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# A classification framework for data marketplaces

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# A Classification Framework for Data Marketplaces


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## Abstract

Trading data as a commodity has become increasingly popular in recent years, and data marketplaces have emerged as a new business model where data from a variety of sources can be collected, processed, enriched, bought, and sold. They are effectively changing the way data is distributed and managed on the Internet. To get a better understanding of the emergence of data marketplaces, we have conducted several surveys in recent years in order to systematically gather and evaluate their characteristics. This paper takes a broader perspective and relates data marketplaces to the neoclassical notions of market and marketplace from economics. We provide a typology of electronic marketplaces, and discuss their approaches to a distribution of data. Lastly, we provide a distinct definition of data marketplaces in order to integrate these new businesses into existing research frameworks, leading to a classification framework that can help structuring this emerging field.

## Keywords

Data as a Service, Data Marketplace, Data Marketplace Survey, Data Marketplace Development, Classification

# 1 Introduction

The Internet allows for almost ubiquitous transactions, access to and exchange of information, and instant communication. Due to the unprecedented supply of data, the Internet has not only altered how people relate to information but has also allowed for an increasing proliferation of data through a facilitation of exchange. Besides the emergence of new markets and new products, it has lead to a major transformation of existing markets. Prior to the Web 2.0 development, a data market could be characterized as a private large-scale information exchange between major companies [Miller, 2012]. In light of the newly available abundance of data sources as well as the variety of storage and processing options, however, it is not surprising that data is increasingly both supplied and demanded publicly on the Internet. Besides free databases such as Wikipedia or Wolfram Alpha, (commercial/for-profit) marketplaces for data have emerged; examples of such marketplaces include `knoema.com`, Microsoft Azure, Freebase, or `datamarket.com` (recently acquired by Qlik). In this development, data services have been standardized to an extent that they can be offered as a commodity.

We have conducted several surveys in the area of data marketplaces in recent years, in order to gain an understanding of their offerings, their functionality, their business models, and their dynamics [Schomm et al., 2013, Stahl et al., 2014]. However, a clear definition of a data marketplace is still missing, as is an understanding of this development from an economical perspective. This paper aims at closing this gap, by providing such a definition and integrating it with existing frameworks of electronic markets and marketplaces.

Every new market is characterized by numerous participants entering and exiting while developing resolutions and strategies for the number of challenges that every new market or product entails. The high number of providers eventually leaving the field in the past few years illustrates that data markets appear to be particularly challenging. Interviews with founders of the visualization tool Swivel closed in 2010 yielded that, aside from the “usual” management issues, the main obstacle to their business was that only users in the “single-digit” area were willing to pay for the services [Kosara, ]. The Internet, the very medium that lead to the transformation of data markets in the first place, is also one of the major threats to their economy: users are accustomed to have constant access to information for free which results in a rather low willingness to pay for data. Companies with a focus on data provision need to find suitable strategies to make revenue from their offering.

Considering how much those strategies are an alluring field of research for business administration and information systems and how much the data market is discussed in the blogosphere, the lack of formal research on the market is surprising. On the Internet, informal evaluations by journalists and platform operators can easily be found. Informative examples are by [Dumbill, , Gislason, , Miller, 2012, Miller, , O’Grady, ]. It should be noted that several of the offerings discussed there are already out of business.

The only evaluations of the market with formalized standards are by SCHOMM, STAHL, and VOSSEN which surveyed the data market on a selected sample size in 2012 and 2013. They characterize the market through an increasing “proliferation of data as a commodity” and identify several trends, most notably a trend towards high quality data [Schomm et al., 2013, Stahl et al., 2014].

Paradoxically, the Internet, the very medium that has led to the emergence electronic data markets in the first place, is also one of the major threats to their economy. Users are accustomed to have constant access to information for free which results in a rather low willingness to pay for data. Companies with a focus on data provisioning need to find suitable strategies to make revenue from their offering.

Providing a definition for data marketplaces allows us to relate this development to traditional markets and marketplaces as known from the field of economics, and to achieve clarity whenever the term is used, which is currently not the case (as the term may refer to platform providers or

vendors alike — the difference will become evident later in this paper). A clear definition also allows for further studies to clearly include and exclude providers of marketplaces, as we have done in the latest iteration of our data marketplaces study currently in preparation [Vomfell et al., 2015].

The theoretical and empirical research concerning data, data markets, and data marketplaces is filled with a number of different, partly contradictory terms: electronic markets, e-hubs, or data vendors [Luomakoski, 2012]. Most of these terms do not properly describe the underlying concepts concerned with data exchange. Furthermore, papers on data portals can be equally applicable as papers on data markets themselves, depending on the author's background and definition.

From an economics perspective, data marketplaces can be defined as electronic marketplaces where the commodity *data* is traded. Data is an information good with special properties that make its distribution quite particular. The differentiation between market and marketplace in economic theory serves as a reference/model for establishing the difference between the concepts *electronic market* and *electronic marketplace*. A discussion of the ways information technology changes or facilitates the market functions compared to traditional markets is also included in this paper, and two ambiguous concepts of electronic marketplaces are explained and discerned.

The remainder of this paper is organized as follows: After a short review of existing classification models from neo-classical economics in Section 2, our own model of categorizing electronic marketplaces is presented as a framework for provider characterization in Section 3; additionally, the obstacles to the marketability of information goods are presented: the difficulty of value attribution, information asymmetries, and the particular cost structure of information goods. How those can be overcome in the case of data and how data is distributed and allocated on electronic marketplaces is discussed in Section 4. Penultimately, a consideration of the relevance to our study is given in Section 5, where we outline our latest survey results. Section 6 concludes the paper.

