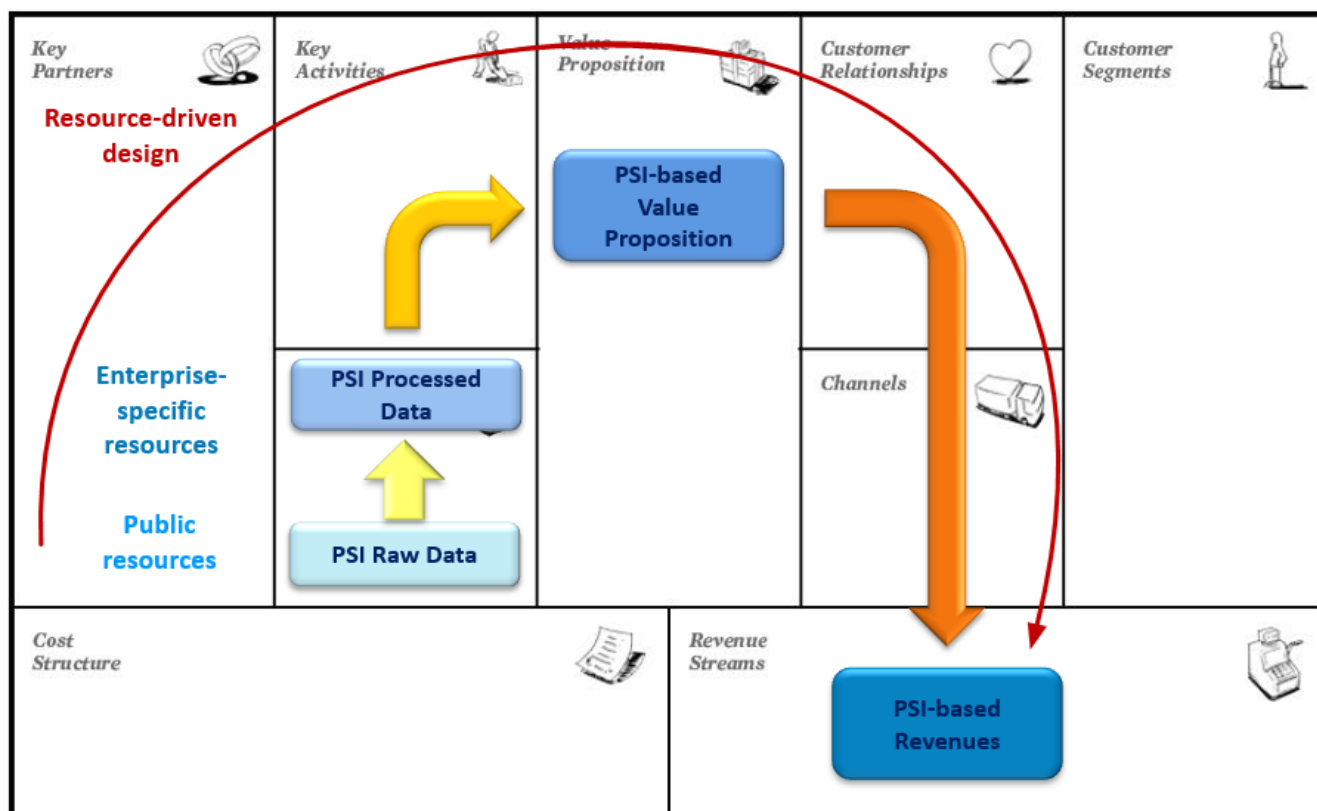
3.1. Understanding data-driven business models

The concept of ‘business model’ has been integral to trading and economic behaviour since pre-classical times ⁽²¹⁾. However, the term became prominent with the advent of the internet in the 1990s and has been gathering momentum since then. Over the years, scholars have proposed various definitions in an attempt to clarify its meaning. The literature, in fact, refers to a business model as a statement ⁽²²⁾, a description ⁽²³⁾, a representation ⁽²⁴⁾, an architecture ⁽²⁵⁾, a conceptual tool ⁽²⁶⁾, a structural template ⁽²⁷⁾, a method ⁽²⁸⁾, a framework ⁽²⁹⁾, a pattern ⁽³⁰⁾ and a set ⁽³¹⁾.

Moving from theory to practice, over the last decade, the business model canvas proposed by Osterwalder and Pigneur ⁽³²⁾ has become widely adopted among professionals as a valuable tool to generate a company-centric representation of the architecture with which any venture generates, delivers and captures value. As a result, the business model canvas enjoys great popularity in the literature on business models and open data ⁽³³⁾. Although a number of alternative versions of the canvas have been proposed to accommodate the specificities of open data reuse ⁽³⁴⁾, the model proposed by Osterwalder and Pigneur still remains the de facto standard, as it allows to simply yet effectively represent the most important aspects having to do with value generation and capture aimed at guaranteeing a company’s long-term financial viability.

The discussion about which business models may be adopted in the exploitation of open data mainly applies to private organisations, as they are more challenged by finding financial sustainability while leveraging a public good. It is important to underline that the discussion does not merely offer an account of the activities conducted or the position covered in the value chain. As a matter of fact, to provide actionable insights to a would-be open data entrepreneur, it is essential to depict the key pillars of the value architecture through which an organisation creates, delivers and appropriates value.

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- ⁽²¹⁾ Teece, D. J. (2010), ‘Business models, business strategy and innovation’, *Long Range Plan*, Vol. 43, No 2–3, pp. 172–194.
- ⁽²²⁾ Stewart, D.W. and Zhao, Q. (2000), ‘Internet marketing, business models and public policy’, *Journal of Public Policy and Marketing*, Vol. 19, pp. 287–296.
- ⁽²³⁾ Weill, P. and Vitale, M.R. (2001), *Place to space: migrating to e-business models*, Harvard Business School Press, Boston, MA.
- ⁽²⁴⁾ Applegate, L. M. (2000), ‘E-business models: making sense of the internet business landscape’, in Dickson, G. and DeSanctis, G. (eds), *Information technology and the Future Enterprise: New Models for managers*, Prentice-Hall, Englewood Cliffs, NJ, pp. 49–101.
- ⁽²⁵⁾ Morris, M., Schindehutte, M. and Allen, J. (2005), ‘The entrepreneur’s business model: toward a unified perspective’, *Journal of Business Research*, Vol. 58, No 6, pp. 726–735.
- ⁽²⁶⁾ Shafer, S. M., Smith, H. J. and Linder, J. (2005), ‘The power of business models’, *Business Horizons*, Vol. 48, pp. 199–207.
- ⁽²⁷⁾ Dubosson-Torbay, M., Osterwalder, A. and Pigneur, Y. (2002), ‘E-business model design, classification, and measurements’, *Thunderbird International Business Review*, Vol. 44, No 1, pp. 5–23.
- ⁽²⁸⁾ Osterwalder, A. (2004), ‘The business model ontology: a proposition in a design science approach’, Dissertation 173, University of Lausanne, Switzerland.
- ⁽²⁹⁾ Amit, R. and Zott, C. (2002), ‘Value drivers of e-commerce business models’, in Hitt, M. A., Amit, R., Lucier, C. and Nixon, R. D. (eds), *Creating Value: Winners in the New Business Environment*, Blackwell Publishers, Oxford, pp. 15–47.
- ⁽³⁰⁾ Afuah, A. and Tucci, C. L. (2001), *Internet business models and strategies: Text and Cases*, McGraw-Hill, New York.
- ⁽³¹⁾ Afuah, A. (2004), *Business Models: A Strategic Management Approach*, Irwin/McGraw-Hill, New York.
- ⁽³²⁾ Brousseau, E. and Penard, T. (2006), ‘The economics of digital business models: a framework for analysing the economics of platforms’, *Review of Network Economics*, Vol. 6, No 2, pp. 81–110.
- ⁽³³⁾ Seelos, C. and Mair, J. (2007), ‘Profitable business models and market creation in the context of deep poverty: A strategic view’, *Academy of Management Perspectives*, Vol. 21, pp. 49–63.
- ⁽³⁴⁾ Osterwalder, A. and Pigneur, Y. (2013), *Business model generation: a handbook for visionaries, game changers, and challengers*, Wiley.
- ⁽³⁵⁾ Clarinval, A., Simonofski, A., Castiaux, A., Gao, Y. and Janssen, M. (2023, July), ‘Formulating open data-based value propositions: An evaluation and comparison of two canvas tools’, *Proceedings of the 24th Annual International Conference on Digital Government Research*, pp. 327–337.
- ⁽³⁶⁾ Gao, Y. and Janssen, M. (2022), ‘The Open Data Canvas – Analyzing Value Creation from Open Data’, *Digital Government: Research and Practice*, Vol. 3, No 1, pp. 1–15.
- ⁽³⁷⁾ Anthopoulos, L. G. and Janssen, M. (2022), ‘Business model canvas for big and open linked data in smart and circular cities: Findings from Europe’, *Computer*, Vol. 55, No 12, pp. 119–133.

