Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 00 (2018) 000–000

Procedia Computer Science

www.elsevier.com/locate/procedia

SEMANTiCS 2018 – 14th International Conference on Semantic Systems

Business Models for Data Assets - The Linked Data Business Cube Revisited

Tassilo Pellegrini[a], Christian Dirschl[b]

[a]UAS St. Poelten, Matthias Corvinus Str. 15, 3100 St. Poelten, Austria
[b]Wolters Kluwer Deutschland GmbH, Freisinger Straße 3, 85716 Unterschleißheim, Germany

Abstract

With the increasing proliferation of interoperable data ecosystems across diverse domains and business sectors, questions arise about the economic value of interlinked data and business models that can be built on top of it. This paper revisits the Linked Data Business Cube, a heuristic approach to model and analyze business models for interoperable data assets. The authors argue that conceptualizing data-centered business models requires an integrated view on all assets involved in the value creation process, shifting the focus away from the isolated asset towards the underlying "data apparatus". Hence, the Linked Data Business Cube identifies various data assets and their plausible interactions with revenue models and stakeholders. This allows to investigate the specificities and interdependencies of asset-centered business models under conditions of highly networked infrastructures and collaborative (multi-stakeholder) value creation.

Peer-review under responsibility of the scientific committee of the SEMANTiCS 2018 – 14th International Conference on Semantic Systems.

Keywords: Linked Data, Business Model, Content Value Chain, Media Economics, IPR, Data Licensing

1. Introduction

Definitions of business models are diverse and context dependent [20]. In this paper the authors refer to business models as a "heuristic logic that connects technical potential with the realization of economic value" [19]. Hence, business models should be understood as a system-level approach to explaining how firms commercialize their products and services, utilize productive factors – such as technology – to diversify their business practices, propose value and realize it through innovation. This view is especially relevant in multi-sided, data-driven markets, where

Peer-review under responsibility of the scientific committee of the SEMANTiCS 2018 – 14th International Conference on Semantic Systems.

competitive advantage and opportunities for diversification rely increasingly on the experienced and professional utilization of digital technologies at each step of the value chain to either improve workflow efficiency or acquire the necessary resources to innovate at the product or service level.

As a design principle Linked Data marks a transition from hierarchies to networks as an organizational principle for data and knowledge [8]. Hence, the primary value proposition of Linked Data is rooted in its modularity and technological connectivity [2], which are central design features of so called "service ecosystems" [23, 24, 36]. By sharing the Resource Description Framework (RDF)[1] as a unified data model, Linked Data provides the infrastructure for publishing and repurposing of data on top of semantic interoperability [16] thus triggering business opportunities in multi-sided, multi-stakeholder environments through exchange and integration of resources.

Anecdotal evidence supports the hypothesis that Linked Data is an enabling technology to improve workflow efficiency and trigger business diversification [6, 11, 12].[2] But Linked Data strategies can be very diverse and context-specific. A closer look at case studies from sectors such as automotive, media & publishing or the life sciences reveals that Linked Data is implemented along the incremental IT development practices of enterprises and public organizations, but additionally brings along disruptive technological effects that pose significant challenges to and opportunities for business development [1, 15, 17, 18, 22]. This includes foremost an appropriate licensing strategy [14] that takes account of the various asset specificities of interoperable data assets as intellectual property and the various stakeholders involved in creating a data ecosystem [i.e. 30, 31, 32].

This line of argument motivates to take a closer look at the business model implications of Linked Data and the added value derived from it. Various papers address particular aspects of business models with respect to Linked Data [9, 10, 16]. This paper builds upon this work and extends an earlier version of this paper [21] by providing a better epistemological grounding of and reflection on the model's initial premises. Additionally, this paper introduces the concept of the "data apparatus", which shall be understood as a mediating layer between data assets as input factors and the data ecosystem as the socio-technical configuration of value creation.

This paper is structured as follows: Chapter 2 briefly discusses the concept of data ecosystem and its relevance to interoperable data assets as an enabling technology. Chapter 3 discusses the Linked Data Business Cube, an OLAP-inspired heuristic to visualize the interdependencies between data assets, revenue models and stakeholders. Chapter 4 closes this paper with a conclusion and reflection on the commercial aspects of Linked Data.

