The Economics of Data: Quality, Value & Exchange in Web Observatories

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ABSTRACT

The aim of this paper is to present a requirement for assessing the quality of data and the development of efficient methods of valuing and exchanging data among Web Observatories. Using economic and business theory a range of concepts are explored which include a brief review of existing business structures related to the exchange of goods, data or otherwise. The paper calls for a wider discussion by the Web Observatory community to begin to define relevant criteria by which data can be assessed and improved over time. The economic incentives are addressed as part of a price by proxy framework we introduce, which is supported by the need to strive for clear pricing signals and the reduction of information asymmetries. What is presented here is a way of establishing and improving data quality with a view to valuing data exchanges that does not require the presence of money in the transaction, yet it remains tied to revenue generation models as they exist online.

Categories and Subject Descriptors
A.0 Conference proceedings, I.6.0 General

General Terms
Economics, Standardization

Keywords
Web Observatory, Valuation, Data Quality, Data exchange, Transaction Costs.

1. Introduction

We are now more than ever information consumers. The data we consume is spread across multiple, distributed, autonomous, and heterogeneous data sources [1]. Multiplicity brings about choices, variety and variable cost based on consumer demand, therefore the quality of data services such as stock quotations can vary widely. As new plans are laid out for making use of distributed information through the construction of Web Observatories, a need for considering the necessary assessment criteria for data sources arises to enable the efficient trading of data. It is important for governments, businesses and academic institutions to begin to realise the real value of their own data, and the added value that can be achieved by augmenting ones own data with that of another institution.

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As a global schema of the Web is yet to arrive, it is appropriate for Web Observatories to be consistent with Naumann's point that 'an easy plug-in and plug-out of data sources is of utmost importance in a highly dynamic environment, such as the www', [2]. Consistency in metadata is possible now using RDF vocabularies such as Dublin Core, although it does not aid directly in criteria-based assessment of data sources, although some researchers have attempted to do so as part of an assessment methodology [3].

2. Measuring quality

Data Quality (DQ) methodologies and strategies are context specific and unique to each organisation. More universal however is the notion that valuing data increases the need to improve data processes and reduce errors [4]. Common phases do exist among DQ methodologies for assessment and improvement that could be performed globally or locally by Web Observatories. To initialise a starting point for discussion we highlight here only the Total Data Quality Management (TQDM) methodology. The four phases of TQDM are definition, measurement, analysis and improvement [5], however these may or may not be common to the existing DQ processes within each of the institutions involved in the Web Observatory project.

Companies and institutions are knowledgeable about the information they keep. If the group of Web Observatories are able to agree to a set of assessment methods these can be used as part of a processing record for data transactions and queries that can be carried out in a public or private market exchange. For instance, take the private company that holds business information on users, and therefore can derive a base demographic. They may wish to extend their business intelligence with further generalised social or economic data available from a government department, a University or another Web Observatory member. The original company data enables a valuation of a user based on generated income, and it is thought that with more information - being mindful of privacy regulations - attributing additional variables to limited user demographics will increase the valuation of some users.

The Web Observatory intends to be a vibrant and global resource, worth more than the sum of its parts [6]. Following this it is both necessary and useful to consider the quality of data sources on the

Web when attempting to access and integrate them [1]. It should not be assumed that a dataset from one institution is automatically fit for purpose by reputation alone. Each dataset holds a unique set of records that can be studied from an economic perspective by enabling a standard for data quality and exchanges can be made based on the reduction of asymmetrical information given. These exchanges are valuable to the wider community and represent a potential research opportunity for the Web Science Observatory as a new Web-based pulse that can be monitored.

The concept put forward here begins a new research area for the ‘economics of data’, which at this point is ideally applied to the Web Observatory, a group of stakeholders from industry, government and academia. As a framework it would encourage data transactions to be recorded to establish their true value as a derivative of return on investment (ROI). As the concepts of value and ROI are not explicitly financial for every stakeholder, and as money will not always be used as a method of exchange in each transaction it is necessary to describe value as a ranked index (the Gaskell Data Index) which is informed directly by a robust set of mutually agreed Data Quality Criteria.