## 2 Markets and Marketplaces

Neo-classical economics – the currently widely accepted economic model – consider marketplaces to be the physical or virtual implementation of markets. *Markets* are defined as the economic place where the interactions of buyers and sellers determine the price and the quantity of a good or a service [Samuelson and Nordhaus, 2010].

On this functional market, the abstract place of trade, potential and realized trading relationships determine the economic equilibrium of price and quantity of a product [Samuelson and Nordhaus, 2010]. Both the entirety or segments of the economic structure can be addressed with the term "market" [Schwickert and Pfeiffer, 2000]. It serves three main functions:

**Institution** The market as an institution is a framework of rules that governs the behavior of the participating agents. It assigns the roles of the agents (e.g., intermediary, seller, etc.) and sets expectations and protocols on their behavior. Further, participants willing to trade find a medium allowing them to satisfy their exchange goals [Schmid, 2000].

**Transaction** The market is constituted by the sum of all market-based transactions. In turn, the market defines the process of transactions [Schmid, 1999]. The transaction itself is according to [Richter and Nohr, 2002] constituted by four distinct phases: 1) the information phase where agents collect information on products and form concrete exchange intentions in the form of bids and offers; 2) the negotiation phase where negotiations on the product, the contract terms, and the price are carried out and which ends in a contract; 3) the transaction phase where the contract is fulfilled and the commodity is exchanged; and 4) the after-sales phase where customer service is crucial to individualize and enhance the customer's satisfaction and commit them. Other authors use different phases, for example [Schmid, 1999] splits the information phase into an information and

intention phase while aggregating the transaction and after-sales phase. In order to be considered part of an electronic market, at least one transaction phase needs to be performed electronically. Most researchers consider the information phase to be the minimal requirement as in this phase demand and supply are matched globally and immediately [Schmid, 1999].

**Pricing Mechanism** Markets are a mechanism through which buyers and sellers interact to set prices. To be more precise, the price is the equalizing element that coordinates the actions of buyers and sellers on a market. Furthermore, prices signal the conditions of exchange to other participants [Samuelson and Nordhaus, 2010]. The market as a pricing mechanism is closely linked to the efficient market hypothesis: once supply and demand have equalized by the optimal price that clears the market, the allocation of goods is pareto-optimal and social welfare is maximized [Mankiw and Taylor, 2012, Samuelson and Nordhaus, 2010].

Additionally, some welfare economists attribute an innovation function to markets, i.e., the capacity to innovate and evolve products, services, and structures [Kerber, 2007].

Opposed to the abstract economic construct of a market, *marketplaces* are the geographical, concrete place of trade [Nieschlag et al., 1994]. It is the explicit place of encounter in terms of time and location where market participants prepare and execute transactions [Grieger, 2003]. A marketplace is the infrastructure where market activities take place. It can be considered the real interpreter of supply and demand that coordinates output [Schwickert and Pfeiffer, 2000]. The constituting difference between market and marketplace is the level of abstraction: marketplaces are the physical or virtual infrastructure that allows the abstract market to form.

# 3 Information Technology, Data, Marketplaces

The rapid development of modern information and communication technology (ICT) also constitutes the development of a new medium through which market relations, transactions, and information can be processed and realized [Schmid, 1999]. This new medium enabled by ICT is an electronic infrastructure which companies, individuals, and governments can use to create virtual marketplaces where they previously did not exist [Coppel, 2000]. These marketplaces have mostly been characterized as B2B, B2C, C2C, G2C (i.e., business-to-business or to customer or government) up to now. Indeed, ICT has led to the creation of virtual trading areas where products, services, and information are sold [Richter and Nohr, 2002]. However, due to the on-demand availability of large computing power and high-capacity storage as a service from the cloud, in combination with application service provisioning, even other categories of *goods* have emerged, most notably *data*. Data in various forms (raw, processed, etc.) can nowadays be traded just like any other form of goods, and platforms supporting this resemble traditional marketplaces. Through the dissolution of traditional barriers of market entry, product distribution, and product differentiation substitution effects and competition have increased. The ICT integration has entailed several configurations of traditional market mechanisms like more flexible price setting or faster transaction performance but its defining new quality is the mechanization of information processing, leading to a drastic increase in the information production [Schmid, 2000].

This reshaping is not without consequences to the current set of definitions. The position of electronic markets in the existing framework is not self-evident because they could either be subordinated as submarkets or could embody a new type of markets. One fundamental drawback to the clarification of this question is the fact that up to date no unitary definition of electronic markets and marketplaces has been established. A patchwork of several definitions ranging from electronic markets as *agora* [Schmid, 1999] to *information systems* [Grewal et al., 2001] hampers the research. We suggest the relationship between electronic markets and electronic marketplaces to be analogous to the (often neglected) distinction between real-world markets and marketplaces.

## 3.1 Electronic Markets

As implied above, “the electronic market as an electronic medium is based on the new digital communication and transaction infrastructure” [Schmid, 1999]. Accordingly, electronic markets are submarkets qualified by the electronic infrastructure they are founded on [Bieberbach and Hermann, 1999]. Analogously to the economic market definition, an electronic market is the abstract summary of all market-based allocation on the basis of electronic media [Schwickert and Pfeiffer, 2000].