2. Designing Value Propositions for Data Assets

In this paper the authors refer to value propositions as "the promised set of benefits the firm offers to its consumers" [34]. According to Frow et al. [35] value propositions mobilise assets and link them together to leverage value-creating processes that unfold through co-creation between resource-integrating actors. Value propositions are realized by designing business models that generate direct or indirect revenues from data assets. As immanent to intangible goods (such as data, content, software or services) value propositions are multidimensional, context-dependent, and subject to negotiation w.r.t. attributes, such as speed, topicality, validity, reliability, accessibility, capacity, or status etc. [34]. Hence, business models for data assets can be very diverse and can have various degrees of complexity, depending on the diversity of assets, actors and revenue models involved.

Designing value propositions for data assets requires a good understanding of the assets' specificities that derive from the technological, organizational and institutional framework, in which their commercial or social value unfolds. It is these circumstances that influence the marketability of data assets as an economic good.[3]

[1] See also http://www.w3.org/RDF/, accessed July 4, 2018.

[2] See also Archer et al. [1] who carried out a study on business models for Linked Open Government Data. A discussion of the data broker industry is provided by US Committee on Commerce, Science and Transportation [5].

[3] According to Hess & Ostrom [29] economic goods can be classified either as private goods, public goods, common-pool resources or toll goods depending on the asset's specificities w.r.t. exclusiveness and subtractability.

2.1. From Data Assets to the Data Apparatus

According to Borgman [25] data is not a unified, well defined concept. Especially in the context of business models a narrow notion of data – such as "things known or assumed as facts" [26] – can be rather hindering than enlightening. Hence, in this paper the authors propagate a broad definition of data as given by OAIS (Open Archival Information System) [27] *incorporating not just the measurements but also the apparatus involved to organize and interpret them.* According to the Oxford Dictionary the term apparatus shall be understood as "the technical equipment or machinery needed for a particular activity or purpose" [33].

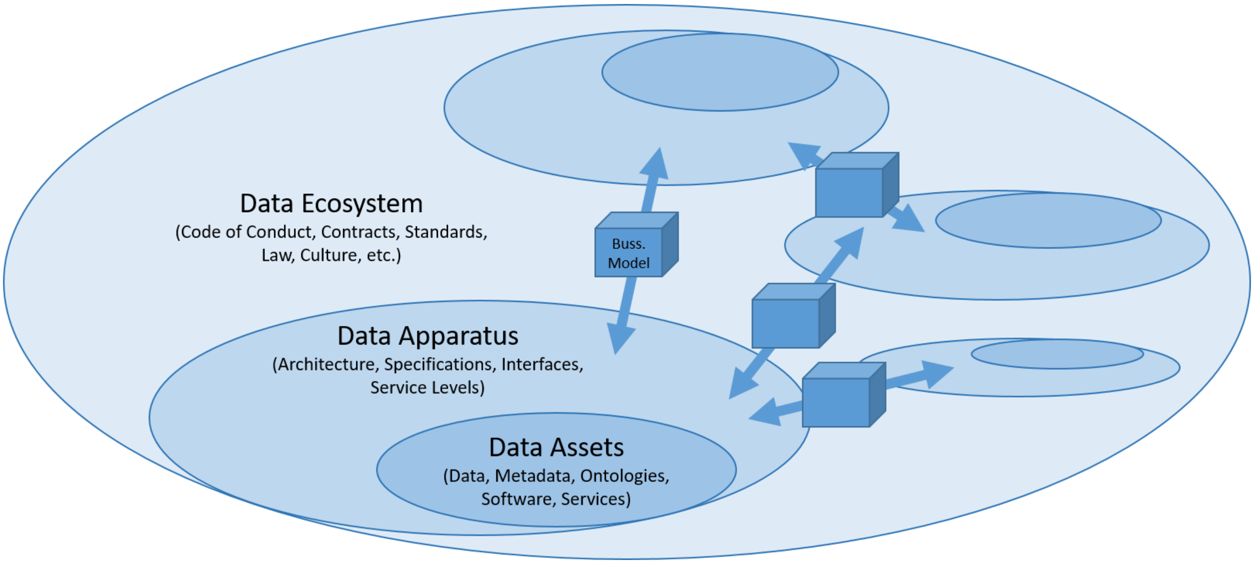

Figure 1: The Interplay of Data Assets, Data Apparatus and Data Ecosystems

Extending the notion of value creation from the singular asset to the underlying apparatus is insofar plausible, as from a business perspective data assets are rarely used in isolation but rather in combination with other artefacts, where each asset type contributes in its specific way to the value creation process and can be protected by appropriate legal instruments such as copyright, database rights, competition law or patent law.