Figure 5: Framework for open data business model analysis ⁽³⁵⁾

As highlighted in **Error! Reference source not found.**, in the case of PSI reuse, the epicentre of the business model lies in a public resource (i.e. one or many datasets) which is accessible by everyone when released in accordance with the open data paradigm (i.e. without technical, legal and price barriers). Subsequently, such a raw resource is elaborated in order to become an enterprise-specific asset that distinguishes the respective owner from the rest of the world. Such processed data is an ingredient of the value proposition that the enterprise offers to the market. In other words, elaborated data is ‘packaged’ and embedded in the bundle of products and services which is supposed to create value for at least one customer segment. In return for such a value, customers generate revenues for the enterprise through alternative forms of payment.

The process of transformation of open data from a public resource to an enterprise-specific resource may leverage the combination of PSI with a number of other items coming from a data spectrum ⁽³⁶⁾ that may present great differences in terms of size (small, medium, big), origin (personal, commercial, governmental), accessibility (internal access, named access, group-based access, public access) and reusability (copyrighted, Creative Commons, public domain).

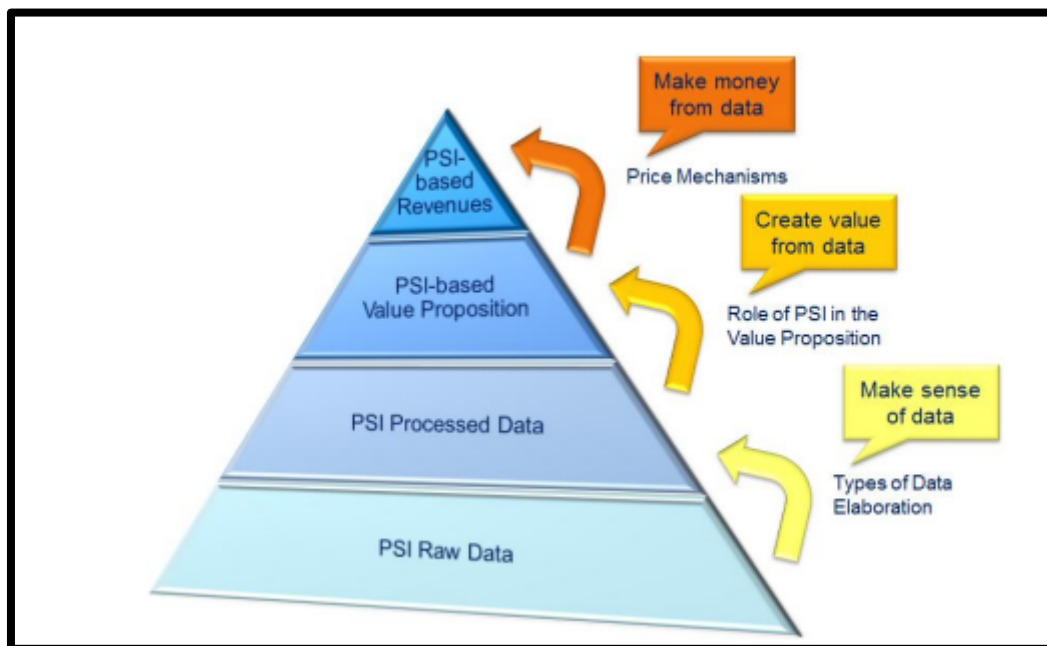
When it comes to designing the business model for a new venture or business line relying on open data, three key design choices need to be made. The first decision has to do with the types of elaborations employed to turn data into relevant knowledge, which may include data aggregation, structuring and classification, geo-referencing, validation, creation of data mash-ups and visual analytics or training of AI algorithms. The second relevant decision is to define the role of open data in the value proposition that will be offered to the market. Broadly speaking, three options are available here: open data may be the final good itself, it may represent a key ingredient of the product or service sold, or it may represent a marginal ingredient of the final value proposition. The third and final decision has to do with finding a mechanism to capture part of the value created for the market. In this respect,

⁽³⁵⁾ Ferro, E. and Osella, M. (2012), ‘Business models for PSI re-use: A multidimensional framework’, in *Using Open data: Policy Modeling, Citizen Empowerment*, Data Journalism Workshop, European Commission, Brussels.

⁽³⁶⁾ Open Data Institute (2017), ‘The Data Spectrum helps you understand the language of data’, <https://theodi.org/data-spectrum>.

three pricing schemes are most commonly selected: premium (payment à la carte, leveraging a subscription fee or royalties), freemium (pricing driven by dimensions such as features, time and size of data assets) or free (leveraging advertising, cross-subsidisation or zero marginal costs) ⁽³⁷⁾.

Figure 6: Design choices in open data business models ⁽³⁸⁾



In the following section, a selection of the business models reported in the literature will be provided, offering an overview of how the European entrepreneurial spirit aimed at generating value through open data has materialised in terms of business models and ventures.

3.2. Open data archetypes, business models and lessons learnt

While the business model canvas has been widely used in the analysis of business models and open data, a certain level of heterogeneity may be found in the literature when it comes to presenting results. Some included the identification of archetypal actors ⁽³⁹⁾ characterised by a specific approach to open data reuse and a clear positioning in the value chain, while others ⁽⁴⁰⁾ mostly focused on the identification of value proposition and revenue model design. The remainder of this section will thus provide an overview of the archetypal actors and a brief account of the main business models identified both in the academic and grey literature.

Error! Reference source not found. provides a synoptic representation of the main archetypal actors identified by four studies conducted during the last decade. The study carried out by Hammell et al. for Deloitte in the United Kingdom singled out five actors operating in the open data ‘marketplace’: suppliers, aggregators, developers,

⁽³⁷⁾ Ferro, E. and Osella, M. (2012), ‘Business models for PSI re-use: A multidimensional framework’, in *Using Open data: Policy Modeling, Citizen Empowerment, Data Journalism Workshop*, European Commission, Brussels.

⁽³⁸⁾ See footnote 43

⁽³⁹⁾ Hammell, R., Perricos, C., Lewis, H. and Branch, D. (2012), ‘Open Growth: Stimulating Demand for Open Data in the UK’, *Deloitte*, London.

Ferro E. and Osella M. (2013), ‘Eight Business Model Archetypes for PSI Re-Use’, *Open Data on the Web Workshop*, 23–24 April, Google Campus, Shoreditch, London.

Magalhaes, G., Roseira, C. and Manley, L. (2014), ‘Business models for open government data’, *Proceedings of the 8th International Conference on Theory and Practice of Electronic Governance*, Guimaraes, pp. 365–370.

Kitsios, F. and Kamariotou, M. (2019), ‘Open data value network and business models: opportunities and challenges’, in Becker, J. and Novikov, D. (eds), *Proceedings of the 21st IEEE Conference on Business Informatics (CBI 2019)*, IEEE, New York, Vol. 1, pp. 296–302, doi:10.1109/CBI.2019.00040.

Zuiderwijk, A., Janssen, M. and Davis, C. (2014), ‘Innovation with open data: essential elements of open data ecosystems’, *Information Polity*, Vol. 19, No 1, pp. 17–33, doi:10.3233/IP-140329

⁽⁴⁰⁾ Gurin, J. (2014), *Open Data Now: The Secret to Hot Startups, Smart Investing, Savvy Marketing, and Fast Innovation*, McGraw-Hill.

Zeleti, F. A., Ojo, A. and Curry, E. (June 2014), ‘Emerging business models for the open data industry: Characterization and analysis’, *Proceedings of the 15th Annual International Conference on Digital Government Research*, pp. 215–226.

enrichers and enablers. Ferro and Osella, instead, in their exploratory study mapped four archetypes (private sector enablers, core re-users, service advertisers and advertising factories) along two different dimensions: position in the value creation process and strategic vision of the PSI realm. Zuiderwijk et al. conducted a study on the business models for infomediaries, i.e. organisations positioning themselves between open data producers and users. The authors identified six categories, partly describing the purpose of the tool developed and partly the activities conducted by the organisations building the tool (single-purpose apps, interactive apps, information aggregators, comparison models, open data repositories and service platforms). Finally, Magalhaes et al. restricted the range of archetypes to three main functions (enablers, facilitators and integrators), while Kitsiosa and Kamariotou extended the description to a wider range of activities: data providers, service providers, infrastructure providers, tools providers and application developers.