Understood as a submarket, the three main market functions defined above – institution, transaction, and pricing mechanism – remain unchanged on electronic markets. Electronic markets deviate from the traditional realization mainly in two regards: the implementation of the institution function is more complex because the ubiquitous nature of electronic markets makes the assignment of rules and language difficult and it deviates in pricing [Schmid, 1999]. As in traditional markets, pricing is the principal signal of the value and the conditions of the offered good. The price composition with regards to transaction costs and the cost structure of virtual goods may be different. Since transaction costs are one of the main elements in pricing, the facilitation via ICT leads to a drastic drop in the costs of a good [Bakos, 1997].

Electronic markets are typically discussed in terms of their transformation power and can be considered a convergence of the market towards a perfect market [Grieger, 2003]. With regard to the higher accessibility, lower entry barriers, and their ubiquity, electronic markets carry a high advantage over traditional markets [Schmid, 1999]. Given their higher transparency, electronic markets are usually attributed an improved allocation coordination [Schmid, 1999]. Those advancements give them an advantage over traditional forms of market organization. Especially transaction cost theory asserts that by implementing electronic infrastructure the transaction costs become negligible, improving the competition and almost completing the conversion towards a perfect market [Strader and Shaw, 1997]. However, the necessary infrastructure investments oppose this at least partly.

## 3.2 Electronic Marketplaces

Following the previous distinction between markets and marketplaces, an electronic marketplace is the concrete agency or infrastructure that allows participants to meet and perform the market transactions, translated into an electronic medium. Yet, the term is often used to describe various concepts of e-commerce and market organization or as a synonym for electronic markets. [Wang and Archer, 2007] present a summary of prevalent definitions and group them concept-wise. They outline two fundamental types in the mass of definitions: electronic marketplaces as governance structures and as business models which can be characterized as follows:

The *Business Model* dimension is effectively the definition of an electronic marketplace: the concrete virtual institution and place of exchange that joins supply and demand and supports the trade between providers and customers, i.e., transferring the market function into an electronic infrastructure. Any type of business action on online platforms or any type of electronic venture falls into this dimension with no regard to whether they are based on competition or on collaboration [Wang and Archer, 2007].

Definitions covered by the *Governance Structure* dimension actually refer to electronic markets in the abstract sense. As such, those definitions do not really reference electronic marketplaces.

## 3.3 Typology of Electronic Marketplaces

Electronic marketplaces manifest in different shapes and can be categorized in various dimensions. As a result of the overlapping definitions of electronic marketplaces, the categorizations are equally confusing. Each model uses different definitions which makes a general classification of the various forms of business models difficult.

In their literature review, [Wang and Archer, 2007] find nine common categories of electronic marketplaces: number of participants; relationship dimension; participant behavior; ownership; industry scope; market mechanism; products; power asymmetries and fee structure. Some models implement all or most of these categories, e. g., [Schwickert and Pfeiffer, 2000, Alt et al., 2002, Grieger, 2003, Skjøtt-Larsen et al., 2003]. Although those models are capable of reflecting every particular manifestation of specific platforms, they do not allow for meaningful conclusions on the prevalence of categories in quantitative empirical research. For example, the application of the model by [Alt et al., 2002] in a study with 31 samples returned zero findings in six categories which illustrates that simpler models with less categories enable a more concise typology.

Other models, e. g., [Fischer and Winkler, 2002, Richter and Nohr, 2002, Ganesh et al., 2004, Ordanini, 2006], differentiate providers based on the relationship dimension into buyer-biased, seller-biased, and neutral. Those simpler models, however, often merge several dimensions, especially the ownership and the relationship dimension, without specifying that they are indeed distinct dimensions. Concerning the evaluation of data marketplaces, an examination of the prevalent forms of electronic marketplaces with regard to the relationship dimension and the market/hierarchy differentiation is most interesting.

All transactions between suppliers and buyers can be classified as either hierarchical or market-based. In the market, the quantity and price of a good are determined by market forces among competitive offerings whereas hierarchical relations are characterized by pre-determined limitations for a specific price and specific buyers or suppliers. The relative advantages of the strategies depend on the transaction costs and the structure of the good [Malone et al., 1987].

As such a model has not yet been developed, we present a new model incorporating the market/hierarchy divide as well as the correlations between the nine categories identified by [Wang and Archer, 2007]. The high correlations between number of participants, relationship dimension and market mechanism and further between ownership and power asymmetries allow for an aggregation of categories [Wang and Archer, 2007].

First, providers are placed on a scale between *hierarchy* and *market*. Furthermore, marketplaces are categorised based on their *ownership*, which can be a) private, i. e., owned by a single company (seller or buyer); b) consortia-based, i. e., owned by a small number of companies (seller or buyer); and c) independent, i. e., the marketplace is run as platform without any connection to sellers or buyers. The differentiation between vendor-based and marketplace-based electronic marketplaces has some implications. While marketplaces as platforms are inherently independent, marketplaces driven by vendors (or buyers) are likely to be biased in their respective favour.

Based on these dimensions, our model differentiates six business models. On the hierarchy level, privately owned platforms typically facilitate the procurement or selling of its owner (a company) in closed systems and only allow for one-to-many or many-to-one relations. In between hierarchy and market, consortia-based platforms implement many-to-few or vice versa relations and are typically a collaboration of several companies in the same industry that seek to facilitate their sales or procurement processes. Those platforms are closed because the entry into the platform (into the consortium) is only theoretically possible.

