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# Business Data Sharing through Data Marketplaces: A Systematic Literature Review

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# BUSINESS DATA SHARING THROUGH DATA MARKETPLACES: A SYSTEMATIC LITERATURE REVIEW

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**Abstract** Data marketplaces are expected to play a crucial role in tomorrow's data economy but hardly achieve commercial exploitation. Currently, there is no clear understanding of the knowledge gaps in data marketplace research, especially neglected research topics that may contribute to advancing data marketplaces towards commercialization. This study provides an overview of the state of the art of data marketplace research. We employ a Systematic Literature Review (SLR) approach and structure our analysis using the Service-Technology-Organization-Finance (STOF) model. We find that the extant data marketplace literature is primarily dominated by technical research, such as discussions about *computational pricing* and *architecture*. To move past the first stage of the platform's lifecycle (i.e., platform design) to the second stage (i.e., platform adoption), we call for empirical research in non-technological areas, such as *customer expected value* and *market segmentation*.

# 1    Introduction

Data marketplaces are expected to play a crucial role in tomorrow's data economy (European Commission, 2020). Business data sharing via data marketplaces may contribute to overall economic growth by stimulating data-driven innovation, improving the competitiveness of Small and Medium-sized Enterprises (SMEs), and opening up job markets (Virkar et al., 2019). A data marketplace can be broadly defined as a multi-sided platform that matches data providers and data buyers, and that facilitates business data exchange and financial transactions. Key actors that provide data marketplace functionalities include data marketplace owners, operators, and third-party providers (TPPs) (Fruhwirth et al., 2020; Koutroumpis et al., 2020; Spiekermann, 2019). However, despite the alleged potential, data marketplaces generally remain conceptual and hardly commercially exploited. For instance, Microsoft's Azure Data Marketplace, xDayta, and Kasabi are among out-of-market data marketplaces (Spiekermann, 2019).

From an academic perspective, recent trends in the European Union policy-making agendas towards business data sharing have led to a proliferation of data marketplaces studies, resulting in a constantly expanding yet fragmented body of literature. Recent work provides understanding of the state-of-the-art of data marketplaces in practice (e.g., Fruhwirth et al., 2020) but does not provide a comprehensive overview of data marketplaces research in academia. Consequently, we have no clear understanding of the knowledge gaps in data marketplace research. Specifically, we lack understanding of whether research is lacking on topics that would advance data marketplaces towards commercialization. As it stands, it might well be that academic research is focusing on topics that do not help resolve the standstill in data marketplace commercialization. To evaluate this assertion, this paper aims to investigate the current state of the art of data marketplace research.

We will conduct a systematic literature review on existing data marketplaces research by adopting the guideline provided by Okoli (2015). To cover the broad range of issues that plays a role in technology commercialization, we use the business model construct as a synthetic device (cf., Solaimani et al., 2015). In this way, our study will be, to our knowledge, the first to provide a comprehensive overview of data marketplace research, which will be beneficial in steering future research towards the commercialization of such marketplaces. In this paper, we consider all data

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marketplaces archetypes revealed by Fruhwirth et al. (2020): centralized, decentralized, and personal data trading. In *centralized data trading*, data marketplaces mediate data exchange from diverse domains and origins, incorporating different data types and pricing mechanisms. Advanced data marketplaces in this archetype employ smart contracts to execute transactions. *Decentralized data trading,* on the other hand, relies on a decentralized architecture to operate data marketplaces. Finally, *personal data trading* refers to a Customer-to-Business (C2B) relationship where individuals can sell their personal information to corporations.

## 2    Research Approach

This research employs a Systematic Literature Review (SLR) approach (Okoli, 2015). Our primary database is Scopus, which comprises a comprehensive database of many scientific research papers, including the area we are examining in this study. We selected articles based on three criteria: articles should be (1) written in English; (2) published in a peer-reviewed journal or conference proceedings; and (3) focused on data marketplaces. We use the search terms of *("data marketplace*") OR ("data market*").* The literature search was conducted on 6 July 2020 and resulted in 496 articles. We complemented these articles with nine additional papers that we consider key literature. The articles did not appear in the initial search because, for instance, they do not use the *data marketplace* term explicitly, neither in the title nor abstract. We extracted the articles' meta-data and saved it in an Excel spreadsheet (available here: https://doi.org/10.4121/14673813.v1).