Figure 7: Archetypal actors in the open data value chain

Hammell, Perricos, Lewis and Branch (2012) ⁽⁴¹⁾	Suppliers, aggregators, developers, enrichers and enablers
Ferro and Osella (2013) ⁽⁴²⁾	Private sector enablers, core re-users, service advertisers, advertising factories
Zuiderwijk et al. (2014) ⁽⁴³⁾	Single-purpose apps, interactive apps, information aggregators, comparison models, open data repositories and service platforms
Magalhaes, Roseira and Manley (2014) ⁽⁴⁴⁾	Enablers, facilitators, integrators
Kitsiosa and Kamariotou (2019) ⁽⁴⁵⁾	Data providers, service providers, infrastructure providers, tools providers and application developers

Despite the presence of some heterogeneity in the semantics used to characterise the different actors, it is possible to observe the need for a collaborative effort in order to extract value from open data and deliver it to the final stakeholders. It is also possible to conclude that the public sector alone would probably not be able to effectively cover all the echelons of the value chain and that a joint public-private effort is required ⁽⁴⁶⁾. In addition, open data may play different roles in terms of centrality within the final product or service delivered and, as Gurin ⁽⁴⁷⁾ points out, it is possible to distinguish between two different types of open data businesses: ‘better business through open data’, where open data is used to improve the services provided in a specific sector (e.g. healthcare, energy, education and finance), or ‘open data pure plays’ that are services that simply would not exist without open data and span across different verticals.

Moving now from archetypes to business models, two literature reviews recently conducted by Charalabidis et al. ⁽⁴⁸⁾ and ODINE ⁽⁴⁹⁾ allow us to offer a reasonably complete picture of the mainstream approaches adopted by

⁽⁴¹⁾ Hammell, R., Perricos, C., Lewis, H. and Branch, D. (2012), ‘Open Growth: Stimulating Demand for Open Data in the UK’, *Deloitte*, London.

⁽⁴²⁾ Ferro, E. and Osella, M. (2013), ‘Eight Business Model Archetypes for PSI Re-Use’, Open Data on the Web Workshop, 23–24 April, Google Campus, Shoreditch, London.

⁽⁴³⁾ Zuiderwijk, A., Janssen, M. and Davis, C. (2014), ‘Innovation with open data: essential elements of open data ecosystems’, *Information Polity*, Vol. 19, No 1, pp. 17–33, doi:10.3233/IP-140329.

⁽⁴⁴⁾ Magalhaes, G., Roseira, C. and Manley, L. (2014), ‘Business models for open government data’, *Proceedings of the 8th International Conference on Theory and Practice of Electronic Governance*, Guimaraes, pp. 365–370.

⁽⁴⁵⁾ Kitsios, F. and Kamariotou, M. (2019), ‘Open data value network and business models: opportunities and challenges’, in Becker, J. and Novikov, D. (eds), *Proceedings of the 21st IEEE Conference on Business Informatics (CBI 2019)*, IEEE, New York, Vol. 1, pp. 296–302, doi:10.1109/CBI.2019.00040.

⁽⁴⁶⁾ Global Data Barometer (2022), *First Edition Report – Global Data Barometer*, ILDA, p. 8, doi:https://doi.org/10.5281/zenodo.6488349.

⁽⁴⁷⁾ Gurin, J. (2014), *Open Data Now: The Secret to Hot Start-ups, Smart Investing, Savvy Marketing, and Fast Innovation*, McGraw-Hill.

⁽⁴⁸⁾ Charalabidis, Y., Zuiderwijk, A., Alexopoulos, C., Janssen, M., Lampoltshammer, T. and Ferro, E. (2018), *The World of Open Data: Concepts, Methods, Tools and Experiences*, Public Administration and Information Technology, Springer International Publishing, p. 115–135.

⁽⁴⁹⁾ ODINE (2016), ‘Business Models, Lessons Learnt and Success Stories’, D6.3 of the ODINE project.

private-sector actors in leveraging open data for business. A collection of the main business models identified is provided below, together with a brief description for each of them.

Freemium. A business model that relies on giving away a core product/service for free and selling a premium product/service. With technology improvements, the marginal cost of some products becomes very low, which enables its distribution for free. Thus, only a small percentage of users need to opt for the paid product to make the business profitable.

Premium. A premium model provides high-end services and products. The model relies on the publisher's image, since the quality of the product is their value proposition. The business seeks a high-profit margin while targeting a lower sales volume.

Open source. A business model using open source offers source code that can be publicly accessed, edited and distributed. This framework enables businesses to use their source code for free but charge on an 'added-value' basis and through dual licensing.

Infrastructure razors and blades. The idea is to sell an initial product at an attractive price or give it out for free (razor), which later encourages users to follow up by purchasing further products or services (blades). In this model, the products (blades) are usually classified as inelastic, i.e. unaffected by changes in income or price. This creates a high margin and makes the business profitable.

Demand-oriented platforms. This model offers customised open datasets. The business charges its customers for the added value built into the original raw open data through aggregation, curation and enrichment activities that allow aligning the final output with the client's most pressing needs.

Supply-oriented platforms. The concept of this business model is to manage, store and maintain data for any data holder. Its revenue model is based on a monthly fee that customers pay in order to get their data maintained, saved and easily accessible.

Free, as branded advertising. This model is about leading customers towards a brand or company by enhancing their visibility with open data. The service provider helps brands make their data accessible, which can be seen as a marketing cost for them. However, this is only convenient when the cost of distribution is very low.

White-label development. This model refers to a product or service built by one company and customised for another one. The latter company buys the product or service without branding so that they can customise it. Therefore, the manufacturer company can focus on making the product as cost-effective as possible without worrying about its marketing.

Dual licensing. The concept is to apply either open (free) or closed (paid-for) licences under different conditions. This model has been used by some open-source products. Fees can be applied regarding the size or value of a company. A license can also limit the use of a product unless it is purchased.

Cost avoidance. This business model may help organisations avoid the costs of freedom of information requests. This applies only to data that is likely to be requested for accountability and transparency purposes or has a very low publishing cost. Organisations that have a high freedom of information spend with significant amounts of requests may find that they can lower the spend by proactively releasing data (and making it easy to find).

Sponsorships. The sponsorship business model lies in giving away a product for free while receiving money from sponsors. The business obtains revenue from organisations that believe a specific dataset should be accessible to the public.

Support and services. Offering support and services is a business model which seems to work well for companies built around open source. In the open data world, data publishers could offer paid packages with guarantees on data availability, prioritisation on bug fixes (both in data and its provision) for paying customers, timely help for customers using the data, services around data visualisation, analysis and mashing with other data. These kinds of services still tend to be coupled with licenses in the data world, whereas in open source they have been successfully disentangled.

Increasing quality through participation. This involves increasing the data quality by enlisting the help of other parties who would benefit from having an up-to-date open statute book. Otherwise, this information would be very costly to obtain. There are any number of potential contributors, including publishers, lawyers, academics and governments.

Supporting primary business. This model may be used when releasing open data naturally supports the primary business goal of the organisation. For example, it may be applied to bicycle-hiring services offered as part of corporate social responsibility activities, where releasing open data about the bikes drives the development of apps that, by combining it with PSI, make it easier for potential customers to use the scheme, thus bringing in revenue to the core business.

As it is possible to notice, a number of common traits are present among some of the business models presented above. Zeleti et al. ⁽⁵⁰⁾ tried to make these commonalities explicit by condensing all the business models into five main categories.

- **Freemium.** Freemium, dual-licensing, charging for changes, open source, free as branded advertising.
- **Premium.** Premium, sponsorship, support and services, demand-oriented platform, supply-oriented platform, white-label development.
- **Cost-saving.** Increasing quality through participation, cost avoidance.
- **Indirect benefit.** Support primary business.
- **Razor blade.** Infrastructural razors and blades.

While business models shed light on the ‘how’ of business, it is felt important to conclude this section with some lessons learnt that could be valuable for would-be entrepreneurs regarding the ‘who’ and ‘why’ of open data for business.

The lessons presented below are based on the experience of incubating start-ups and on research carried out as part of the Open Data Incubator for Europe programme and published in a white paper released by the Open Data Institute on open data entrepreneurship ⁽⁵¹⁾.

You don’t have to be an ‘open data start-up’ to benefit from open data. While some businesses are set up to explicitly take advantage of the opportunities presented by open data, many others are building new products and services or enhancing their existing offering with open data.

Beyond consumption: open data publishing is creating value for small businesses. Access to open data presents businesses with a valuable opportunity to innovate, but businesses are increasingly publishing open data to attract new customers, improve customer experience and capture new markets.

Freemium subscription models are being used to generate revenue from publishing open data. Revenue models for products and services based on open data tend to adopt ‘as-a-service’ subscription revenue models and, when it comes to publishing open data, businesses are increasingly using freemium models to derive revenue while keeping data open.

⁽⁵⁰⁾ Zeleti, F. A., Ojo, A. and Curry, E. (June 2014), ‘Emerging business models for the open data industry: Characterization and analysis’, *Proceedings of the 15th Annual International Conference on Digital Government Research*, pp. 215–226.

