Elements for the development of an open data marketplace

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Abstract: Numerous open data infrastructures are currently under development aiming to stimulate the potential advantages of the publication and use of open government data. In particular the development of open data infrastructures in the form of marketplaces, where open data providers and open data users trade and share data and data services, can stimulate the realisation of these advantages. Yet, only little research has been conducted on the development directions of open data infastructures to realise such marketplaces. This study aims to identify elements for the development of future electronic open data marketplaces. This aim is attained by using a literature review and expert discussions, which resulted in the following elements: 1) bring stakeholders together, 2) provide rich metadata, 3) enable data quality assessment, 4) ensure trust, security and critical mass, 5) have an appropriate revenue model, 6) provide use cases, training and support, 7) provide technical support: open data tools, 8) provide a full API for machine-to-machine operation and 9) target multiple nationalities. The results of this study can be used to develop and improve open data marketplaces to stimulate the realisation of open data advantages.

***Keywords**: Open data, e-government, marketplace, elements, development directions, future, infrastructure*

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1. Introduction

Various studies have shown that the publication of public data has considerable potential to provide citizens, researchers, companies and other stakeholders with many advantages. These advantages include, but are not limited to, increased transparency (Bertot, Jaeger, & Grimes, 2010; McDermott, 2010), increased democratic accountability (Janssen, 2011; Meijer, 2007), better services to citizens (Charalabidis, Ntanos, & Lampathaki, 2011), increased participation and interaction of stakeholders, empowerment of users and providers of open data (Neuroni, Riedl, & Brugger, 2013) and economic growth and more value creation (Borzacchiello & Craglia, 2012).

To stimulate these potential advantages of the publication and use of open government data, numerous open data infrastructures have been developed in the last decade. For instance, open data infrastructures have been developed by national governments (e.g., Data.gouv.fr, 2013; Data.gov.uk, 2013), local governments (e.g., Berlin_Open_Data, 2013; Open_Government_Wien, 2013), the European Commission (European_Commission, 2012) and organisations and projects

which are not country related (Junar, 2009, Author, year). These infrastructures have diverse characteristics, focus on different aspects and may complement each other (Author, year).

The literature argues that open data infrastructures which facilitate interaction between open data providers and open data users could play an important role in stimulating the realisation of the advantages of open data (e.g. Chun, Shulman, Sandoval, & Hovy, 2010; Evans & Campos, 2013; Lee & Kwak, 2012; Maier-Rabler & Huber, 2011). Interaction between open data providers and users can be stimulated by so-called *marketplaces*. Marketplaces are places where suppliers and customers can meet each other (Henderson & Quandt, 1980) to indicate their intention to buy or sell certain products which eventually match and may be settled (Schmid & Lindemann, 1998). In the case of open data, open data providers and users can use a marketplace in order to interact and collaborate by trading and sharing open data and data services including advice and assistance in an open cooperative environment. As such, a marketplace can encompass various stakeholders and provide many types of data and numerous data services.

Despite the fact that numerous open data infrastructures have been developed, only few existing open data infrastructures actively stimulate the interaction between open data providers and open data users in the form of marketplaces. In addition, only few researchers have paid attention to the potential development directions of open data in general, and open data infrastructures in particular, in the near future (for example, Lindman, Rossi, & Tuunainen, 2013, Author, year; Vickery, 2011). Furthermore, these studies are mainly focused on high-level development directions for open data marketplaces, and do not pay attention to specific elements that these marketplace could have, and which are necessary for progressing in this area. Research on what should be the specific elements of open data infastructures in the near future in order to realise open data marketplaces is lacking. The objective of this study is to contribute to filling this research gap by identifying elements for the development of future electronic open data marketplaces. The identification of elements for the development of open data infrastructures can help in making better predictions for their evolution and in taking actions which may positively or negatively influence future developments.

This paper is organised as follows. In the following section the the most important literature about electronic marketplaces and futures research is discussed and used to present the research approach. Thereafter, development directions for open data infrastructures are developed using trend analysis. Expert consultation and discussions are used to identify the elements for future open data marketplaces. We bring this paper to a close with conclusions about elements that need to receive attention for the development of future open data marketplaces.

2. Background

As the objective of this study is to identify elements for the development of future electronic open data marketplaces, in this section initially we report briefly about electronic marketplaces (section 2.1) and then on literature about futures research (section 2.2).