An additional argument that promotes the concept of the data apparatus stems from the fact that the validity, interpretability and accessibility of data is often bound to specific technological conditions such as a certain type of software that has been used to create and process the data, a specific service (such as an application programming interface and its service levels) under which data is being provided, or the factual representation of the data when it is provided for processing.

Hence, the concept of "data apparatus" refers to the system-level design and functional combination of data assets in the production and processing of data. The apparatus determines the assets' specificities and the value propositions that can be assigned to them [28] in the course of service delivery.

2.2. From Data Apparatus to Data Ecosystems

Data ecosystems can be understood with reference to Borgman's [25, p. 4] concept of "knowledge infrastructures", "an ecology of people, practices, technologies, institutions, material objects and relationships" that shape the nature of data either as "assets, as liabilities of both". This marks a clear reference to business models as a link between the data apparatus (as technological provision of data assets) on the one side and their broader institutionalization as ecosystems on the other. From this perspective data ecosystems evolve from the functional coupling of two or more data apparatuses with the purpose to derive value from data assets by applying business models (Fig. 1).

With reference to service science [23] Vargo and Lusch [24] define ecosystems as "relatively self-contained, self-adjusting systems of resource integrating actors connected by shared institutional logics and mutual value creation through service exchange" [24]. This view draws attention to the stakeholders, their practices and various levels of institutions such as norms, rules, standards, codes of conduct and contracts. Institutions provide the "glue" [24] that holds ecosystems together and they govern the circumstances under which data is being produced and marketed. In data ecosystems business models should be understood as governance mechanism with the purpose of generating revenue from value propositions attached to data assets and specific combinations thereof.

3. Business Model Perspective on Data Assets – The Linked Data Business Cube Revisited

The Linked Data Business Cube (Fig. 2) is a heuristic method to model and investigate business models for data assets in data ecosystems. It has been inspired by the OLAP-approach and provides an integrated view on the interdependencies between assets, stakeholders and revenue models. The X-axis lists prototypical stakeholders involved in a business transaction. The Y-axis lists potential revenue models. And the Z-axis lists various data assets that occur along the value chain. In the following sections we will discuss these dimensions[4] and illustrate how the Linked Data Business Cube changes its shape when data assets are mapped to stakeholders and revenue models according to the data assets' specificities.

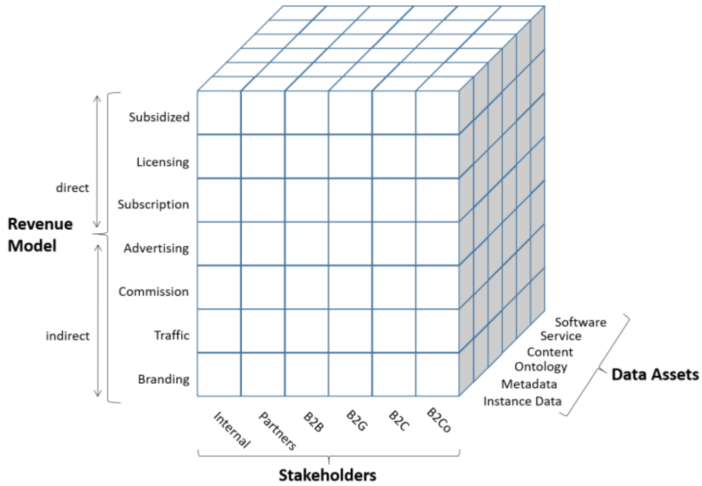

Figure 2: Linked Data Business Cube

3.1. Data Assets from a Legal Perspective - From Instance Data to Software

The Linked Data Business Cube distinguishes the following asset types: instance data, metadata, ontology, content, service and software. Assets are being created by applying intellectual property law to valuable artefacts. Property rights allow the rights holder to exclusively act upon assets and define the terms and conditions under which third parties can make use of them.