On the market level, many-to-many platforms are usually operated by an independent intermediary and only have minimal entry restrictions. Many-to-many platforms where the operator is also

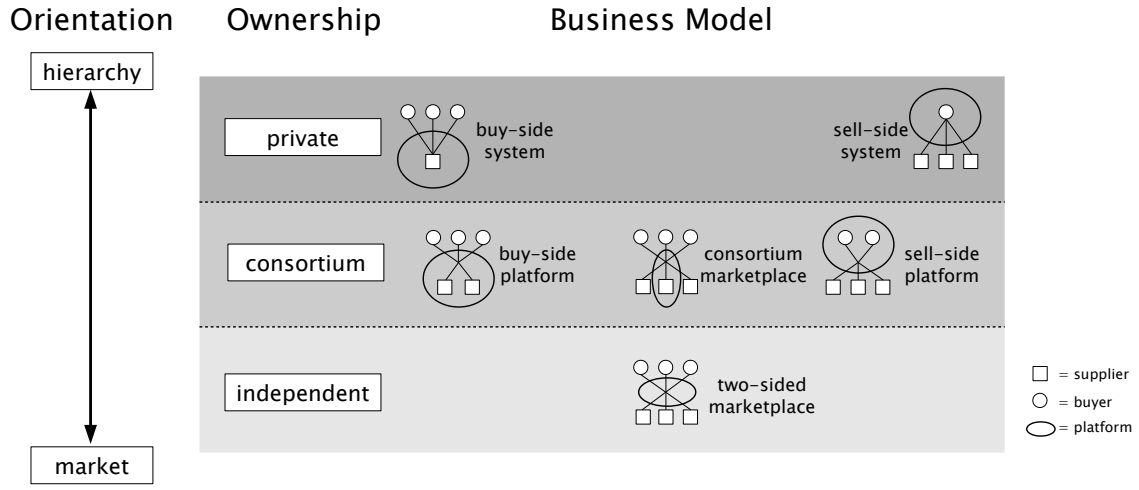


Figure 1: A model of electronic marketplaces discerning between three ownership types, inspired by [Richter and Nohr, 2002] and [Fischer and Winkler, 2002, cited from [Winkler, 2005]].

trading on its own marketplace are a special case. Those platforms are not independent and neutral because the operator runs the platform with the biased interest of facilitating his sales [Luomakoski, 2012]. The operator and the competing suppliers on the platform together form the supply side even though the association between the agents may not be formalized. For the purpose of our model, they are consortium marketplaces because they operate in a similar way to real consortia. The competition on consortium platforms is higher than on pure hierarchic systems but still lower than on marketplaces due to the entry restrictions [Samuelson and Nordhaus, 2010].

This model, depicted in Figure 1, intends to close the gap between theoretical models that are hard to apply in empirical studies and simpler models with little explanatory power and a simplified focus on the ownership. Through the aggregation of ownership, power asymmetries, and number of participants into six different business models the number of types is manageable while allowing for meaningful conclusions. Another interesting finding could unfortunately not be incorporated into the model. VAN HECK and RIBBER assert that open platforms have a long reach and tend to have a simpler functionality owed to the need for compatibility whereas closed platforms manage to accomplish a more complex functionality due to their fewer participants [Van Heck and Ribbers, 1997, cited from [Grieger, 2003]].

## 3.4 Data as an Information Good

Data[1] are pieces or units of information. Their connection becomes evident when considering that information is built upon data. Data consists of uninterpreted, structured characters without meaning on their own. When data is provided with a context and a purpose it results in information [North, 2011]. In economics, information always has a double meaning. First, it is an assumption in the economic system: as a “state of awareness” [Bates, 1990], information is considered to be perfect, complete, and instantly available to all agents free of charge. It is one of the main assumptions of economic theory and a key condition for a perfect market [Samuelson and Nordhaus, 2010]. Secondly, information is often considered a scarce private good, demanded and supplied by agents on information markets. Those two concepts only seem contradicting because

[1] While technically plural, from now on the singular form of *data* will be used similar to the way the term information is used.

they are very different sections of theory: one is an assumption of economic theory, the other a subject of theory [Bates, 1990].

First and foremost, one needs to bear in mind that it is not actually information that is traded on markets but data which is then processed to information or knowledge [Linde, 2009]. The lower level of abstraction of data allows its exchange and turns it into a tangible good, an *information good*. Information goods are defined as "everything that can be digitalized" [Shapiro and Varian, 1999], meaning that at least potentially, the underlying data can be exchanged.

### 3.4.1 The Marketability of Information Goods

Information goods have some *anomalous* features that make studying their economy difficult. It has long been debated whether they are economic goods at all because "information violates some features generally attributed to consumer goods" [Bates, 1990]. The definition of an economic good itself is subject for debate, the general concept usually describes economic goods broadly as a means to an end for human need satisfaction [Bates, 1990]. When it comes to determining whether something is an economic good, however, most authors fall back on more pragmatic requirements like transferability, utility, and value attribution or the demand for them [Bieberbach and Hermann, 1999]. In any case, information goods can be established as economic goods because all named criteria are fulfilled.