Next, we analyzed the quality of the identified articles by employing a two-step screening approach. First, we looked into the title and abstract of the selected papers to assess their relevance. We discussed our assessment internally to reach a consensus, resulting in an exclusion of 225 papers. Second, we combined quantitative traditional metrics (e.g., citation numbers) and next-generation metrics (e.g., social media, usage, captures, and mentions) to further select the reviewed papers. The next-generation metrics provided by the Scopus database are known as the PlumX Metrics (Champieux, 2015). To do so, we first calculated the average number of citations from the existing 280 articles as a threshold, in which we include any articles above this average citation number (7.3). If the number of citations of an article was below the threshold, we checked whether the article was published in a high-quality journal or conference proceedings (i.e., ranked above the

50th percentile in its respective domain). For articles not meeting these criteria, we used the average number of next-generation metrics from the existing 280 articles (social media = 2.1, usage = 44.8, captures = 43.2, mentions = 0.2) to check whether policymakers or practitioners have read the article. In this way, we ensure that the inclusion of our sampling papers reflects both scientific reliability and relevance. In this stage, the number of included papers was 158.

Following Solaimani et al. (2015), we used the STOF model to structure the identified articles. It is a generic framework to reconstruct the logic of a business and its ecosystems (Bouwman et al., 2008). Thus, the STOF model enables a high-level representation of the service domain (S), technology domain (T), organization domain (O), and finance domain (F). The STOF model is suitable for our purpose since it is explicitly designed for ICT-enabled services like data marketplaces. Unlike frameworks such as business model canvas, the STOF model explicitly captures the role of technology in commercialization. Moreover, the STOF model helps understand the dynamics involved in developing successful business models, i.e., market adoption and sustainable profitability of the designed services. Due to the lack of commercialized data marketplaces, it is crucial to understand what we (do not) know about the breadth of the business models of data marketplaces, ranging from their value to how they deliver and capture value. Hence, the STOF model is highly appropriate to structure our discussion.

We then read the full text of the 158 remaining articles and classified each article into **a STOF model domain**. Furthermore, each article was further classified into **a category.** In classifying an article, we identified its main objective while paying attention to the primary unit of analysis. For example, Munoz-Arcentales et al. (2019) propose an architecture for providing data usage and access control. Since the discussion emphasizes technology needs, we classified this paper into the *architecture* category in the STOF *technology* domain. Although some articles can have multiple overlapping topics, we still attempted to assign each article into a single category. We justified this by analyzing the central theme of the discussion. Various articles were independently categorized by multiple authors to assess inter-rater reliability (see the supplementary material). In general, there was a high level of agreement between the authors. We also further excluded some irrelevant articles, including those that did not discuss data marketplaces. **Our final sample consisted of 137 articles.**

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## 3       Results: STOF Model Categorization

This section describes the results of our STOF model categorization. In total, we identified seventeen categories. Figure 1 provides the categorization of the articles. Given the page limitation, we only provide the topic examples for each category. For the whole topic list, please refer to the supplementary material.
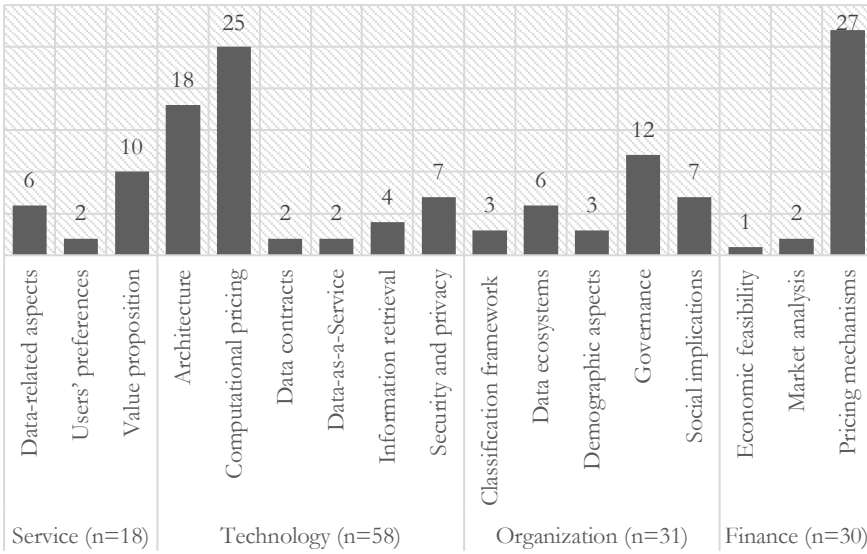
**Figure 1 The selected articles categorized using the STOF model (n=137)**