According to the European legislation[5] Copyright protects the creative value of a literary, artistic or scientific work. It is also applicable to computer programs and databases (for the latter case only as long as they are electronically

[4] A detailed discussion of the cube's dimensions is provided in [21].

[5] See also Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the harmonisation of certain aspects of copyright and related rights in the information society. See also http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32001L0029, accessed April 20, 2014

accessible). Special protection issues with respect to databases are covered by Database Right.[6] Competition law[7] regulates behavioural aspects of entrepreneurial and corporate conduct under special consideration of anticompetitive practices and the misuse of dominant market power. And patent law[8] protects technological inventions and are increasingly applied to computer programs. Table 1 provides an overview over data assets and related property rights.[9]

Table 1: Data Assets and related Property Rights

	Copyright	DB Right	Comp. Law	Patent Law
Instance Data	NO	YES	PARTLY	NO
Metadata	NO	YES	YES	NO
Ontology	YES	YES	YES	NO
Content	YES	NO	YES	NO
Service	YES	NO	YES	PARTLY
Software	YES	NO	YES	PARTLY

These four legal regimes are being complemented by open licensing instruments.[10] Creative Commons[11] allows to define tiered licensing policies for the reuse of work protected by copyright. Open Data Commons[12] does the same thing for assets protected by database rights. And open source licenses complement the patent regime as an alternative form of resource allocation and value generation in the production of software and services [7].

It is important to stress that license terms determine the good characteristics of an asset with respect to exclusiveness and subtractability. While any protectable good is initially a private good, public domain licenses (such as CC0 or ODC) create public goods, copyleft licenses (such as GPL) create toll goods and permissive licenses (such as APACHE or MIT) are often associated with common-pool resources. In consequence, the goods characteristics influence the revenue models that can be applied to data assets and have an impact on the assets' accessibility and reuse by specific stakeholders. From this perspective, licensing shall be understood as a design mechanism that allows to assign complementary and mutually supportive value propositions to data assets with the aim to maximize revenue by strategically serving specific stakeholders.

3.2. Revenue Models for Data Assets

In the following section we look at various revenue models in the commercialization of data assets. To do so, the authors refer to a classification of revenue models discussed by Brinkner [3] who distinguishes between direct and indirect revenue models.[13] Direct compensation takes place where assets are directly being paid for, wherein indirect

---

[6] See also Directive 96/9/EC of the European Parliament and of the Council of 11 March 1996 on the legal protection of databases. See also http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0009:EN:HTML, accessed April 20, 2014

[7] See also consolidated versions of the Treaty on European Union and the Treaty on the Functioning of the European Union - Official Journal C 326, 26/10/2012 P. 0001 – 0390. See also http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:12012E/TXT&from=EN, accessed April 20, 2014

[8] See also http://www.epo.org/law-practice/legal-texts/html/epc/1973/e/ar52.html, accessed April 20, 2014

[9] A detailed discussion of the various protection instruments can be found in [21].

[10] A detailed discussion of licensing issues related to Linked Open Data is provided by [13, 14].

[11] See also http://creativecommons.org/, accessed May 21, 2014

[12] See also http://opendatacommons.org/, accessed May 21, 2014

[13] In 2010 Scott Brinkner addressed the issue of Linked Data business models on his private blog chiefmartec.com. In his post he lists a handful of revenue models and discusses their relevance for various stakeholders. Brinkner's view is strongly marketing-oriented laying an emphasis on indirect revenue streams as a result of new marketing practices on top of Linked Data. Brinkner approaches the problem from a purely heuristic perspective. His classification lacks an empirical backing. Nevertheless it has been widely cited, i.e. by [4, 9, 16] and discussed in the Linked Data community.

compensation takes place, where assets are being used as mechanism or vehicle to generate revenue at a later stage in the consumption process or by leveraging the value of another asset.