2.1 Electronic marketplaces

Schmid and Lindemann (1998) write that historically marketplaces have evolved as institutions which allow "customers and suppliers to meet at a certain place and a certain time in order to

announce buying or selling intentions which eventually match and may be settled" (p. 193). The evolution of information and communication technologies has led to the development of electronic marketplaces, which have enabled buying and selling at various times and spaces in the most efficient manner (Schmid & Lindemann, 1998). Electronic marketplaces are virtual, technology-enabled trading spaces (Matook & Vessey, 2008), which can also be seen as intermediaries (Matook, 2013). Electronic markets emerge in various fields nowadays, such as stock exchange (e.g. NASDAQ Stock Exchange) and goods exchange (e.g. eBay). These electronic marketplaces support the exchange of numerous types of products and services with different types of actors (Schmid & Lindemann, 1998). Electronic marketplaces do not only facilitate the exchange of goods and services, but also the exchange of information and payments among multiple buyers and sellers (Matook & Vessey, 2008). Regarding the open government data landscape, recent developments are moving towards a second generation of more advanced open data infrastructures, which provide a wider range of open data marketplace functionalities, influenced by the principles of the Web 2.0 paradigm, and oriented towards the elimination of the clear distinction between providers and consumers of such data, and the support of data 'pro-sumers' (i.e. users who both consume and produce such data) (Author, year).

2.2 Futures research

Futures research is a useful approach for the research presented in this paper, as we want to gain more insight into future developments for open data marketplaces. Futures research can be defined as "the complete range of methods that can be used to look at the future" (Bouwman & van_der_Duin, 2003, p. 9). One type of futures research that can be used to identify development directions and elements for future open data marketplace is scenario building. "Scenario are expectations regarding possible futures that provide insight into the way the future may develop based on clearly defined assumptions concerning the relationship between relevant developments" (Bouwman & van_der_Duin, 2003, p. 10). Using a slightly different focus, scenarios can also be defined as narrative descriptions of expected interactions between users and proposed systems (Potts, 1995).

Scenario building can be used to stimulate perspectives and images on the future to create better predictions for evolution (Bicking, Janssen, & Wimmer, 2006). Scenarios can be used to enforce interdisciplinary learning (Weidenhaupt, Pohl, Jarke, & Haumer, 1998), since they capture possible future worlds and provide a diverse overview of the use and acceptance of innovative products and services (Bouwman & van_der_Duin, 2003). Scenarios can also be used to learn more about the structure and dynamics of a problem domain (Carroll, 2000). An important assumption of using scenarios is that it is impossible to make straightforward predictions (Bicking et al., 2006; Bouwman & van_der_Duin, 2003). For this reason, scenarios reveal alternative futures (Bouwman & van_der_Duin, 2003). One must be aware that scenarios are biased and reflect potential futures based on the past and current knowledge of actual developments. This implicit bias can never be turned off fully (Bicking et al., 2006), but can be reduced through cooperation with a diverse group of experts.

Bicking et al. (2006) suggest three steps to develop future scenarios. In the first step of their methodology, trend analysis is conducted, which includes 1) identifying the main developments, 2) classifying the developments, 3) organizing developments, 4) deriving concerted scenarios and 5) developing scenario stories. The second step consists of organizing workshops in different

countries to take into account expertise, political visions and circumstances from different national contexts and the third step concerns the organization of a validation workshop to validate the scenarios and group them into clusters of developments, and visionary sketches (Bicking et al., 2006). In addition, Van der Heijden (1996) identified a number of criteria for developing scenarios. Scenarios need to be plausible in the sense that they are not science fiction, yet, they need to provide a new perspective. They need to provide a bridge between what we already know and alternative views. Moreover, they need to be consistent in the sense that they do not describe incompatible trends, complete in the sense that they show variation, and the underlying assumptions need to be valid (Bouwman & van_der_Duin, 2003; Van der Heijden, 1996). In the following section we elaborate on how we apply the scenario building methodology as a type of futures research to this research.

3. Research approach

In this research we focus on the first step recommended by Bicking et al. (2006), and we focus on development directions and elements for open data marketplaces rather than future scenarios. This first step can be divided in three sub steps that are applied to our research. The first step of our research methodology consisted of identifying and classifying the developments influencing open data marketplaces. This was done by performing a review of the literature in the field of open data. The literature was found in databases such as Science Direct, Scopus, ACM Digital Library, IEEE Xplore and Google Scholar. We sought for journal and conference articles, books, governmental and non-governmental reports and other information in various databases. Eventually 22 papers were used to provide an overview of the main developments in the field of open data infrastructures.