Data is now considered a national resource, an infrastructure upon which the National Information Framework [1](NIF) has already been established to bring multiple stakeholders together with a view to addressing issues of quality, standards, licensing, attribution, accessibility, linkage and security. The NIF already recognise that ‘the state, business and other bodies could run much more efficiently and effectively and civic society could function more effectively with more appropriate data and information’ (NIF document). Deriving valuation of data by proxy as set out in this paper may provide answers to the NIF cited issues, which in turn may influence the Web Observatories’ goals for data management. With this in mind we present the concept of value online, followed by a new method of valuation by proxy by which sets out the structure of an Index that is linked to data quality.

3. The Concept of Value Online

Value creation is the primary aim of any business entity, and it refers to anything that can enhance the total value created by an organization [7]; that in turn, is the sum of all values that can be appropriated by the participants in online business transactions [8]. It is the ultimate measure by which it is judged, and this raises the notion as to how one can calculate this.

According to Ho et al. [9], valuation is currently done through the process of estimating market prices [10], [11]; the process of determining the value of a business or ownership interest within it [12]; and a number of analytical procedures with the purpose of assessing the defined interest of an asset if sold on the open market; or its value to the occupying business [13].

However, this type of valuation is not as simple with Internet companies as it is with typical bricks and mortar businesses of the past. This is because they often have limited historical data, the growth path is often unclear and there is usually no competitor to benchmark them on; subsequently, there is a lot of associated risk based on optimism for future revenue growth; for example, with the dotcom boom between the years 1997 and 2000, a lot of the investment was based on companies harnessing the network effects through operating at a sustained net loss in order to build market share, thus it dramatically overvalued online business models.

Similarly, Facebook, Zynga and Groupon have all recently gone public and have been growing via buying up organisations with the aim to increase their revenue growth in the future. For example, when Facebook went public in May 2012 its IPO was valued at $38 per share, valuing the company at around $100 billion. The argument rests on several reasons such as an engaged user-base, network effects, scalability and as a platform where the content helps the company grow without the need for further investment.

However, investment is only justified if the company can monetise these social exchanges through increased revenue streams. Primarily, companies such as Facebook have largely based their future revenue on advertising [14]. This is because they are not selling a product and the users do not pay for the use of the service; thus advertising is seen as the most viable means of generating revenue - companies can augment their own data with Facebook’s data (i.e. demographic data), which can be used to enhance their return on the investment through an increased and improved understanding of their audience, which results in an increase in sales. However, this implies that these social exchanges are largely valued by their worth in terms of advertising revenue generation as opposed to being valued separately in their own right.

4. Is The Web a Content Exchange or an Advertising Platform?

The necessity to fund these services with revenue generation models remains. Key to the understanding, governance and exploitation of the web as a socio-economic resource is the ability to translate these sharing activities into the context of the wider economy.

The revenue generation model that underpins the majority of information sharing platforms is advertising. Here, the disconnection between the users understanding of the purpose of a service and the sources of revenue that make the service possible is explicit. The online ad-serving industry views a website as a marketplace, providing particular demographics of users for the

[1] http://www.nationalarchives.gov.uk/documents/nif-and-open-data.pdf

advertiser to bid on to improve brand awareness and increase sales of products and services. Each page impression is a contract between the service owner and the advertiser where the cost of advertising is based on the probability of the user generating return on investment for the advertiser. The user of the service, however, is participating in an exchange of content either with the service itself or often with other users of the service without explicitly searching for new products and services. The price incentive for the service owner is then at odds with the incentives of its user base. Parts of the web can therefore be described as content exchange platforms that provide a market for advertising, which in turn financially supports the exchange of content to be without a direct cost to the user.