By mapping revenue models to data assets we can modify the Linked Data Business Cube as illustrated in Figure 3. The cube's shape indicates that the higher the value proposition of an asset – in terms of added value – the higher the willingness to pay and derive direct revenue from it. Assets that are unique and difficult to substitute, i.e. in terms of intellectual effort and investments necessary to provide them, carry the highest potential for direct revenues. This applies to assets like content, service and software. Assets that are easily substitutable or non-exclusive generate little incentives for direct revenues but can be used to trigger indirect revenues. This basically applies to instance data and metadata.

Ontologies seem to function as a "mediating layer" between "low-proposition assets" and "high-proposition assets". This means that ontologies can be capitalized in a variety of ways, depending on the business strategy of the asset provider.

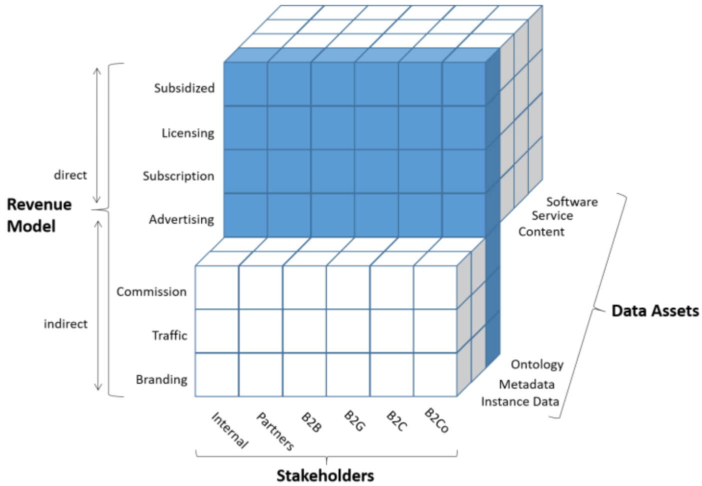

Figure 3: Revenue Models for Linked Data

It is important to note that the applicability of revenue models on data assets is highly influenced by the asset's specificities and requires various degrees of organizational effort and governance to work properly. Furthermore, revenue models often occur in combination as they are functionally complementary and can be used to address and engage various stakeholders in the value creation process.

3.3. Mapping Stakeholders to Revenue Models and Data Assets

By mapping stakeholders to revenue models and data assets we can finally model prototypical interactions between the three dimensions of the Linked Data Business Cube as illustrated in Figure 4.

In data ecosystems the consistent and friction free exchange of information between mutually dependent stakeholders is crucial. Hence, sharing of and granting access to data assets is a common practice, be it within or across organizational boundaries. Thus, we distinguish between the following prototypical exchange scenarios: internal use, strategic partnership, business to business (B2B), business to government (B2G), business to consumer (B2C) and business to community (B2Co).

Internal Use: In corporate environments it is most obvious that data assets are shared internally among business units. The more information is available and the higher the degree of interlinking, the higher the added value potential of this information for applications, products and services [6, 12]. In most cases the internal use of data assets does not generate revenue. Nevertheless, in some cases it might be necessary to set up internal licensing agreements or a subsidization policy if data assets are being shared between profit centers of the same enterprise or corporation.

Strategic Partners: By sharing resources, strategic partners can theoretically apply all revenue models to capitalize their data assets. They can use each other's data to improve branding and traffic along their online channels. In a more advanced manner commissioning can be used to leverage each other's revenues. Resources with higher value propositions – such as ontologies, content, services or software – can be applied to generate direct revenues. I.e. partners can combine their assets to leverage advertising revenues within their ontologies, content or services. Partners can bundle products based on a shared subscription or licensing model, which is especially relevant for services or software. And partners can contribute unique products to the public domain or specific stakeholders by subsidizing them.

B2B (Business to Business): Similar to the partnership scenario the B2B scenario allows a capitalization of data assets along all types of revenue models. But there exists a significant difference between these two scenarios: while in the partnership scenario the focus of cooperation will most likely be on non-monetary forms of cooperation, in a B2B scenario partners will be eager to generate direct revenues from their assets. Hence revenue models like subscription and licensing will be more relevant under such circumstances, whereas subsidies as a financing model occurs to be irrelevant (at least for the time the asset itself can claim exclusivity).