We identify three categories within the STOF **service domain.** The first one, the most dominant category, is the *value proposition*. The studies in this category are generally concerned with means to identify value for end-users of data marketplaces. For example, Perera et al. (2017) and Anderson et al. (2014) explore the value of trading IoT and healthcare data, respectively. An additional example is the value exploration of data marketplaces that trade anonymous personal data (Robinson, 2017). Another category that has received considerable attention from scholars concerns the *data-related aspects*. This category explores data properties as a unit of analysis, such as data characteristics as economic goods (Demchenko et al., 2018) and approaches to identify data quality problems (Zhang et al., 2019). Meanwhile, literature on the *users' preferences* discusses data providers' willingness to share data

considering aspects such as anonymity (Schomakers et al., 2020) and data ownership (Kamleitner & Mitchell, 2018).

Most publications fall within the STOF **technology domain**, which can be divided into six categories. In our sample, the most discussed category is the *computational pricing,* which focuses on technical discussions for data pricing. Publications in this category propose, for instance, online query-based mechanisms (Zheng et al., 2020), an algorithmic solution for data pricing and revenue distribution (Agarwal et al., 2019), a bi-level mathematical programming model that considers data quality (Yu & Zhang, 2017). Following this, many scholars discuss topics related to *architecture*, generally referring to the various technical components of data marketplaces. Examples of architecture in data marketplaces include blockchain-based system architectures (e.g., Jeong et al., 2020; López & Farooq, 2020), an architecture for data access and control (Munoz-Arcentales et al., 2019), and a reference architecture (Roman & Stefano, 2016). The *security and privacy* category has also gained much attention in the literature. The topics covered in this category are related to privacy-preserving technology (e.g., Niu et al., 2019; Zhao et al., 2019), property right enforcements (Sørlie & Altmann, 2019), and secure information models (Shaabany et al., 2016). *Information retrieval* topics such as schema (Hatanaka & Abe, 2015) and ontologies (Morrison et al., 2011) are also discussed in the literature. Another category examines the model for *data contracts* to explicitly specify data usage (Truong et al., 2012). Finally, the *data-as-service* category explores the structured model for services offered in the Application Programming Interface (API), e.g., Vu et al. (2012).

We identify six categories in the STOF **organization domain**. The most-discussed category is *governance*, which broadly refers to governing processes by certain actors (e.g., platform owners) via several mechanisms, such as norms or power (Bevir, 2012). Examples of governance topics include discussion about policies and strategies in data marketplaces (Tupasela et al., 2020), construction of a data property protection system (Yu & Zhao, 2019), governance mechanisms in the platform design process (Otto & Jarke, 2019), self-regulation for fairness and transparency for data sharing (Richter & Slowinski, 2019). Moreover, the *social implications* category explores topics such as ethical concerns (e.g., Ahmed & Shabani, 2019; Ishmaev, 2020), implications of data trading for social, political, economic, and cultural context (Virkar et al., 2019), and challenges faced by private data marketplaces

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(Spiekermann et al., 2015). The next category is *data ecosystems,* which covers the topics of reviewing data ecosystems (Oliveira et al., 2019; W. Thomas & Leiponen, 2016) or exploring market mechanisms for data (Koutroumpis et al., 2020). The category of *classifying data marketplaces* by developing business model taxonomies (e.g., Fruhwirth et al., 2020; Stahl et al., 2016) is also examined. Finally, the selected research discusses topics such as the composition of the actors' population (Macdonald & Frank, 2017) and the geographical distribution of victim in stolen data markets (Smirnova & Holt, 2017) is categorized in the *demographic aspects*.

Finally, we identify three categories in the STOF **finance domain**. Articles in this domain are not equally distributed across categories because most scholars are interested in the *pricing mechanism*. Unlike the computational pricing (in the STOF technology domain) that focuses on technical aspects, the pricing mechanisms here discuss mathematical or economic approaches in evaluating, valuating, or pricing data in data marketplaces. The topic examples of this category are data trading models that consider privacy valuation (Oh et al., 2020), a debt-credit mechanism for data pricing (Liu et al., 2019), auction-based query pricing (Wang et al., 2019), and pricing mechanisms that aim for revenue or profit maximization (e.g., Mao et al., 2019). Other examples explored in this category are pricing mechanisms based on the Stackelberg game approach (Shen et al., 2019) and data quality scores for data pricing (Stahl & Vossen, 2016). Other categories in the finance domain are the *market analysis* that includes topics such as estimating the economic value of stolen data market (e.g., Holt et al., 2016; Shulman, 2010), as well as the *economic feasibility* category that examines Nash equilibria in competition between actors (Guijarro et al., 2019).