⁽⁵¹⁾ Fawcett, J., Chauvet, L. and Goodman, R. (2017), ‘Data entrepreneurship: exploring successful business models with open data’, *Open Data Institute*, ODINE programme.

Greater value is created by combining different data from multiple sources. Strong value propositions are often built to solve very complex problems. Businesses often address them by combining a wide variety of data types from different open, shared and closed sources.

Services built on open data are valuable to a wide range of organisations and individuals. The products and services built with open data are useful to a diverse range of businesses, governments and individuals from across the whole economy.

The topic of business models for open data exploitation still requires time and effort to reach a maturity stage, also considering that new and emerging exponential technologies have the potential to significantly disrupt and innovate the logic of value creation that may be applied to open data reuse and exploitation. As the availability and the quality of open data increase, it could be worth conducting a new wave of studies that go beyond mapping and formalising business models by looking at their performance and long-term sustainability from a financial, legal and operational point of view.

3.1 Barriers, competitive advantages and an emerging new paradigm

The topic of open data reuse may be approached from two perspectives. The first one, covered in the first sections of this paper, looks at quantifying the opportunity and clarifying how it may be turned into a business venture. The second focuses on removing the barriers to reuse in order to optimise the process of data liberation while simplifying the processes of data sourcing, integration and elaboration.

Barriers to open data reuse may be of different natures. Janssen et al. ⁽⁵²⁾ clustered them into six categories: institutional (e.g. unclear trade-off between public values, risk-averse culture), task complexity of handling the data (e.g. lack of access, no information about quality), use and participation in the open-data process (e.g. no incentives for users, slow reactivity of public organisations), legislation (e.g. privacy, security), information quality (e.g. incomplete or obsolete information) and technical (e.g. not machine readable, lack of metadata).

When analysing the barriers from a stakeholders' perspective, ODINE ⁽⁵³⁾ found that barriers are related to either data providers (resulting in not wishing to publicise data) or data users (resulting in an inability to use the data easily). The institutional level concerns barriers from the data provider's point of view, whereas task complexity and use and participation are from the user's perspective. The remaining categories (legislation, information quality and technology) can be relevant for both. Organisations with more red tape, weak links with performance and high involvement with elected officials tend to have a risk-averse culture ⁽⁵⁴⁾ and are thus less prone to promote open innovation initiatives.

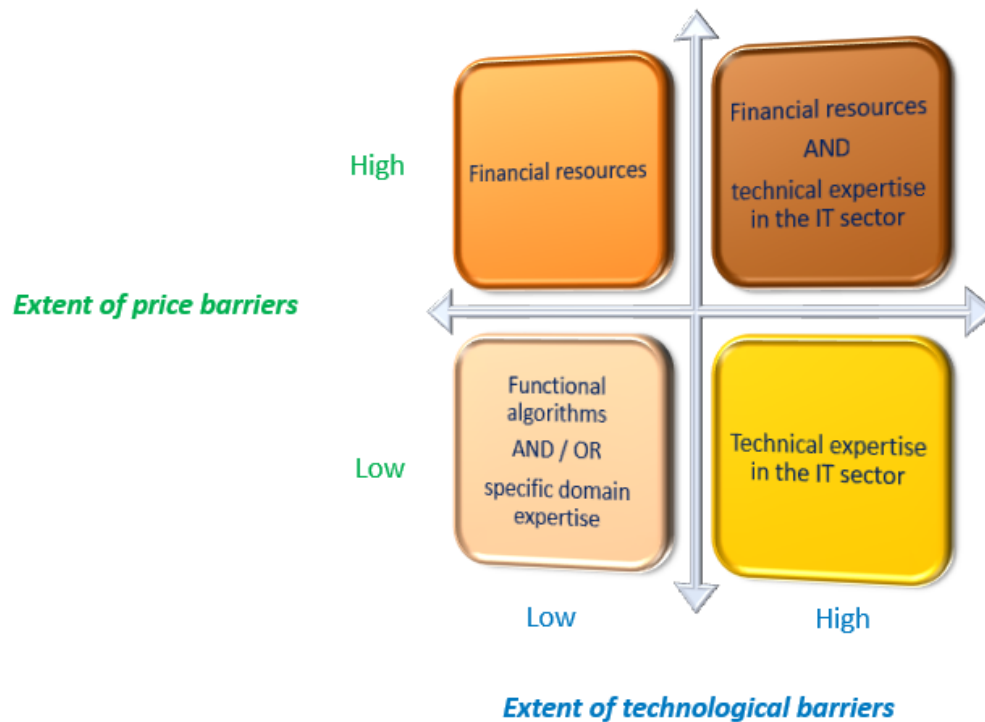
When it comes to business models, a slightly different approach to the analysis of barriers is offered by Charalabidis et al. ⁽⁵⁵⁾. In their book, barriers are mapped along two dimensions (price and technology) and viewed as an opportunity for the creation of different types of competitive advantage (**Error! Reference source not found.**).

⁽⁵²⁾ Janssen, M., Charalabidis, Y. and Zuiderwijk, A. (2012), 'Benefits, adoption barriers and myths of open data and open government', *Information Systems Management*, Vol. 29, No 4, pp. 258–268.

⁽⁵³⁾ ODINE (2016), 'Business Models, Lessons Learnt and Success Stories', D6.3 of the ODINE project.

⁽⁵⁴⁾ Bozeman, B. and Kingsley, G. (1998), 'Risk culture in public and private organizations', *Public Administration Review*, Vol. 58, No 2, pp. 109–118.

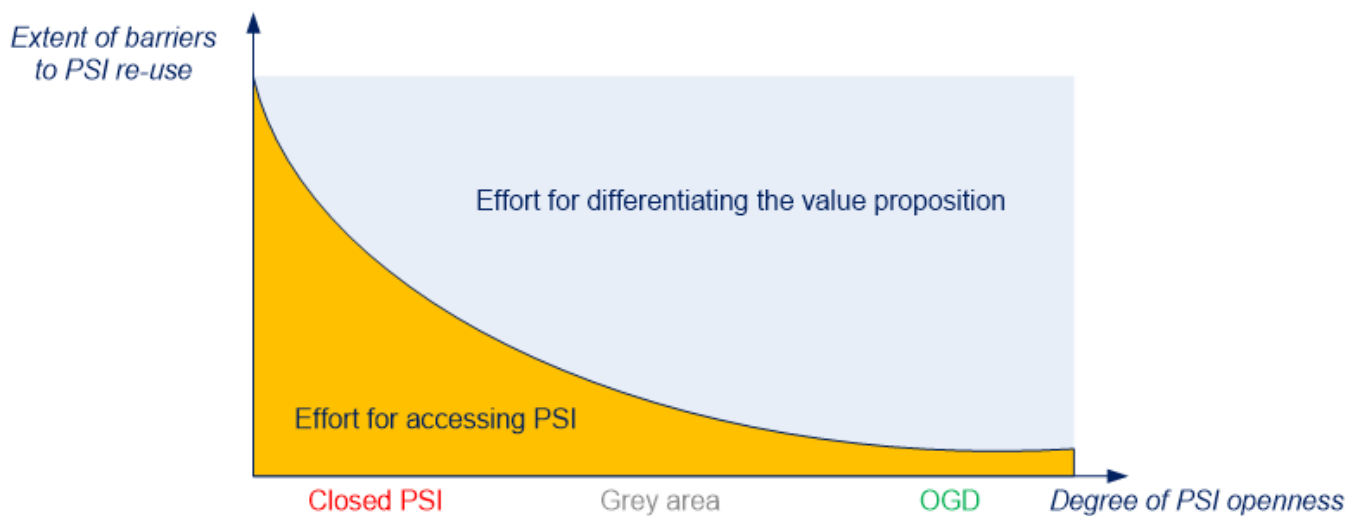
⁽⁵⁵⁾ Charalabidis, Y., Zuiderwijk, A., Alexopoulos, C., Janssen, M., Lampoltshammer, T. and Ferro, E. (2018), *The World of Open Data: Concepts, Methods, Tools and Experiences*, Public Administration and Information Technology, Springer International Publishing, p. 115–135.

Figure 8: Barriers and sources of competitive advantage ⁽⁵⁶⁾

The matrix depicted in **Error! Reference source not found.** clarifies the potential sources of competitive advantage that a company may exploit based on the presence and extent of price and technological barriers. When price barriers are significant and technological obstacles are negligible, the availability of financial resources becomes the primary competitive edge discriminating between who can afford to access the information asset and who cannot. When, instead, technological barriers dominate over price barriers, technological skills become a must-have to excel in data acquisition, harmonisation and integration. In contexts where both types of barriers are present, the presence of both significant financial resources and robust technological competencies is required. Finally, when neither price nor technological barriers are present or are negligible, it is interesting to note that the sources of competitive advantage are no longer connected to the process of data acquisition, but rather related to functional algorithms for the treatment of data and the presence of domain-specific expertise. While the former plays a horizontal role and allows to differentiate the application logic of the service provided, the latter allows contextualising the offering within a given vertical market.