Information goods mirror the issues of non-rivalry and non-excludability in the consumption of public goods [Linde, 2009]. The provision of public goods on markets is always inefficient if functioning at all. Both issues reduce supply and demand: non-rivalrous goods are available in an almost infinite amount which reduces the incentives for private producers to supply the good. For consumers there is little incentive to pay for non-excludable goods because of free-riding opportunities. [Mankiw and Taylor, 2012]

Technically, both limitations apply which would mean a complete non-marketability of information goods. The issues can be resolved when differentiating information goods. [Bates, 1990] proposes a distinction between different information goods based on the impact their consumption has on the stock value, i. e., "[t]he expected value of information at any particular point" [Bates, 1990], is influenced by the number of exchanges of the information.

The distinction is founded on the assumption of rivaling consumption. For information with positive network effects, a high number of exchanges is at minimum neutral, often beneficial to the producer's stock value. Such information goods, for example entertainment, can be considered public goods with non-rivalrous consumption [Bates, 1990]. Certain information without network effects such as sensitive market information loses value when consumed by a large number of individuals. Therefore, producers consider the loss in stock value a marginal cost which makes the good subject to rivalry in consumption with pricing as a coordinating mechanism [Bates, 1990]. In the case of regular economic goods the individual consumption is influenced by other's consumption choices because of scarceness considerations. In the case of information goods the consumption is rivalrous because of the decreasing value of the information.

The marketability of a product is also highly dependent on its standardization. Complex products that require high amounts of individualization and consumer input are usually not traded on markets because the transaction costs (the costs of implementation to be more precise) for them are too high. When integrating the acquisition of these products into hierarchical structures the transaction costs are significantly lower [Luomakoski, 2012]. Products with a simpler structure that presuppose very little and that therefore feature lower transaction costs are more likely to be traded in market structures because of the higher price competition [Malone et al., 1987]. However, even on markets the competition remains low as long as the products differ significantly from each other in terms of form, quality, and functionality because they are not directly comparable. Producers of these

unique goods act as monopolists and set prices as such. The more homogenous products are, the more competitive is their market. Commoditization is often confounded with commodification which is the economization of social values in the Marxist context where commoditization is the process of de-individualization and standardization of products [Rushkoff, 2005, Langman, 2012]. At the end of commoditization stand commodities, products so standardized that they can be acquired unseen [Kaplan and Sawhney, 2000]. For commodities, the price is the main factor of difference between offerings which means complete competition among the producers [Langman, 2012].

In the case of data, its procurement on markets is a rather new phenomenon [Schomm et al., 2013]. The different competing providers offer still differentiable products that are approximating. It is rather unlikely that data will exhaust the entire spectrum of commoditization because the scope of commoditization is naturally limited for data because the content of the information (i. e., what buyers make of the data) cannot be standardized. Furthermore, information is valuable due to its uniqueness which also confines the demand for commoditization. That said, the persistence of the data market is dependent on a standardization of completeness and quality. Only with lower transaction costs and an improvement in data quality are buyers willing to realign their procurement in favor of markets [Rostkowski, 2014].

The level of commoditization on the data market is highly relevant. On the one hand, the progression of commoditization can potentially predict the further development of data markets. If, after the initial overture into commoditization, the data offered remains rather unique and differentiated, the market will presumably remain fragmented, differentiated by product functionalities and qualities. Producers tend to have higher profits as customers are less price sensitive. A progression in the direction of commoditization on the other hand implies less differentiated, more stable competition and a convergence towards a perfect market [Reimann et al., 2010]. Information quality and implementation standards are factors which allow for commoditization. An indicator for the state of commoditization is, in turn, the level of competition because it shows how comparable the offerings are. The specificity of the data can indicate how comparable the data products are. Also, the flexibility of producers in terms of accommodation of consumers' demands can provide clues.

Secondly, when considering data markets as an illustration and real-time use of the opportunities offered and enabled by Cloud Computing, the obstacles and concerns raised in the proliferation of data on data marketplaces should be reflected in the research concerning Cloud Computing.

Even with an increasing commoditization, the economy of data remains subject to imperfect market mechanisms because some properties of information goods and subsequently data make it prone to inefficiencies or even market failure [Linde, 2009]. All those properties are related to the pricing of information goods. Prices signal the value attributed to a certain good, moderate demand and supply, and coordinate production and consumption [Samuelson and Nordhaus, 2010]. The equilibrium price is composed by consumers' value attribution, their willingness to pay for it, and the producers' cost calculations. In the case of information goods value attribution, information asymmetries, and the cost structure hamper appropriate pricing.

### 3.4.2 Utility Value of Information Goods

Two qualities of data make assigning value to information difficult: the decreasing value of information and the fact that information is an experience good. For traditional goods, neo-classical economics predict that the price is determined on the market by the price consumers and suppliers are willing to trade the product for [Samuelson and Nordhaus, 2010]. While the willingness to pay varies for every consumer and every good depending on their preference order and consequently their utility assessment, the utility of information goods is evaluated even more heterogeneously [Shapiro and Varian, 1999]. Due to the non-consumability of information, meaning that after every transfer all previous holders still have the information, the stock value decreases with ev-

ery additional exchange [Bates, 1990]. The expected value of an information good is therefore interdependent and fluid.

The evaluation of the real value is limited by the second quality of information. As an experience good the utility of information is only rateable after its use. Different from other goods there is virtually no way of previewing or testing the information to reduce buyers' uncertainty which leads to the information paradox formulated by [Arrow, 1962]: "its value for the purchaser is not known until he has the information, but then he has in effect acquired it without cost". Additionally, the consumer cannot or only with considerable effort check the quality and trustworthiness of the information which therefore remains unknown, possibly even after the consumption [Shapiro and Varian, 1999]. In short, consumers can neither know how much the information is worth, nor can they be certain that it keeps its stock value after the acquisition.