## 4    Discussion and Conclusion

This paper aims to investigate the current state of the art of data marketplace research. As shown in figure 1, we reveal that that data marketplace research is still primarily dominated by technical literature. Based on this fact, the pattern of evolution of data marketplace research tends to follow the *technology push* (i.e., technological advancement drives innovation). We argue that one possible reason behind this may be the availability of funding and projects that are intensely focused on the technological development of data marketplaces (refer to the description of

EU-funded projects on data markets[1]). Based on the platform's lifecycle by Henfridsson and Bygstad (2013), many of these projects are still in the initial phase of the platform's lifecycle, i.e., the platform design process. This may explain why debate focuses on technical rather than non-technical aspects. This phenomenon indirectly contributes to the limited options for publication venues. The conferences and journals that publish on data marketplaces are primarily found in the technical venues, e.g., the IEEE Access and IEEE Internet of Things Journal.

As indicated in the introduction section, data marketplaces are hardly commercially exploited, even though concepts have existed for years. Apparently, they struggle to move from the initial stage into the second stage of the platform's lifecycle, i.e., the platform adoption. One possible explanation could be that previous studies have not dealt extensively with non-technical topics. Hence, contributions from the academic perspective towards data marketplace commercialization are still scant. For example, little attention has been paid to topics categorized in the service domain (this domain was covered least by our studied papers). Based on business model ideas, this domain is essential and should be the starting point for data marketplaces to be commercially exploited. The topics in the service domain are essential to design services that fulfill customers' needs. Although a few attempts have been made to discuss relevant topics such as *value proposition*, many other topics such as *customer expected value* and *market segmentation* have barely been discussed in the selected articles.

Considering the organizational domain, one crucial overlooked aspect in current literature is *value networks* that describe actors and their interactions. It is essential to understand the dynamic to align their vision by developing *organizational arrangements* to achieve the common goal. For the finance domain, current literature mainly emphasizes data pricing. Future data marketplace research should cover other essential topics in the finance domain, such as *investments* and *cost sources,* because they are essential to build operating models of data marketplaces. Moreover, data marketplace projects are often conducted in a consortium based on academia-practitioners collaborations (e.g., the EU-funded projects). Academic publications may also reflect the work conducted by practitioners. Hence, considering non-technical investigations may open opportunities to speed up the platform adoption

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[1]  https://ec.europa.eu/digital-single-market/en/programme-and-projects/eu-funded-projects-data, accessed on February 19, 2021

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process in practice. We also suggest looking into the STOF model (Bouwman et al., 2008) for inspiration during the topic exploration process.

Our additional impressions after reading and analyzing the articles are as follows. We only found a few studies, e.g., Schomakers et al. (2020), Spiekermann and Korunovska (2017), that conduct empirical investigations in non-technical literature. Moreover, the many technology-focused studies hardly consider the link between technology solution and problem, such as is common in Design Science Research (DSR) approaches (Hevner & Chatterjee, 2010). Stronger links between technical solutions and value-related problems would help focus data marketplaces research so that practical problems are being resolved. Besides, the literature hardly discusses solutions to some core non-technical challenges of data marketplaces, such as: defining data ownership (Koutroumpis et al., 2020), assessing data quality (Koutroumpis et al., 2020), lacking legal frameworks (Richter & Slowinski, 2019), lacking technical expertise and resources to operate the ecosystem (Oliveira et al., 2019), and unclear organizational structure (Oliveira et al., 2019).

A limitation of this study is that the topic identification process is subject to the researchers' knowledge and interpretations about the topic, i.e., different readers may have different judgments. However, independently categorizing the present papers by different authors showed overall alignment. Moreover, the study is limited by its scope and the number of publications included in the analysis due to our criteria, e.g., a single database, the timeframe selection, and a paper quality check. Nonetheless, we argue that we have reached a sufficient level of saturation, i.e., analyzing the last couple of papers did not lead to new categories being identified or major shifts in the distribution of papers among categories.

This study contributes to the literature by a) providing a comprehensive overview of current data marketplace research and b) identifying neglected research topics that may contribute to data marketplaces' growth towards commercialization. We set out potential research topics to shift data marketplaces from the first stage of the platform's lifecycle, i.e., the platform design, to the second stage, i.e., the platform adoption. Our research provides the essential basis for future research towards the commercialization of data marketplaces. Finally, we call for (empirical) research in non-technological domains to complement the current technology-focused data marketplace research.

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