In the second step of the research methodology, the general developments which may influence the development of open data marketplaces were organized by discussing them with seventeen experts from various fields, including the field of open government and e-democracy, public administration and engineering. The experts were mainly researchers in the field of open data. The experts came from seven countries, namely England, Scotland, Germany, The Netherlands, Austria, Greece and Uganda. Experts from various countries were consulted because we wanted to take into account open data marketplace developments in various national contexts. As we were not able to conduct multiple workshops in various countries, we only conducted one workshop in …, and in addition we consulted experts in various countries via e-mail. The workshop in … was conducted … [this contains information that could lead to the identification of the authors, this information will be added later].

Based on the identified development directions for open data infrastructures and the expert discussions in which the developments were classified, the third step of the research method was conducted. The third step of the research method concerned the identification of elements for the development of future open data marketplaces. Nine elements were identified in total.

4. Identifying elements for open data marketplaces

In this section the elements for open data marketplaces are identified using the three steps of trend analysis (Bicking et al., 2006), as explained in the previous section.

Step 1 - Identifying and classifying the developments influencing open data marketplaces

A literature review was used to identify developments in the field of open data infrastructures which may influence the development of open data marketplaces. We focused specifically on open data infrastructures and not on open data in general. Subsequently, these developments were mapped in a two-by-two matrix as shown in Table 1. Bicking et al. (2006) write that "developments having a high uncertainty and high impact result in contradictory and alternative futures and thus feed into different scenarios", while "developments having a high impact and low uncertainty result in one type of future" and "developments having a low impact (independently of the level of uncertainty) do not influence the future" (p. 399). As a consequence, we use the developments which have a high impact and a high uncertainty to identify a diversity of development directions (see the grey cell in Table 1). Developments having a high impact and low uncertainty are not used in the rest of the analysis, because these developments have a high chance of being realised and there are less measures required for realising these developments than for realising those which have a high impact but also high uncertainty.

The classification into the four cells of Table 1 was done by one of the authors of this paper and reviewed by two other authors. Developments were selected based on their relevance for the topic of this paper. The authors who analyzed the developments are all researchers working in the field of open data, and they are familiar with general developments in this area.

Table 1: Developments in the field of open data, organized according to their level of impact and level of certainty.

↑ Impact	High	• Increasing release of open government data (Whitmore, 2012) • Considerable differences in the development of open data infrastructures (Braunschweig, Eberius, Thiele, & Lehner, 2012) and policies (Schellong & Stepanets, 2011) • Variety of contexts; different types of data need a different treatment (Author, year) • Different types of data in different countries, difficult to compare (Author, year) • Uncertainty and difficulty to predict the value of open data (Jetzek, Avital, & Bjorn-Andersen, 2013) • Increasing attention of politicians (European_Commission, 2013a; Obama, 2013)	• Many actors involved, from different countries, but little collaboration, user participation and monitoring of data use (Tinholt, 2013) • Lack of infrastructures containing all kinds of services (e.g. security, authorization and payment) and applications and tools for the use of open data (e.g. curation, visualization, linking) (Author, year, Charalabidis et al., 2011) • Little information about the quality and relevance of datasets (Evans & Campos, 2013) • Mainly flat metadata; lack of contextual metadata (Author, year) • Complexities in creating value from open data (Meijer, de_Hoog, van_Twist, van_der_Steen, & Scherpenisse, 2014; Tinholt, 2013) • Data fragmentation (Bichard & Knight, 2012; Conradie & Choenni, 2012) • Lack of full API for machine-to-machine operation for open data infrastructures (Kuk & Davies, 2011) • Difficulties with interoperability and standards of data infrastructures (semantics, language) (Ojo, Janowski, & Estevez, 2009) • Data publishing in machine-readable formats (i.e. RDF) (Author, year)

	Low	• Interoperability issues of national open data catalogues (European_Commission, 2013b) • Releasing documents via Freedom of Information Requests • Offering basic functionalities for downloading and uploading data (Authors, years)	• Availability of standards, data and process models (e.g., National_Information_Standards_Organization, 2004) • Development of guiding open data policies (European_Commission, 2011; Obama, 2013)
		Low	**High**
		→ **Uncertainty**	

The developments having a high impact and high uncertainty are used in the next step in the trend analysis.