### 3.4.3 Information Asymmetries

The problem of value attribution is closely linked to the issue of information asymmetries. With the non-transparency of value on information markets, consumers do not possess all relevant information which can in turn lead to market failure.[2] As in Akerlof's (1970) "lemon market" sellers hold asymmetrically more knowledge on the quality than buyers leading to a process of adverse selection. When consumers are unable to attribute the correct value they lower their willingness to pay to match the assumed lower value of the product. Suppliers of high quality products or services eventually leave the market due to the low prices, effectively lowering the prices further which can result in the collapse of the market [Akerlof, 1970]. Products with varying degrees of quality are especially prone to adverse selection processes as opposed to commodities [Akerlof, 1970].

The incentive for producers to strategically exploit those asymmetries is high and can only be countered by research effort on the consumer's side [Linde, 2009]. Although information cannot really be tried without consuming it (i.e., "ARROW's information paradox"), several measures can be taken to maintain market efficiency.

### 3.4.4 Cost Structure

In competitive markets the cost structure of the good determines its price because it is sold at marginal cost [Mankiw and Taylor, 2012]. The cost structure of information goods is quite particular and can best be summed up as "costly to produce, cheap to reproduce" [Shapiro and Varian, 1999]. This means that the fixed costs of production dominate the variable costs. The cost of production of the very first copy, the development and acquisition of all necessary resources is immense [Shapiro and Varian, 1999]. The costs of every additional copy, the marginal cost, tends towards zero, reflecting the easy reproducibility and distributability of information [Bates, 1990]. The domination of variable costs benefits large producers. Only those producers can effectively exploit economies of scale and use their high market share to counter the low profits per unit [Shapiro and Varian, 1999].

According to neo-classical theory, information goods would not be produced because in a competitive market producers have to lower prices in the long term until the products are sold at marginal cost [Shapiro and Varian, 1999]. With marginal costs of zero there would be little incentive for producers to operate. Obviously, as information goods are being produced, the real cost and market structures are more complex which allows for the provision. For some information goods like books the price is shaped by the value of the medium of distribution which makes the marginal costs significant and allows for normal market mechanisms. But also other goods without

[2] It should be noted that "information" in this paragraph refers to the assumption of perfect information in economic theory as explained in Section 3.4.

distribution costs like data have a marginal cost when bearing in mind the argumentation of BATES explained above that considers the loss in stock value by each exchange a marginal cost. It means that there is a limit to the number of times producers can sell an information until it becomes worthless which is why they set a certain price to retrieve the production costs [Bates, 1990]. It can be considered the price of exclusivity that consumers pay in order to reduce the availability of a particular information to the public.

## 3.5 Distribution of Data on Electronic Marketplaces

The preceding paragraphs are mainly concerned with fitting the concept of information goods into existing frameworks on economic goods and with identifying in what way their production and distribution differs from physical goods. In light of the fact that there is a market for data some of the issues outlined may seem unrealistic and purely theoretical. Those preparatory remarks are necessary though to understand the practical models that evolved around the economics of data distribution. This section deals with how consumers attribute value to data, how producers calculate their prices, and how exactly data can be priced on electronic marketplaces.

### 3.5.1 Value Attribution and Cost Calculation

In practice, the issue of interdependent expected values where the acquired information may lose stock value after the purchase is less severe than in theory. Customers are willing to pay for the data if guaranteed a limited spreading. The second issue of information asymmetries owed to only experiencable utility can be countered by a number of measures and institutions. Formal institutions like contracts contain the scope of the product or certifications guarantee a sufficient quality so that consumers trust the provider enough to pay for the offered information [Akerlof, 1970]. Informal institutions like reputation or reviews are also common means of reducing information asymmetries [Holmstrom, 1985]. Most news distributors work like this: today's news are credible because they have proven to be so in the past.

Additionally, the main factor in value attribution to data has shifted away from the content of the information. The economy of data is characterized by an oversupply of data which makes processed and structured data far more valuable than the content itself. The main challenge for consumers lies no longer in paying the appropriate amount for the data but rather in finding the right data. The function of data vendors moves to curating relevant, meaningful data and providing stable access to the cleaned and formatted data [Shapiro and Varian, 1999]. In consideration of the sheer amount of data that converges towards commoditization, producers need to differentiate their offering not only by the content of their data but by high quality dissemination, processing, enrichment, and conveyance. The real service of data providers is stabilized access to protected, formatted quality data [Ge et al., 2005].

### 3.5.2 Pricing Strategy

Although a number of considerations should be made when establishing a business model the main challenge remains pricing. Data distributors find it difficult to choose an appropriate pricing strategy because strategies for information goods embedded in tangible media cannot be transferred to digital data [Lee et al., 2006]. The most effective strategy to incorporate those issues is price discrimination. In markets with one fixed price consumers with a low price elasticity would be willing to pay more for the product than the given clearing price [Mankiw and Taylor, 2012]. In order to reach those segments and increase the profit different pricing strategies need to be applied. It should be noted that price discrimination is only possible in imperfect markets [Mankiw and Taylor,

2012]. SHAPIRO and VARIAN identify three general strategies for information goods: personalized pricing, group pricing, and versioning [Shapiro and Varian, 1999].