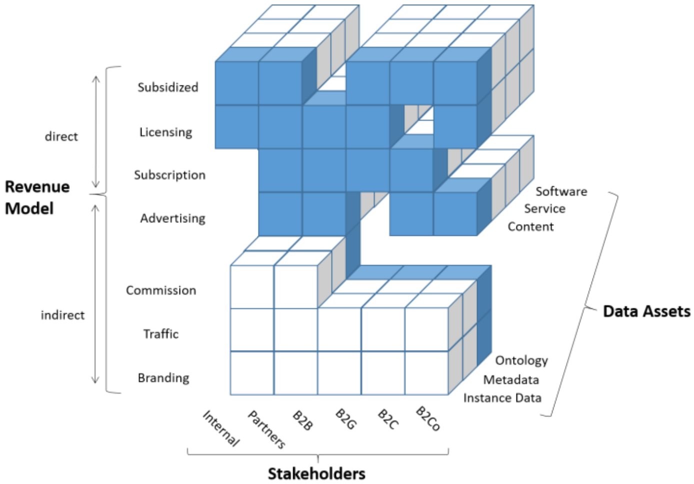

Figure 4: Mapping Stakeholders to Revenue Models

B2G (Business to Government): The specific mandate of governmental bodies to use standards and to participate in open data initiatives make them a crucial player in data ecosystems as every new dataset published by governmental bodies has the potential to create new business opportunities.[14] Although certain premises of the B2B scenario can be applied to the B2G scenario, differences exist with respect to authority-based revenue models like commissioning and advertising. These revenue models can cause conflicts with respect to credibility and integrity of provided data assets, in case third party content (like ads or proprietary data) is being added to a government's original dataset – even if marked as such. Beside that all other revenue models can be applied to generate direct and indirect revenue from governmental datasets.

B2C (Business to Consumer): Under B2C circumstances a variety of revenue models can be applied. Customers could use data assets to improve branding and traffic of their own sites. Herein companies could place advertising information within their ontologies, content or services or give these resources away for free by subsidizing certain assets as part of a freemium model. Additionally customers can subscribe to data assets, which might be a reasonable revenue model for unique assets that are difficult to substitute. Licensing of assets that goes beyond obligatory terms of trade and that include direct payments between two parties, is of minor importance in a B2C environment as end consumers usually do not re-use assets for further commercial purposes.

[14] For a detailed analysis of Linked Open Government Data see [1].

B2Co (Business to Community): The last view addresses the scenario of open innovation and collaborative value creation. Communities are often ignored as stakeholders when business models are concerned. Still, phenomena like crowdsourcing or co-creation are built on shared resources and mutually accepted codes of conduct. Hence, an asset provider can apply a variety of revenue models to data assets when addressing communities. By sharing each other's data they can improve branding and traffic. They can apply advertising, licensing and subsidization techniques to generate revenues for their activities. But it is less likely to see subscription of commission models for community-derived assets as these revenue models usually require a high amount of administrative effort.

4. Conclusion

The Linked Data Business Cube is a heuristic method to model and investigate business models for data assets. Summing up, data assets generate business opportunities, but the commercialization is highly context specific. Data assets can have various specificities, depending on the licensing terms under which they are being provided. These specificities determine to a high degree the applicable revenue models and stakeholders involved in the value creation process. Having a good understanding of the interactions between assets specificities, revenue models and stakeholders is crucial in assigning value propositions for data assets and designing the data apparatus to commercialize them within data ecosystems.

This is sometimes difficult to achieve. Fragmented IT landscapes, division of labor among business units, institutional arrangements that foster intra-company competition and last but not least the reactance to change in established organizational structures pose various challenges to the design and adoption of new business models.

By presenting a revised version of the Linked Data Business Cube this paper tried to illustrate the spectrum of the business models for interoperable data assets. It is just a first step in understanding the economic benefits and obstacles that occur when data becomes a network good. If and how data assets can gain economic importance as a driver of service diversification and new business opportunities is open to observation and future empirical research.