When released in a fully open and reusable format, information may be considered a public good characterised by non-rivalry and non-excludability in consumption. As a consequence, access to this type of resource may not be considered in itself a source of competitive advantage. **Error! Reference source not found.**9 shows how the focus of effort allocation shifts as a function of the degree of openness of the datasets exploited. In a situation where legal, technological and price barriers are present, the company willing to exploit a given dataset is required to spend significant resources in the process of data acquisition (especially concerning technological and price barriers, as legal barriers may not be overcome). As the barriers to data reuse diminish, the focus of the company efforts moves from the process of data acquisition to the differentiation of its value proposition with respect to the competitors, who increase due to lower barriers to entry.

⁽⁵⁶⁾ See footnote 66

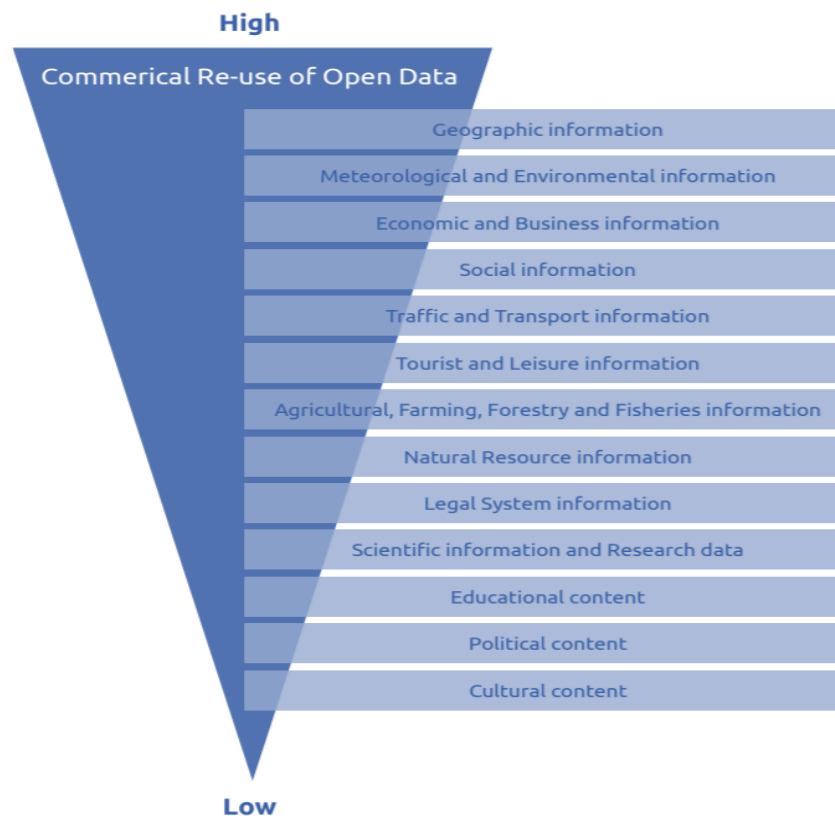
Figure 9: Shift in effort focus across the closed-openness spectrum ⁽⁵⁷⁾

In trying to accelerate the reuse of open data, another important aspect to keep in mind has to do with the commercial appeal of the different datasets for private sector organisations in order to: prioritise investments in data liberation, allocate the resources necessary to guarantee the required levels of data quality and, finally, define a fair pricing model that may lead to a long-term sustainability of the process of data provision.

In this respect, a study conducted by Capgemini ⁽⁵⁸⁾ looked at the commercial reuse of open datasets. This study shows the different types of data generated by the public sector during its daily operations by appeal in terms of commercial reuse for profit-oriented businesses (**Error! Reference source not found.**). Aside from noting that geographical, meteorological and economic information are at the top of the classification, it is important to note that not all data carry the same appeal and, as a consequence, should not be exploited at the same time. This is to say that some datasets are more readily reusable by the business ecosystem, while other types of datasets (e.g. cultural content) may require a longer lead time to find a viable exploitation avenue.

⁽⁵⁷⁾ See footnote 66

⁽⁵⁸⁾ European Commission, Directorate-General for the Information Society and Media, Carrara, W., Fischer, S., Steenbergen, E. et al., *Creating value through open data – Study on the impact of re-use of public data resources*, Publications Office of the European Union, Luxembourg (2015).

Figure 10: Commercial appeal of open datasets ⁽⁵⁹⁾

Finally, despite the efforts of an international and highly motivated community of open data advocates operating from both within and outside the public sector, the ‘open-by-default’ approach to date is still struggling to become a widespread practice and to generate the expected impact on the European socio-economic system. The latest report published by the Global Data Barometer ⁽⁶⁰⁾ highlights that while shaping data for public good is possible, there is still a long way to go and open data agendas are alive but not spreading. For this reason, there is an urgent need to take a new perspective on the topic in order to put cities, companies and citizens in a position to benefit from the significant, yet untapped, value residing in the public sector’s data vaults. More specifically, it is important to acknowledge the self-interested nature of human behaviour by focusing on the benefits public administrators may gain as stewards of government data vaults while viewing current drivers of data liberation as significant, yet second-order, positive externalities. Drawing on the principle that a thriving open data ecosystem requires the attainment of sustainability from both the demand and supply sides, the perspective proposed endorses governments’ return on investment as the yardstick for gauging the ultimate feasibility of open data programmes. In this respect, Charalabidis et al. ⁽⁶¹⁾ propose a new open data paradigm entailing a radical shift in the way civil servants look at open data that may be summarised as follows:

- from legal obligation to operational necessity;
- from outward orientation to inward orientation;
- from cost to opportunity;
- from clerical function to strategic function;

⁽⁵⁹⁾ See footnote 69

⁽⁶⁰⁾ Global Data Barometer (2022), *First Edition Report – Global Data Barometer*, ILDA.

⁽⁶¹⁾ Charalabidis, Y., Zuiderwijk, A., Alexopoulos, C., Janssen, M., Lampoltshammer, T. and Ferro, E. (2018), *The World of Open Data: Concepts, Methods, Tools and Experiences*, Public Administration and Information Technology, Springer International Publishing, pp. 115–135.

- from requiring a leap of faith to generating evidence-based impact.

At an operational level, the implementation of such a paradigm requires the replacement of the ‘data liberation’ approach with an ‘open-by-design’ principle, allowing data to be open by default through a revision of their generation process. This would represent a valuable tool in facing the challenges posed by a steadily growing pressure on public budgets. In addition, it could contribute to making a further step towards the obtainment of an outcome-based government whose actions demonstrate a clear link with the results generated (i.e. outcomes) in terms of value that, in turn, could be internalised by the governments (e.g. efficiency, effectiveness) without overlooking the quest for the creation of value for society at large (‘public value’).

4. Open data and emerging technologies

4.1. Artificial intelligence and open data

The advent of AI has had a transformative impact on various sectors of the economy, including the public sector and the data ecosystem.

Examples of AI applications span across sectors such as climate, manufacturing, mobility and health, with the potential to generate significant benefits for the European society and economy (**Error! Reference source not found.**). Not surprisingly, a growing number of AI companies have emerged and AI technologies have penetrated into almost every crevice of the economy. For example, AI mobility services will reform passenger experience through the deployment of automatic vehicles and buses, and largely improve road efficiency through advanced traffic management operations and robot logistics. Healthcare is one of the most important sectors benefiting from AI’s rapid development. Applied to large datasets, AI can identify new drug solutions, enable the selection of candidates for clinical trials and monitor patients with specific conditions. AI can also enable remote patient care, increase diagnosis accuracy, improve hospital efficiency, etc. ⁽⁶²⁾

Looking at education, AI techniques enable the application of new educational models oriented to personalised learning. Firstly, students would play a more active role in their learning process by knowing their own evolution and being more aware of how to optimise it. Secondly, it would allow educational and training centres to identify those students who require more support.

Figure 11: Benefits of AI to the European economy and society ⁽⁶³⁾

Target Groups	Benefits examples
For citizens	Improved health care, fewer breakdowns of household machinery, safer and cleaner transport systems, better public services.
For business development	A new generation of products and services in areas where Europe is particularly strong (machinery, transport, cybersecurity, farming, the green and circular economy, healthcare and high value added sectors like fashion and tourism).
For services of public interest	Reducing the costs of providing services (transport, education, energy and waste management); Improving the sustainability of products and equipping law enforcement authorities with appropriate tools to ensure the security of citizens, with proper safeguards to respect their rights and freedoms.