Step 2 - Organizing developments: expert discussions

In this step the developments that were identified in the previous step are organized with the aim to end up with only a limited number of principal ones, which can then be used to derive development directions. In line with the scenario building methodology, the main developments which had a high impact as well as high uncertainty were categorized in order to identify the main directions. The proposed possible developments were focused specifically on one open data infrastructure, in this way making them more clear and specific. For instance, we stated that a specific open data infrastructure should focus on a certain development. Thereafter the experts could make clear to which extent they agreed with the statement. The key developments for open data infrastructures were discussed with seventeen experts. Based on these discussions, development directions for open data marketplaces were identified. These are described in the following section.

Step 3 – Identification of elements for open data marketplaces

In this section we discuss existing, traditional open data infrastructures and the elements of future open data infrastructures in the form of a marketplace. Figure 2 shows how open data providers and open data users usually interact in traditional open data infrastructures. The data providers, who usually belong to governmental organizations, publish their data in open data infrastructures. Open data users can find data in these infrastructures. The open data providers usually just publish their data without having any contact with the data users. After the data users have found the data, they are usually not able to use the same open data infrastructure where they found the data to analyse, visualise, cleanse, curate, combine or link the data. Often they have to search somewhere else for the tools to use the data in these ways. As a consequence, only the users with the appropriate technical capabilities and knowledge, such as developers, can use the data. The use of open data by citizens or other people with less of those skills is barely stimulated in traditional open data infrastructures.

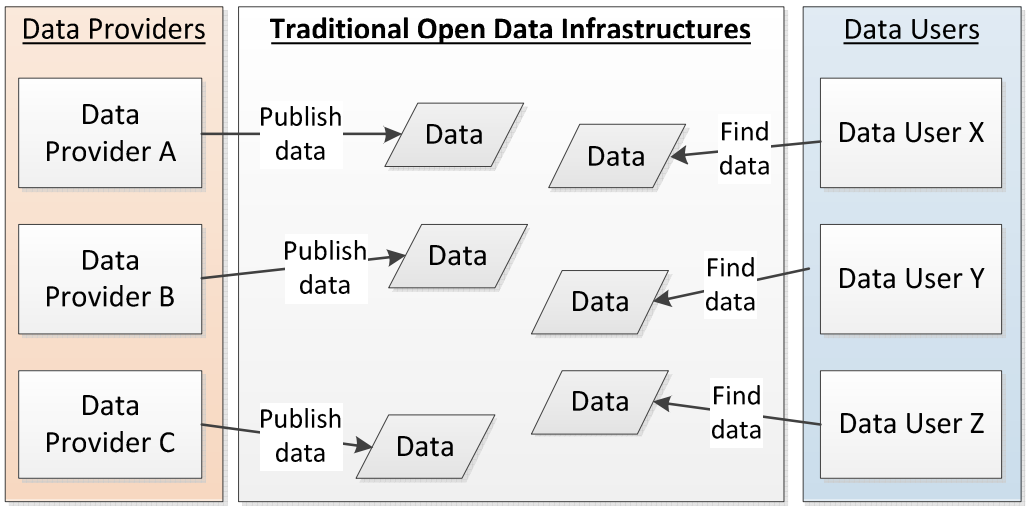

Figure 2: Traditional open data infrastructures.

Our discussions with experts revealed that future open data marketplaces should stimulate the interaction of open data providers with open data users more than traditional open data infrastructures. One of the experts stated that "other data.gov sites do not provide this facility so it could be [a] unique selling point […]". Another expert stated that the development of open data marketplaces is important for sustainability purposes. Based on the discussions with the expert, an envisioned future open data marketplace was developed (see Figure 3).