References

[1] Archer, Phil; Dekkers, Max; Goedertier, Stijn; Loutas, Nikolaos (2013). Study on business models for Linked Open Government Data (BM4LOGD - SC6DI06692). Prepared for the ISA programme by PwC EU Services See also: http://ec.europa.eu/isa/documents/study-on-business-models-open-government_en.pdf, accessed May 10, 2014

[2] Berners-Lee, Tim (1998). Web Architecture from 50,000 feet. In: http://www.w3.org/DesignIssues/Architecture.html, accessed May 20. 2014

[3] Brinkner, Scott (2010). Business models for linked data and web 3.0. In: chiefmartec.com, 10.03.2010. See also: http://chiefmartec.com/2010/03/business-models-for-linked-data-and-web-30/, accessed April 10, 2014

[4] Cobden, Marcus; Black, Jennifer; Gibbins, Nicholas; Carr, Les; Shadbolt, Nigel (2011). A Research Agenda for Linked Closed Data. In: Second International Workshop on Consuming Linked Data, Bonn: Ceur Workshop Proceedings. See also: http://ceur-ws.org/Vol-782/CobdenEtAl_COLD2011.pdf, accessed April 10, 2014

[5] Committee on Commerce, Science and Transportation (2013). A Review of the Data Broker Industry: Collection, Use and Sale of Consumer Data for Marketing Purposes. Staff Report for Chairman Rockefeller, December 18, 2013. See also: https://law.ku.edu/sites/law.ku.edu/files/docs/media_law/2014/Data_Broker_Industry_Senate_Report.PDF, accessed May 5, 2014

[6] Cranford, Steve (2009). Spinning a Data Web. In: Price Waterhouse Coopers (Ed.). Technology Forecast, Spring 2009. See also: http://www.pwc.com/us/en/technology-forecast/spring2009/index.jhtml, accessed September 20, 2012

[7] Ghosh, Rishab Ayer et al. (2006). Economic impact of open source software on innovation and the competitiveness of the Information and Communication Technologies (ICT) sector in the EU. Final report prepared on November 20, 2006 (Contract ENTR/04/112.). See also http://ec.europa.eu/enterprise/sectors/ict/files/2006-11-20-flossimpact_en.pdf, accessed May 10, 2014

[8] Halford, Susan; Pope, Catherine; Weal, Mark (2012). Digital Futures? Sociological Challenges and Opportunities in the Emergent Semantic Web. In: Sociology, 47/1

[9] Kinnari, Tomi (2013). Open data business models for media industry. A Finnish case study. Master Thesis, Department of Information and Service Economy, Aalto University. See also: http://epub.lib.aalto.fi/fi/ethesis/pdf/13166/hse_ethesis_13166.pdf, accessed March 29, 2014

[10] Latif, Anif; Us Saeed, Anwar; Höfler, Patrick; Stocker, Alexander; Wagner, Claudia (2009). The Linked Data Value Chain: A Lightweight Model for Business Engineers. In: Proceedings of I-Semantics 2009, the 5th International Conference on Semantic Systems. Graz: Journal of Universal Computer Science, p. 568–577

[11] McHugh, Linda (2009). Measuring the Value of Metadata. White Paper: Baseline Consulting

[12] Mitchell, Ian; Wilson, Mark (2012). Linked Data. Connecting and exploiting big data. Fujitsu White Paper, March 2012. http://www.fujitsu.com/uk/Images/Linked-data-connecting-and-exploiting-big-data-%28v1.0%29.pdf, accessed September 12, 2012

[13] Pellegrini, Tassilo; Ermilov, Ivan (2013). Guide and Best Practices to Licensing Interlinked Data. Public Deliverable 7.4. EU-Project LOD 2. Grant Agreement No: 257943. See also http://svn.aksw.org/lod2/WP7/D7.4/public.pdf, accessed 03.01.2014

[14] Pellegrini, Tassilo (2014). Linked Data Licensing – Datenlizenzierung unter netzökonomischen Bedingungen. In: Schweighofer, Erich; Kummer, Franz; Hötzendorfer, Walter (Hg.). Transparenz. Tagungsband des 17. Internationalen Rechtsinformatik Symposium IRIS 2014. Wien: Verlag der Österreichischen Computergesellschaft, S. 159-168

[15] Rayfield, Jem (2012). Sports Refresh: Dynamic Semantic Publishing. In: http://www.bbc.co.uk/blogs/bbcinternet/2012/04/sports_dynamic_semantic.html, visited April 20, 2012