Taking an evolutionary perspective, AI may be said to come in three generations ⁽⁶⁴⁾. The first one is able to automate processes that are routine and do not change over time. The second generation of AI is able to adapt to and learn from changes in the automated process, while the third generation proactively provides new and innovative insights by being able to analyse and learn from its previous actions. Currently, this third generation of

⁽⁶²⁾ European Institute of Innovation & Technology (2021), ‘Emerging AI and Data Driven Business Models in Europe’, Cross-KIC Activity, <https://eit.europa.eu/library/emerging-artificial-intelligence-and-data-driven-business-models-eu>.

⁽⁶³⁾ European Commission (2020), ‘White paper on artificial intelligence – a European approach to excellence and trust’, COM(2020) 65, <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0065>.

⁽⁶⁴⁾ <https://data.europa.eu/en/publications/datastories/leveraging-ai-public-sector-open-data>.

AI is the most advanced technology in the private sector, but the expectation is that more complex AI levels with larger potential value will be created in the future. In the public sector, on the other hand, some government departments have adopted AI mainly for its ability to automate processes, without making use of its predictive analytic capabilities as seen in the private sector.

Concerning AI-related business models, a quite comprehensive study has been conducted by EIT to map the European landscape ⁽⁶⁵⁾. A wide range of business models have been tested by companies leveraging AI in their business, depending on the nature of the company (AI developers and AI adopters). Nevertheless, two major business models emerge when systematically scanning the current AI applications across sectors: providing AI application as a service and AI infrastructure as a service.

For AI application-as-a-service, AI technology start-ups develop applications for specific use cases defined by their customers and provide AI applications that could be integrated with other components. Such AI applications are priced by transactions and completed computations, i.e. per study or by monthly subscriptions.

For AI infrastructure-as-a-service, AI technology companies provide computational services including both infrastructure for computing power and pre-trained algorithms. These are typically operated by leading AI global firms with rich resources, which charge customers based on API calls.

AI-driven business models could sometimes be assessed as data-driven business models ⁽⁶⁶⁾. Data collaboration is thus very common among AI-related companies, regardless of size. Some companies may partner with AI development start-ups specialised in tailor-made solutions through a revenue-sharing business model. They both agree to build a proof of concept and if it is successful, they share the benefits. It is thus important to investigate the relationship between AI and data.

In general terms, AI systems are a combination of statistical and mathematical techniques, an understanding of the world and data ⁽⁶⁷⁾. Large amounts of quality data are crucial not only as an input during the operation of AI systems, but also to train them in the first place. Without access to lots of high-quality data, algorithms cannot learn. Even the most powerful AI techniques with cutting-edge hardware are significantly less useful without access to quality data. In this respect, global data oligopolies are likely to turn into global AI oligopolies if access to data is not managed strategically from a technological and policy perspective. As a matter of fact, the current wave of interest and investment in AI is characterised in part by a preference for business models that prioritise the collection and segregation of data into silos. For companies taking this approach, access to data is seen as the key to securing a competitive advantage when building, implementing and operating AI systems ⁽⁶⁸⁾. Thus, in providing products and services, these companies often restrict access to some or all of these resources. Because of the ubiquity and commodification of hardware, access to sufficient hardware is relatively uncompetitive, though it may have an impact on the initial development conducted by start-ups ⁽⁶⁹⁾. Any business attempting to create a competitive advantage through the development of bespoke hardware would encounter large upfront costs and, in many applications, this would be unlikely to provide a sufficient competitive advantage to justify that cost. However, it is a strategy that can be employed by large corporations running cutting-edge AI systems.

The 'Open Algorithm + Closed Data' setup (**Error! Reference source not found.**) has led to great disparities in access to data across the AI sector, creating a huge gap between the 'data haves' and the 'data have-nots' in the AI sector. It is the big corporations and companies that have a significant amount of data, but not necessarily the skills necessary to use it, to build effective AI systems. On the other hand, AI start-ups lack the relevant and high-quality datasets to actually train their models. For this reason, the presence of a flourishing open data ecosystem could be conducive to the creation of a plurality of data-driven AI services for the benefit of society and the

⁽⁶⁵⁾ European Institute of Innovation & Technology (2021), 'Emerging AI and Data Driven Business Models in Europe', Cross-KIC Activity, <https://eit.europa.eu/library/emerging-artificial-intelligence-and-data-driven-business-models-eu>.

⁽⁶⁶⁾ Brownlow, J., Zaki, M., Neely, A. and Urmetzer, F. (2015), 'Data and analytics – Data-driven business models: A blueprint for innovation', *Cambridge Service Alliance*, No 7 (February), pp. 1–17.

⁽⁶⁷⁾ Open Data Institute (2018), 'The Role of Data in AI Business Models', <https://theodi.org/insights/reports/the-role-of-data-in-ai-business-models/>.

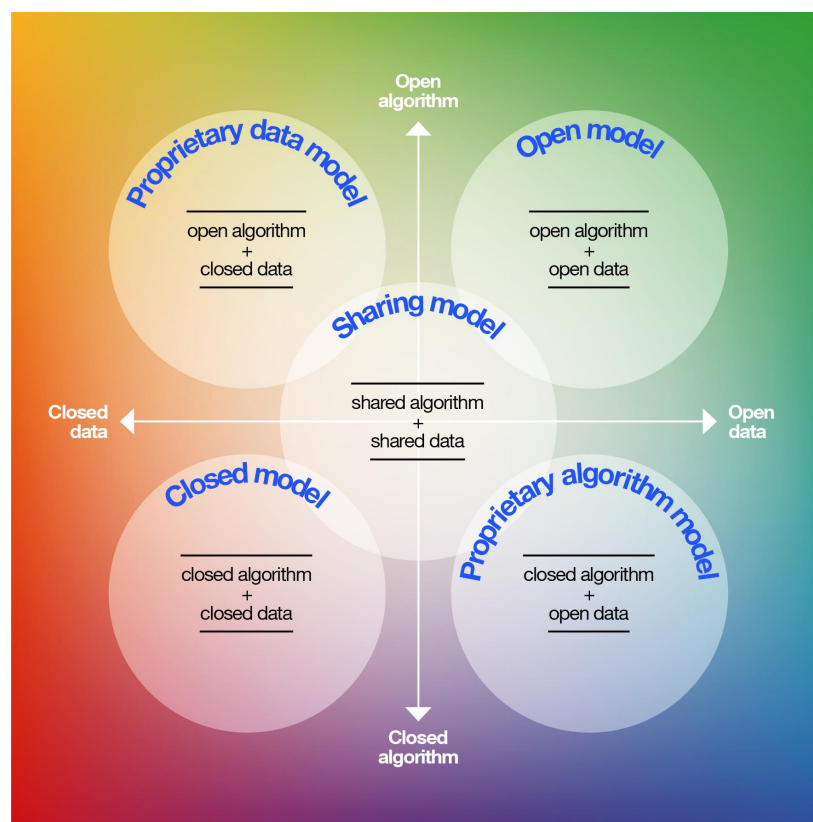
⁽⁶⁸⁾ See footnote 78

⁽⁶⁹⁾ Digital Catapult Centre (2018), 'Machines for Machine Learning', https://www.digitalcatapultcentre.org.uk/wp-content/uploads/2018/01/MIG_MachinesforMachineIntelligence_Report_DigitalCatapult-1.pdf.

economy. As a matter of fact, open data and AI have the potential to support and enhance each other's capabilities in a mutually reinforcing fashion ⁽⁷⁰⁾. On the one hand, open data can improve AI systems. In general, exposing AI systems to a larger volume and variety of data increases the chance of the system returning accurate and useful predictions. As such, open data can be a supply of large amounts of diverse information for AI systems. In this way, the availability of open data contributes to better performing AI.

On the other hand, AI can unlock additional value from open data. AI can analyse large volumes of data and identify trends and patterns that might not have been revealed through other analysis techniques. Open data contains rich information and complex patterns from which insights can be derived. As a powerful analysis tool, AI can thereby leverage the value of open data. For example, an AI system trained to predict forest fires can search for patterns across weather data, satellite images and historical trends that standard statistical comparisons cannot identify ⁽⁷¹⁾.

Figure 12: The AI business model matrix ⁽⁷²⁾



Open data encompasses a broad range of subject areas. This variety of data widens the possible use cases for which AI systems can be developed, making new AI-driven products and services possible. These use cases can only be developed if the relevant data is available and easy to access. The free availability of diverse datasets, as through open data, is essential to drive innovation and bring new economic opportunities. The hope is that innovative AI systems can then be used to help solve challenges facing society, creating socio-economic value.

The diverse pool of information that open data can particularly provide for AI systems can enable multidisciplinary applications that combine data on several topics to derive new insights. For example, a weather dataset can be used to make weather predictions. However, when combined with data on seed genetics, soil characteristics and environmental conditions, an AI system can be trained to have good contextual knowledge of the variables

⁽⁷⁰⁾ <https://data.europa.eu/en/publications/datastories/open-data-and-ai-symbiotic-relationship-progress>.