Personalized Pricing – sometimes called first-degree or full price discrimination – means that each individual is offered the product at a different price. It aims at maximizing profit by exploiting each customer's individual willingness to pay. The individualization requires a high level of information on the customers and can be based on location, past purchases, or demographic factors [Shapiro and Varian, 1999]. This model is practically impossible to implement for legal, technical, and economic reasons [Mankiw and Taylor, 2012].

Group pricing or third-degree price discrimination is essentially aggregated personalized pricing. The prices do not differ because of individual features but rather because of group affiliation which enables easier application [Shapiro and Varian, 1999]. Group pricing factors in distinct price elasticities in different market segments and reflects those in price disparities and different accesses [Shapiro and Varian, 1999].

Versioning means that different versions of the good can be differentiated and are sold at different prices. Possible points for differentiation are different qualities, delayed access, or technical support. When using the former strategies, producers must identify the customer segments themselves. Versioning causes customers to reveal information about their willingness to pay themselves: by choosing a certain version from a transparent product palette line they self-classify [Shapiro and Varian, 1999]. Versioning is particularly attractive when the information is easily differentiable, e. g., lower qualities can easily be produced [Lee et al., 2006]. This pricing strategy often leads to freemium-models where lower quality versions are given away for free in order to make use of lock-in effects, gain first-mover advantages, standardize, or raise brand-awareness [Lee et al., 2006].

Several business models emerge from those pricing strategies. Since a complete review on all possible and realized business models would go beyond the scope of this section, here the most common will be highlighted. Most pricing models offer either a time or an amount based plan [Balazinska et al., 2011]. Time based plans charge monthly or annually and are flat rates with full access or subscription plans with varying quantity limits [Muschalle et al., 2013]. The price discrimination in this model is basically versioning as consumers choose the subscription fitting to their needs and willingness to pay. Quantity-based models charge per unit (query or tuple) retrieved [Stahl et al., 2013]. Pure Pay-per-Use models are rather rare due to the marginal cost structure of data [Stahl et al., 2013]. Often, it is combined with a hybrid pricing model. Hybrid models can form in both categories and charge different prices at certain limits. Two-part-tariffs cover the high fixed costs with a fixed subscription combined with a use-dependent tariff [Muschalle et al., 2013]. Freemium is a similar concept where consumers can use the service free of charge for a limited amount of time, functions, or data before paying the full price [Stahl et al., 2013]. Other conceivable pricing models like auctions or individual price discrimination are quasi non-existent in reality [Stahl and Vossen, 2013]. Readers further interested in the topic are referred to [Balazinska et al., 2011, Muschalle et al., 2013, Stahl et al., 2013].

# 4 Discussion

Following the integration of electronic data marketplaces into the existing neo-classical framework for markets, several qualifiers and disqualifiers can be developed to allow for a clear identification and characterization of data marketplaces as *electronic* marketplaces. In particular, the following criteria are defined:

1. The providers' primary business model needs to be providing data.

2. The providers offer an infrastructure to upload and to browse or download to buy and sell machine-readable (e.g., RDF or XML) data of other users. The data has to be hosted by the providers and it needs to be clear whether the specific data comes from the community or the operator. This type is the electronic marketplace in the narrow sense.

3. The providers offer or sell proprietary data they host themselves. Whether they created or collected the data themselves or acquired them from other providers is not a criterion, there must, however, be transparency and traceability on the data sources. Providers of analyzed data must disclose the sources and methods of calculation.

4. The data analyzing tools must be online tools and provide storable data as their main offering. They need to use proprietary data in their calculations; services like algorithm-based analyses of customers' data or the provision of crawling code do not classify for this type.

Additionally, several disqualifiers are necessary when trying to draw conclusions on the data marketplace as a distribution medium. One criteria is the machine-readability of the data. It can be argued that only machine-readable data successfully indicates a commoditization of data on marketplaces. Otherwise, the information is simply shared because users personally deem them useful without being concerned about allocability and effective distribution. This rule applies for example to Wikipedia: its marketplace-like infrastructure allows users to freely upload or access information which is not machine-readable though. Data vendors only linking to data locations without hosting them (like `KDnuggets.com`'s list of data sets) also do not fulfill the criteria. Online tools that process the user's data or re-use them in software products without use of proprietary data like OpenCalais.com are other examples for providers not fully matching the criteria. Software as a service (SaaS) suppliers are also disqualified based on the non-storability of their data.

Some offerings that meet all requirements are generally disregarded. Government agencies or non-government organizations providing free data can only tangentially relevant as they publish data as a side effect of their general purpose and are not set on commoditizing data or even finding an appropriate business model. A large number of cities, provinces, and countries – the Global Open Data Index counts 79 countries – participate in the Open Government movement [Global Open Data Index, 2014]. This movement aims at publishing government data to allow for more transparent and citizen-orientated participation and innovation [O'Reilly, 2010]. Transnational organizations like the United Nations or the World Bank and NGOs like interaction.org promote their objectives by sharing their findings. The research on this emerging field is still developing, two notable works are by [Chun et al., 2010] and [Scholl et al., 2012]. Institutional data providers do hold special relevance with regard to the number of participants as they are one of the few types that work in a consortium-like fashion.

# 5 Relevance

The purpose of defining data marketplaces is to closely monitor relevant real implementations of the opportunities offered by a cloud infrastructure. Empirical research on this emerging field is still scarce. Three surveys on data marketplaces have been conducted between 2012 and 2014. The most current one, which is still to be published, has employed the definition system presented here [Schomm et al., 2013, Stahl et al., 2014, Vomfell et al., 2015].