[16] Vafopoulos, Michalis N. (2011). A Framework for Linked Data Business Models. 15th Panhellenic Conference on Informatics (PCI) 2011. Available at SSRN: http://ssrn.com/abstract=1850365, accessed April 10, 2014

[17] Wood, David (Ed.) (2010). Linking Enterprise Data. New York: Springer

[18] Wood, David (Ed.) (2011). Linking Government Data. New York: Springer

[19] Chesbrough, H., 2002. The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. Industrial and Corporate Change 11, 529–555. https://doi.org/10.1093/icc/11.3.529

[20] Zott, C., Amit, R., Massa, L., 2011. The Business Model: Recent Developments and Future Research. Journal of Management 37, 1019–1042. https://doi.org/10.1177/0149206311406265

[21] Pellegrini, T., Dirschl, C., Eck, K., 2014. Linked data business cube: a systematic approach to semantic web business models. ACM Press, pp. 132–141. https://doi.org/10.1145/2676467.2676489

[22] W3C, 2018. Semantic Web Case Studies and Use Cases [WWW Document], n.d. URL https://www.w3.org/2001/sw/sweo/public/UseCases/ (accessed 7.4.18).

[23] de Grandbois, Y., 2013. The business of Service Science. Business Information Review 30, 204–209. https://doi.org/10.1177/0266382113518837

[24] Vargo, S.L., Lusch, R.F., 2014. Inversions of service-dominant logic. Marketing Theory 14, 239–248. https://doi.org/10.1177/1470593114534339

[25] Borgman, C.L., 2015. Big data, little data, no data: scholarship in the networked world. The MIT Press, Cambridge, Massachusetts.

[26] Oxford Dictionaries, 2018. data | Definition of data in English by Oxford Dictionaries [WWW Document], n.d. URL https://en.oxforddictionaries.com/definition/data (accessed 7.5.18).

[27] Lavoie, B. 2000. The OAIS reference model [WWW Document], 2015. URL https://www.oclc.org/research/publications/library/2000/lavoie-oais.html (accessed 7.5.18).

[28] Riordan, M.H., Williamson, O.E., 1985. Asset specificity and economic organization. International Journal of Industrial Organization 3, 365–378. https://doi.org/10.1016/0167-7187(85)90030-X

[29] Hess, C., Ostrom, E. (Eds.), 2007. Understanding knowledge as a commons: from theory to practice. MIT Press, Cambridge, Mass.

[30] van Schalkwyk, F., Willmers, M., McNaughton, M., 2016. Viscous Open Data: The Roles of Intermediaries in an Open Data Ecosystem. Information Technology for Development 22, 68–83. https://doi.org/10.1080/02681102.2015.1081868

[31] Demchenko, Y., de Laat, C., Membrey, P., 2014. Defining architecture components of the Big Data Ecosystem, in: 2014 International Conference on Collaboration Technologies and Systems (CTS). Presented at the 2014 International Conference on Collaboration Technologies and Systems (CTS), IEEE, Minneapolis, MN, USA, pp. 104–112. https://doi.org/10.1109/CTS.2014.6867550

[32] Ann, C., 2013. Personal Data Ecosystem (PDE) – A Privacy by Design Approach to an Individual's Pursuit of Radical Control. Stand Alone 89–101. https://doi.org/10.3233/978-1-61499-295-0-89

[33] apparatus | Definition of apparatus in English by Oxford Dictionaries [WWW Document], 2018. Oxford Dictionaries | English. URL https://en.oxforddictionaries.com/definition/apparatus (accessed 8.28.18).

[34] Biloshapka, V., Osiyevskyy, O., 2018. Value creation mechanisms of business models: Proposition, targeting, appropriation, and delivery. The International Journal of Entrepreneurship and Innovation 19, 166–176. https://doi.org/10.1177/1465750318782774

[35] Frow, P., McColl-Kennedy, J.R., Hilton, T., Davidson, A., Payne, A., Brozovic, D., 2014. Value propositions: A service ecosystems perspective. Marketing Theory 14, 327–351. https://doi.org/10.1177/1470593114534346

[36] Vargo, S.L., Akaka, M.A., Vaughan, C.M., 2017. Conceptualizing Value: A Service-ecosystem View. Journal of Creating Value 3, 117–124. https://doi.org/10.1177/2394964317732861