⁽⁷¹⁾ <https://data.europa.eu/en/publications/datastories/high-value-datasets-forest-fires-eu>.

⁽⁷²⁾ Open Data Institute (2018), 'The Role of Data in AI Business Models', <https://theodi.org/insights/reports/the-role-of-data-in-ai-business-models/>.

affecting agriculture production. Such a system could be used to aid decision-making to increase crop yields, prevent plant disease or optimise other business decisions.

4.2. Blockchain and open data

Blockchain technology has emerged as a disruptive force with the potential to revolutionise how data is managed, shared and reused across various sectors, including the public sector. Since 2008, blockchain has evolved as a general-purpose technology and found various areas of applications where a ‘trust’ problem is observed in a system of transactions ⁽⁷³⁾. The public sector has become a principal area of application, in which governments and other actors have announced more than 200 use cases all around the world. Digital currency/payments, land registration, identity management, notarisation, supply chain traceability, healthcare, education, corporate registration, data management, auditing, energy market, taxation, voting and legal entity management are some areas where blockchain is currently being tested for public services (**Error! Reference source not found.**) ⁽⁷⁴⁾. As it is possible to notice, blockchain technology has now moved beyond the realm of financial applications and is expanding its impact to include goals of sustainability, transparency, traceability and empowerment ⁽⁷⁵⁾. As highlighted by the Organisation for Economic Co-operation and Development, blockchain technologies may also contribute to more user-friendly public services, improved transparency and the elimination of corruption ⁽⁷⁶⁾.

Figure 13: Blockchain applications for smart cities ⁽⁷⁷⁾

Smart city application area	Energy	P2P transaction platform	Corporate energy transactions	Crowdfunding platform	Carbon asset management	Science & research
	Transportation	Ride sharing	Tolls	Parking	PEV charging	Container logistics
	Building	Property transactions	Energy consumption		Funding	Building access authorization
	Health	Patient records	Pharmaceutical authenticity verification	Research data provision	Emergency alerts	Digital nudging
	Government	Registry services	Voting	Donation tracking	Citizen dialogue	Digital citizenship

The most notable initiative promoted by the Commission in this field is the European Blockchain Services Infrastructure ⁽⁷⁸⁾, a collaborative effort in decentralised governance consisting of a peer-to-peer network of interconnected nodes running a blockchain-based services infrastructure. It allows public organisations to develop applications that connect to and make use of a Europe-wide common infrastructure that will eventually be extended to private organisations. The initial use cases foreseen for such infrastructure are shown below.

- **Notarisation.** Leveraging the power of blockchain to create trusted digital audit trails, automate compliance checks in time-sensitive processes and prove data integrity.
- **Diplomas.** Giving control back to citizens when managing their education credentials, significantly reducing verification costs and improving authenticity trust.
- **European digital identity.** Implementing a generic digital identity capability, allowing users to create and control their own identity across borders without relying on centralised authorities, and enabling compliance with the EU eIDAS regulatory framework on electronic and trust services for electronic transactions.

⁽⁷³⁾ Nagel, E., Kranz, J., Sandner, P. and Hopf, S. (2019), ‘How blockchain facilitates smart city applications – development of a multi-layer taxonomy’, *Proceedings of the 27th European Conference on Information Systems (ECIS2019)*, Stockholm.

⁽⁷⁴⁾ See footnote 84

⁽⁷⁵⁾ Medaglia, R. and Damsgaard, J. (2020, June), ‘Blockchain and the United Nations Sustainable Development Goals: Towards an Agenda for IS Research’, *PACIS 2020 Proceedings*, p. 36.

⁽⁷⁶⁾ OECD (2017), ‘Does Technology Against Corruption Always Lead to Benefit? The Potential Risks and Challenges of the Blockchain Technology’, <https://www.oecd.org/cleangovbiz/Integrity-Forum-2017-Kim-Kang-blockchain-technology.pdf>.

⁽⁷⁷⁾ Nagel, E., Kranz, J., Sandner, P. and Hopf, S. (2019), ‘How blockchain facilitates smart city applications – development of a multi-layer taxonomy’, *Proceedings of the 27th European Conference on Information Systems (ECIS2019)*, Stockholm.

⁽⁷⁸⁾ <https://digital-strategy.ec.europa.eu/en/policies/european-blockchain-services-infrastructure>.

- **Trusted data sharing.** Leveraging blockchain technology to securely share data amongst authorities in the EU, starting with the Import One-Stop Shop VAT identification numbers, and import one-stop shops amongst customs and tax authorities.

Blockchain technology allows people and organisations who may not know or trust each other to collectively agree on and permanently record information without a third-party authority. By creating trust in data in ways that were not possible before, blockchain has the potential to revolutionise how we share information and carry out transactions online.

In order for this potential to materialise, the Commission has put forth a strategy to promote a ‘gold standard’ for blockchain technology in Europe that embraces European values and ideals in its legal and regulatory framework⁽⁷⁹⁾. This ‘gold standard’ for blockchain unfolds along five main dimensions.

- **Environmental sustainability.** Blockchain technology should be sustainable and energy-efficient.
- **Data protection.** Blockchain technology should be compatible with, and where possible support, Europe’s strong data protection and privacy regulations.
- **Digital identity.** Blockchain technology should respect and enhance Europe’s evolving digital Identity framework. This includes compatibility with e-signature regulations such as eIDAS, and supporting a sensible, pragmatic decentralised and self-sovereign identity framework.
- **Cybersecurity.** Blockchain technology should be able to provide high levels of cybersecurity.
- **Interoperability.** Blockchains should be interoperable between themselves and legacy systems in the outside world.

Looking now at blockchain-related private ventures, a survey of 80 start-ups analysed their business models in an attempt to clarify the main pillars of their value proposition and the benefits that may stem from them (**Error! Reference source not found.**).

Figure 14: Business models of blockchain-based ventures⁽⁸⁰⁾

Business model	<i>Value proposition</i>	<i>Primary blockchain benefit</i>	Security by design	Auditability	Smart contracts	Micro-transactions	Disinter-mediation	User verification	Data reconciliation speed	Tokenization	Anonymity
	<i>Value delivery</i>	<i>Customer type</i>	Consumers		Prosumers		Businesses			Governments	
		<i>Product composition</i>	Cyber-physical					Purely digital			
	<i>Value capture</i>	<i>Revenue model</i>	Free		Freemium		Fee-based		Subscription		Upfront payment

As in the case of most innovations relying on information and communication technologies, one major benefit offered by blockchain applications is represented by the reduction of transaction costs which result from uncertainty or unforeseen contingencies and from writing and enforcing contracts⁽⁸¹⁾. It is possible to distinguish between three core benefits of blockchain with regard to transaction cost reduction (security by design, auditability and smart contracts). Blockchains are secure by design, as the decentralised ledger renders entries tamper-proof⁽⁸²⁾. For example, start-ups operating in the field of government registry services, voting and house access solutions benefit from this feature. Instead, auditability refers to the transparency afforded by blockchain’s

⁽⁷⁹⁾ <https://digital-strategy.ec.europa.eu/en/policies/blockchain-strategy>.

⁽⁸⁰⁾ Nagel, E., Kranz, J., Sandner, P. and Hopf, S. (2019), ‘How blockchain facilitates smart city applications – development of a multi-layer taxonomy’, *Proceedings of the 27th European Conference on Information Systems (ECIS2019)*, Stockholm.

⁽⁸¹⁾ Tirole, J. (1999), ‘Incomplete contracts: Where do we stand?’, *Econometrica*, Vol. 67, No 4, pp. 741–781.