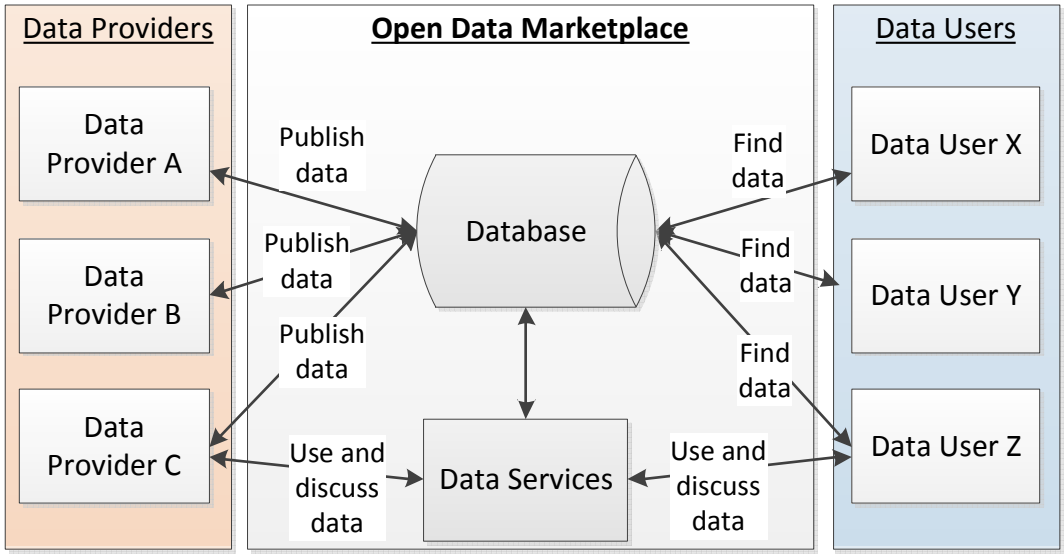

Figure 3: An envisioned future open data marketplace.

Figure 3 represents an envisioned open data marketplace which integrates the identified elements for open data marketplaces. The integration of these elements could help in creating an open data marketplace which stimulates the advantages of open data, such as participation, accountability, economic growth and transparency. Although the experts sometimes disagreed on the importance of certain developments, in general we could identify the following nine elements for the envisioned open data marketplace.

1. Bring stakeholders together (match supply and demand)

Several experts emphasized the need of an open data marketplace to provide mechanisms for interaction and collaboration, such as exchanging messages and data. The envisioned open data marketplace allows for open data providers and users to find each other and interact. The provision of data should be connected to requests for data, in this way gearing the provided data to the needs of open data users. Open data providers do not have to be merely governmental organisations, but they can also be private organisations or individuals uploading a dataset. In the envisioned open data marketplace open data providers can also offer data services to open data users for free or to earn money. The users can decide whether they want to make use of the service and whether they want to pay for it. Open data providers can be open data users as well, as they can make use of the knowledge of the crowd and use new knowledge to improve their data provision, as well as their policy making and decision making. One of the experts stated that an open data marketplace "should make users aware of what's on offer and facilitate its distribution".

Moreover, quoting from one of the experts, "marketplace provision requires a high degree of accessibility design to facilitate strong use". The reason for this is that in a marketplace for open data collaboration, different stakeholders involved in publishing and using open data are connected, such as civil servants, journalists, citizens and researchers. The marketplace should make it possible for the stakeholders to collaborate, for instance, by creating groups and working on or using datasets together or by helping each other in finding certain data. Such a marketplace could stimulate interaction and collaboration among stakeholders.

2. Provide rich metadata

With regard to the essential elements and development directions of an open data marketplace, the experts emphasized that the envisioned open data marketplaces should provide a "combination of many datasets, rich metadata, some processing facilities and – specially –associated social networking / cooperative support […]". Emphasis should be put on rich metadata by combining discovery, contextual and detailed metadata (Author, year), so that advantages such as increased interoperability, better interpretation and better organisation can be achieved (Berners-Lee, 2009; Duval, Hodgins, Sutton, & Weibel, 2002; National_Information_Standards_Organization, 2004). For instance, the CERIF metadata model could make it easier to interpret datasets by providing information about how the data were created, by who, when, and other information. This model also makes datasets more interoperable, as it allows for interconverting common metadata formats used in open data using CERIF as the superset exchange mechanism (Author, year). CERIF can be mapped to various other metadata models commonly used on open data infrastructures.

3. Enable data quality assessment

One of the experts noted that the envisioned open data marketplace should provide information about the reliability and quality of datasets, as several types of open data users need this information to assess whether a particular dataset is appropriate for their purpose. Based on a quality rating a user can decide whether he/she will use the dataset in a certain way. Thus, a rating system could make it easier to use data and generate value from it. Moreover, open data providers can use the wisdom of the crowd to learn from their feedback and to improve their

datasets and policies. Based on the rating, they could perform further research and improve datasets. The literature on Information Quality (IQ) can be used to select the appropriate quality aspects that need to be rated (e.g., Batini, Cappiello, Francalanci, & Maurino, 2009; Bharosa, 2011).