5. Calculating Return on Investment from Data Exchange

For companies or web based services to grow sustainably demands the creation of positive feedback between investment in the system and realised returns to that investment. In terms of the revenue generation models that underpin many web-based services this means that investment in technologies and services has to generate ROI through increased advertising revenue. In terms of the users of the service this means investing time into data creation and sharing that generates ROI though a better sharing experience.

The difficulty is that these two different types of positive feedback are not necessarily aligned. Features of an online service like Facebook that aim to maximise advertising revenue can impact negatively on the user experience of the platform [15]. In a perfect world we would want to align data exchange and revenue generation as part of the same positive feedback mechanism, aligning investment in the service with calculable returns.

This is particularly important when considering systems like Web Observatories. Individuals participating in an online social network take on little cost or associated risk. In terms of businesses exposing their data for exchange, the potential costs and risks involved are much greater. Here, an understanding of the potential for ROI based on investment is essential to creating the positive feedback necessary for the system to grow.

What is required is a system of valuation of data exchange transactions that allows participants in the exchange to calculate ROI from the transaction. This need not necessarily be in money. ROI could be through the acquisition of more data through an exchange and thus never be linked to a monetary transaction. We argue, however, that in order to align the positive feedback in terms of the business process required to run Observatories and the motivation for purely data - data exchange, the valuation of data exchanges needs to be ultimately translatable into the same terms that ROI is calculated in the wider economy.

Key to this process is to value the data within the system. As without valuation the ROI cannot be measured. Therefore, when analysing these data exchanges it requires some sort of derivative, such as money, where value can be calculated. Problematically, the issue for valuing data at the point of exchange is that money tends not to be exchanged with the majority of data sets. Therefore, this raises the notion for developing new ways to capture and calculate this value at the point of transaction.

6. Potential and Realised Value

An important aspect of understanding valuation in economic terms is in understanding when the true value of a good or service is realised in an exchange, and when it is not. For the true value to be realised certain conditions have to be met at the point at which goods in our case data are exchanged. In the simplest case information asymmetries occur when either party does not have complete information about the nature of goods being exchanged, at the point at which they are exchanged. In the typical economic sense, this can be because the provenance or true nature of the good is not known [16].

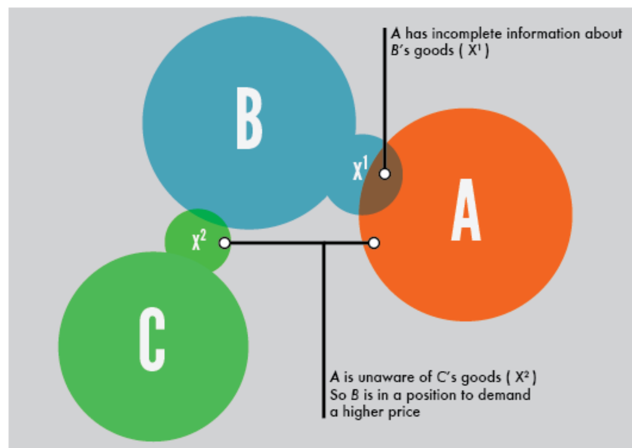

Figure 1: Information asymmetries: A, B and C are persons whose transactions with data (X1, X2) are denoted by an overlap between persons. B and C have complete information for X1 and X2 respectively.

Participants in an exchange may not know of suitable substitute datasets that might be available. The example shown in Figure 1 presents this as person A agrees to exchange a dataset with person B. If person C has a better dataset, more suitable to person A's task but A doesn't know about it, then person B may demand a higher price from A due to the fact A does not know another dataset exists. Similarly if person B does not disclose the provenance of the dataset then B may demand a higher price for a dataset which may be unsuitable for A's requirement. In either case, if we were to record the exchange between A and B as an indicator of the value of the corresponding datasets the valuation would not be a true reflection of either dataset.