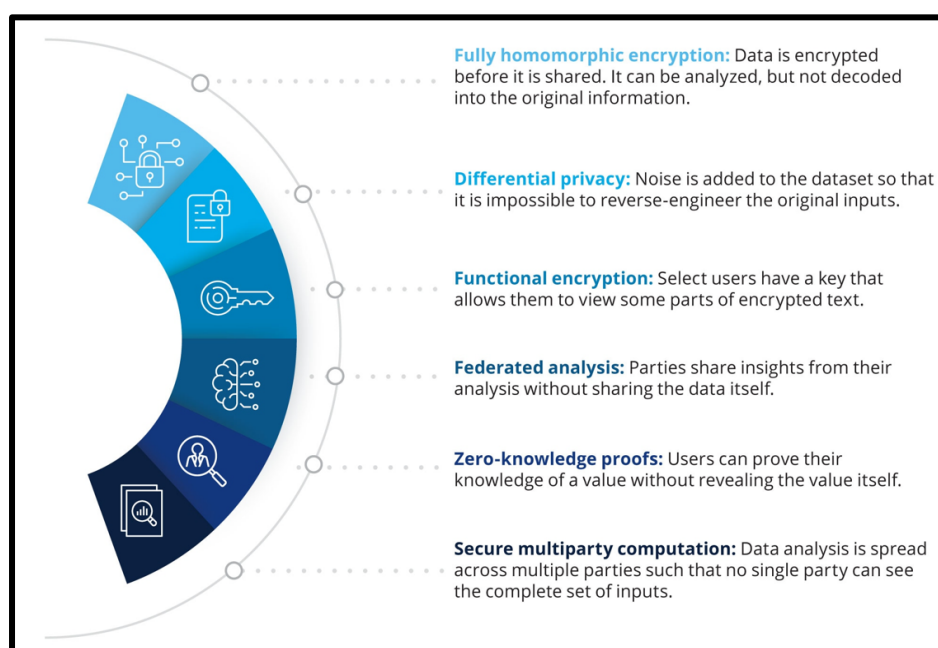
⁽⁸²⁾ Zyskind, G. and O. Nathan (2015), ‘Decentralizing privacy: Using blockchain to protect personal data’, *2015 IEEE Security and Privacy Workshops*, San Jose, CA, pp. 180–184.

ability to review past entries and a token's history⁽⁸³⁾. This feature is primarily exploited by start-ups in the areas of donation tracking, pharmaceutical authentication, voting and logistics. Finally, smart contracts reduce transaction costs because expenses for writing and enforcing contracts are significantly lowered⁽⁸⁴⁾. Smart contracts are particularly effective in lowering transaction costs when transactions are highly standardised and occur frequently, as in the energy sector, or when they occur between parties otherwise unknown to each other, as in ride-sharing or real estate funding.

With respect to access to the market, digital technologies promoted a shift towards direct company–customer interaction throughout industries⁽⁸⁵⁾. Blockchain in particular has facilitated niche products targeting small, technology-minded communities⁽⁸⁶⁾. The start-ups analysed in the sample cater to both businesses and end customers. Start-ups further address individual professionals such as doctors or solar scientists. This type of technology is often related to disintermediation, as it fosters peer-to-peer transactions and enables novel prosumer markets. Start-ups heavily relying on peer-to-peer may be found in the smart city areas of energy and transportation.

Moving to the relationship with open data, the presence of a vibrant ecosystem of blockchain service providers could represent a significant contribution towards the improvement and increase of data-sharing practices among public agencies. An initial example of such a contribution is related to breaking some of the existing trade-offs between conflicting public values. In this respect, it is important to mention the role blockchain can play as a privacy-preserving technology within a portfolio of solutions collectively known as confidential computing. As a matter of fact, approaches such as zero-knowledge proofs, homomorphic encryption and functional encryption make it possible for organisations to reap the benefits of data-sharing without sacrificing privacy (**Error! Reference source not found.**).

Figure 15: Privacy-preserving techniques for data sharing⁽⁸⁷⁾



Another example of the contribution that blockchain may offer to open data has to do with the certification of data provenance. As automated data generation and processing become a cornerstone in strategic decision-making across all industries, it is paramount to guarantee data provenance and integrity⁽⁸⁸⁾. The application of

⁽⁸³⁾ Davidson, S., P. De Filippi, P. and Potts, J. (2016), 'Economics of blockchain', SSRN, <http://ssrn.com/abstract=2744751>.

⁽⁸⁴⁾ Kiviat, T. (2015), 'Smart Contract Markets: Trading Derivatives on the Blockchain', https://www.academia.edu/10766594/Smart_Contract_Markets_Trading_Derivatives_on_the_Blockchain.

⁽⁸⁵⁾ Wikström, S. (1996), 'Value creation by company – Consumer interaction', *Journal of Marketing Management*, Vol. 12, No 5, pp. 359–374.

⁽⁸⁶⁾ Malović, M. (2014), 'Demystifying Bitcoin: Sleight of Hand or Major Global Currency Alternative?', *Economic Analysis*, Vol. 47, No 1–2, pp. 32–41.

⁽⁸⁷⁾ Deloitte (2022), 'Data Sharing Made Easy', <https://www2.deloitte.com/us/en/insights/focus/tech-trends/2022/data-sharing-technologies.html>.

⁽⁸⁸⁾ Pini, M. and Ferro, E. (2021), 'Satellite Navigation and Blockchain Promise to Protect our Health and That of the Oceans Through Improved Data Integrity', Overtheblock Innovation Observatory, LINKS Foundation.

blockchain to geo-time tagged data coming from satellite sources, for example, may be instrumental in overseeing and enforcing numerous public policies from health safety to fishing quotas ⁽⁸⁹⁾. Even researchers collaborating from different locations need a method to capture and store scientific workflow provenance that guarantees provenance integrity and reproducibility. As modern science is moving towards greater data accessibility, researchers also need tools for open-access data sharing. A blockchain-based platform may provide secure, trustworthy storage for scientific workflow provenance to reduce research fabrication and falsification, thus leading to better informed policy decisions and a higher level of trust in scientific results.

One final contribution that blockchain may offer to promote a flourishing open data ecosystem has to do with data monetisation. More specifically, the possibilities of disintermediation, automation and more effective management of intellectual property offered by this technology open up significant opportunities for the exploration of new monetisation pathways ⁽⁹⁰⁾. For example, linking information products to smart contracts may turn them into 'self-driving business entities' capable of autonomously managing their intellectual property via a smart contract that is executed every time the product is downloaded. The contract can trigger an automatic payment and flex based on user identity; for example, a large enterprise would pay more than an individual consumer ⁽⁹¹⁾.

5. Conclusions and recommendations

Open data is a source of power. It can and must be deployed for the public good, as a resource for tackling social challenges, enabling collaboration, driving innovation and improving accountability ⁽⁹²⁾. As an international community, we have to recognise that top-down pressure from policy alone is unlikely to improve the state of ecological data availability and accessibility ⁽⁹³⁾. A collaborative effort is thus required to harness the entrepreneurial spirit of new generations of innovators and the strength of established corporations.

The analysis presented in this discussion paper shows how open data reuse may be regarded to be a multi-billion and multi-dimensional opportunity for European corporations, SMEs and start-ups, with the potential to unlock value-generation processes impacting top and bottom lines of companies' balance sheets and the well-being of society at large.

Businesses making use of open data can benefit from favourable economics that may exert a positive impact on their profitability once a sufficient level of competitive advantage is generated. Sources of competitive advantage may vary depending on the type of barriers encountered in the processes of data acquisition and analysis and can come from the combination of open data with company-specific assets (skills, data, relationships, etc.) or the adoption of innovative business models relying on emerging technologies. AI and blockchain, in fact, represent useful technological evolutions in supporting the sharing, reuse and monetisation of open data, contributing to a smarter, more secure and automated data economy.

The design of value propositions leveraging open data usually requires a resource-based approach where three strategic decisions need to be made in order to define a complete business model. Namely, the type of elaboration needed, the role of the knowledge generated in the final product or service and, finally, the pricing mechanism. The review of the literature conducted on business models for open data allowed us to identify 14 business models that may be clustered into five broad categories: freemium, premium, cost-saving, indirect benefit and razor-blade.

⁽⁸⁹⁾ See footnote 99

⁽⁹⁰⁾ Ferro, E. et al. (2023), 'Digital assets rights management through smart legal contracts and smart contracts', *Blockchain: Research and Applications*, Vol. 4, No 3.

⁽⁹¹⁾ Deloitte (2022), 'Blockchain: Ready for Business', <https://www2.deloitte.com/us/en/insights/focus/tech-trends/2022/blockchain-trends.html>.

⁽⁹²⁾ Global Data Barometer (2022), *First Edition Report – Global Data Barometer*, ILDA, doi:<https://doi.org/10.5281/zenodo.6488349>.

⁽⁹³⁾ Tierney, N.J. and Ram, K. (2021), 'Common-sense approaches to sharing tabular data alongside publication', *Patterns*, Vol. 2, No 12.

Finally, a new paradigm for open data management is proposed, entailing a shift in the way civil servants approach the release of data. The necessary change may be summarised through the following list of transitions:

- from legal obligation to operational necessity;
- from outward orientation to inward orientation;
- from cost to opportunity;
- from clerical function to strategic function;
- from requiring a leap of faith to generating evidence-based impact.

At an operational level, the implementation of such a paradigm requires the replacement of the ‘data liberation’ approach with an ‘open-by-design’ principle, allowing data to be born open through a revision of their generation process. This would represent a valuable tool in facing the challenges posed by a steadily growing pressure on public budgets. In addition, it could contribute to making a further step towards the realisation of an outcome-based government whose actions demonstrate a clear link with the results generated (i.e. outcomes) in terms of value, that in turn could be internalised by the government (e.g. efficiency, effectiveness) without overlooking the quest for the creation of value for society at large (‘public value’).

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ISBN 978-92-78-43829-6

OA-02-23-227-EN-N