4. Ensure trust, security and critical mass

To create a position of trust in the open data marketplace, a critical mass of users is needed. For instance, many users are needed to assess the quality of the data to make the quality rating system useful. If only few people rate the quality of datasets, the reliability of this rating is low, while rating from many users could reinforce trust. Moreover, a critical mass of users is needed with regard to bringing together suppliers and users of datasets. If there are not enough stakeholders demanding data, the suppliers would not use the marketplace and trust would be low. At the same time, if many people would demand datasets, but there would be only few suppliers, trust in the marketplace would also be low. Trust should also be increased by clearly showing where certain data are coming from and how they were created. Related to trust, open data marketplaces need to ensure security. For instance, security can be created by using authorisation systems for users, by using secure payment systems to pay for open data services and by clearly explaining to the users which licenses and conditions apply to the use of specific datasets.

5. Have an appropriate revenue model

Various revenue models can be used for open data marketplaces (Ferro & Osella, 2013). One possible model is that open data marketplaces may be funded by one or more governments. They can also be funded by private organisations or users of the marketplace. As an example, entrepreneurs can create applications based on open data and earn money be exchanging this product or service for money (Ferro & Osella, 2013). The same can be done with other open data services, such as selling services like aggregating, comparing, analysing and visualising data. The revenue model needs to take into account the ways that the users of the marketplace currently earn money. For example, if data providing organizations currently receive money for the data that they provide, the marketplace should allow for making money as well.

6. Provide use cases, training and support

The open data marketplace can stimulate the advantages of open data by developing exemplar cases of using the infrastructure and providing training and support for less experienced open data providers and users. This could also stimulate the interaction between various stakeholders involved in the publication and use of open data. Use cases can provide an example of how open data infrastructures can be used, in this way also providing help, training and support.

7. Provide technical support: Open data processing tools

Future open data marketplaces can provide services which help with analysing, visualising, cleansing, curating, combining or linking the data on the marketplace itself, so that the users do not have to search for tools for performing the above types of data processing from other sources. This characteristic of the marketplace enables and assists open data users with less technical

knowledge and skills to use open data as well. Thus, the data cannot only be found in the open data marketplace, but they can also be used and discussed there. Additionally, data can be visualised, which can make it easier to understand and interpret the data. Thus, this type of technical support could make the use of open data easier and more effective and useful. The use of open data tools is facilitated greatly by richer metadata to ensure the appropriate context contains both the data and the tools.

8. Provide a full API for machine-to-machine operation

The envisioned open data marketplace should provide a full Application Programming Interface (API) for machine-to-machine operation. Such an API can be used, for example, to enable automated search to find datasets or to make the publication process easier. Furthermore, API's allow for the development of value added services. In this way the API provides technical support for the better and more effective use of open data infrastructures. Naturally rich metadata enables such an API.

9. Target multiple nationalities

Open data infrastructures make it possible to collaborate on an international level. The use of thesauri, lexicons and automated translations should stimulate international collaboration in the use and exploitation of open data. Especially the comparison of heterogeneous data from different countries poses a risk, as there may be differences between these data which complicates their interpretation, but these comparisons could create much value. Once again rich metadata (including multilingual ontologies) is the underpinning.

5. Conclusions

The objective of this study was to identify elements for the development of future open data marketplaces. Steps from futures research were used to identify the elements. The identification of those elements can help in making better predictions for evolution towards this new paradigm of an open data infrastructure. In the first step of our methodology we made a literature review to identify those developments related to open data infrastructures which have a high impact and a high uncertainty. Subsequently, the developments were discussed with seventeen experts, so that we could assess and organize them. This step resulted in an overview of nine elements for the development of open data marketplaces, namely 1) bring stakeholders together (matching supply and demand), 2) provide rich metadata, 3) enable data quality assessment, 4) ensure trust, security and critical mass, 5) have an appropriate revenue model, 6) provice use cases, training and support, 7) provide technical support: open data processing tools, 8) provide a full API for machine-to-machine operation and 9) target multiple nationalities.

For this research experts in several countries were consulted, but most of them were from Europe. It would be interesting to examine whether these development directions are also valid outside Europe, and in agreement with the perceptions of the main stakeholders there. Moreover, the implementation of the development directions should be tested and monitored. Future research could concentrate on testing whether the development directions can be applied.

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