The last survey has looked at 72 specific manifestation combinations among data providers to characterize data markets and to identify trends in their business models. Through empirical research using the provider definition outlined, it becomes evident that the technical side of information provisioning is far less severe than its economic side, e. g., choosing the appropriate pricing strategy. Most issues presented here from a theoretical perspective can be cleared through price differentiation or a reframing of marginal costs. Arrow's information paradox, however, remains

unresolved: the providers are very reluctant to provide access to their data and prefer to not close every potential business deal rather than give out more than the absolutely necessary information. Apparently, the commonly assumed adaption to on-demand services through facilitated access is somewhat limited by pricing concerns. As long as data pricing and data access remain constrained by such concerns, their ubiquitous implementation and distribution will stay relevant for only a small group of users.

Regarding the pricing models, flat rates enjoy a clear advancement over pay-per-use models among the surveyed data providers, often combined with freemium models. Whether this is to accommodate customers or to make use of lock-in effects should be subject to future research. Customers might be unsatisfied with granular pricing models that also restrict unfocused data exploration and prefer simpler subscriptions. Up to now, flat rates remain the most attractive pricing model for providers because of the more stable revenue generated by subscription plans without additional costs due to the marginal costs of zero. Furthermore, pay-per-use models have not (yet) reached the necessary level of sophistication necessary to prevent arbitrage exploitation. Research is currently conducted to find technical and policy amendments [Balazinska et al., 2011]. Until then, the trend towards flat rates is not surprising and most likely indicates a rather low competition among the providers so that they still have plenty of options for differentiation and that pricing competition is not very pronounced.

The study presented by [Vomfell et al., 2015] suggests two distinct scenarios with very different data access requirements. In the first scenario, the data is used as a type of manufacturing input. The customer expects complete, formatted, and reliable data. In order to process the acquired data further and use it as a basis for the production of another good, its quality must be extremely high and the access to it must be reliable. However, it does not need to be very specific and pre-analyzed. In the second scenario, the data is considered an add-on in the process of decision making and a specialized product that can be spot purchased whenever necessary or be acquired on a regular basis. Its quality is not of crucial importance compared to the importance of its specificity. In the add-on scenario, the customer does not depend on the data quality but rather expects a higher individuality of the product to match their particular wishes while data buyers in the first scenario would more likely expect a constant standard which they can depend on. Examples of the first scenario are the financial data APIs offered by xignite, Bloomberg PolarLake, or Interactive Data. The specialized inputs in the second scenario could be some enrichment services like CrowdSource, crawling services like 80legs or address sellers like xDayta [Muschalle et al., 2013].

In general, hierarchical structures are more prevalent among the providers than intermediate platforms [Vomfell et al., 2015]. This could possibly be linked to the reach/scope hypothesis touched upon in Section 3.3. The more obvious explanation is, considering that the data market is mainly a B2B market, that hierarchical relationships are easier to implement which is a favorable feature in a B2B markets. Also, private customers tend to have a lower willingness to pay for data [Potoglou et al., 2013]. The data market are observed in the provider sample seems to orientate towards a mainstream market also targeting non-technical companies and users: a high number of providers offers several, some even all, access possibilities but limits the number of data formats. The restriction to mostly standard formats like reports or CSV probably aims at reducing presupposition on data use. The high number of API accesses indicates that this development does most likely not involve a withdraw from the initial target group.

# 6 Conclusion

The development of IT have brought along innovations in both technical and commercial areas which have led to the emergence of new business models for data exchange. The question of how to make data provisioning profitable is relevant to entrepreneurs and academic research alike. Still, the successful distribution of data is impeded by complex pricing mechanisms combined

with a generally low willingness to pay on the buyers' side. Well-studied economical principles for marketplaces and information goods can, as elaborated upon in this paper, help explain and mitigate those concerns which make an integration of electronic data marketplaces into the existing economic framework necessary. The provision of such a theoretical foundation as in this paper complements previous studies by ourselves and others regarding the dynamics of data services. It allows for further research regarding the business models of data providers, pricing strategies, and the distribution of data.

As we have said earlier, the Internet and the cloud have enabled a number of service developments in recent years. Many of these resemble traditional phenomena from the real world, or try to transform such phenomena to the virtual world, often even without realizing what is going on. It then happens that only after a while the originators of such a transition discover that what they consider "new" in the virtual world has had quite a tradition in the real world already, and there are indeed underpinnings that could help to a better understanding of the virtual world.

It is our conviction that this study can help to avoid to unnecessarily explore what has been explored already in other domains. At the same time, this study ensures that a common language is at hand to understand what is happening on the data market and on data marketplaces.

Several further research topics immediately arise, in particular when considering data markets, as we have mentioned, as an illustration and real-time use of the opportunities offered by the cloud. Indeed, the obstacles and concerns raised in the proliferation of data on data marketplaces should lead to research concerning Cloud Sourcing and Computing. Pricing strategies, trading options, or auctioning systems are all to be reconsidered for data marketplaces, and to be adapted to the digital nature of the goods being at stake. Moreover, as any markets, even data markets will undergo, or already have undergone, a diversification into "black" and "white" markets, where data is traded illegally in the former. To this end it will be both interesting and relevant how to detect this, and how to protect data from being traded on a black market.

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