In the case of data exchange both of these issues are exaggerated by the nature of the good being exchanged. Knowing enough about the nature of a dataset to understand its value, or which other datasets may be suitable substitutes for it is not always a trivial task. Traditional economic arguments about conducting research into the value of the data in advance are problematic due to the difficulty of investigating complex datasets.

Another case is transaction costs [17], where person A may wish to purchase a dataset from person B but there are prohibitive costs accrued to person A in completing the transaction. This could be due to legal costs associated with researching data protection or privacy law, or physical costs associated with transporting and storing the data. The price person A demands from person B for exchange to take place will then necessarily have to decrease to justify these costs. Again, if we record the exchange between A and B the value of the exchange will be biased by these costs (see Figure 2).

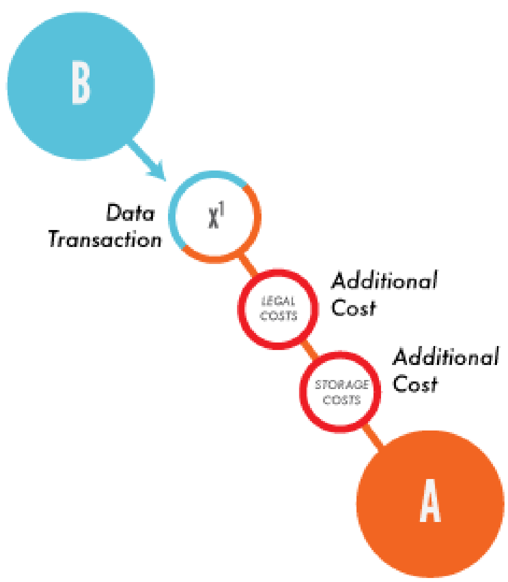

Figure 2: Person A purchases a dataset from B, potentially accruing additional costs which ultimately affect the price A is willing to pay

7. Pricing by Proxy

In summary of the discussion so far;

1. We wish to create a platform where stakeholders (from the Web Observatory) can come together and exchange data and where this data can be used to understand the development of the web. For this to happen the system must be able to sustain itself.

2. Current models of information sharing online disconnect the information sharing aspect of the system from its underlying revenue generation model. The information sharing transaction itself is not valued in terms of ROI.

3. For a project like the Web Observatory to succeed each transaction needs to be valued in a way that the participants can use to calculate ROI.

5. Value comes with caveats - transaction costs and information asymmetries must be considered when attempting to understand where the true value is at the point of exchange.

The argument we advance here is that if we can identify occasions online where appropriate conditions are met for valuation of an exchange of data, then we can extrapolate from this value the value of subsequent exchanges. So if we have we take a dataset A, assuming perfect information about A exists and there are no transaction costs associated with the exchange, if dataset A is purchased for £x then the value of data(A) = £x.

If data(A) is the traded for another dataset B, and no money is exchanged in the transaction then providing our assumptions still hold the value of data(B) = data(A) = £x.

It may be the case that data(A) is exchanged much more often online for other data that money. In this case it makes sense to think of the value of data in terms of A. So in the wider exchange of information we might wish to think of value in terms of a unit of data(A) rather than money. This would be the language of value online but remain ultimately translatable into the language of value in the wider economy.

Using similar logic we can also calculate the value of data that in itself cannot be traded for money. A company may possess a dataset of geolocation data but there may exist no other party who wishes to purchase it on its own. In order to value this information it is possible to attach it to another dataset that is openly traded for money and calculate the difference in the price. So building on the original example data(A) may be augmented with geo-location data(G), then traded again in the existing market for data(A);

£x = data(A)

£y = data(A)+data(G)

£z = £y-£x

£z = data(G)

In the first case £x and the second £z are the proxy valuations of data that need never be exchanged for money. The importance of this in terms of the Web Observatory project and data/information exchange online is it gives us a language to understand exchange in terms of the wider economy, both when data/information exchange is directly connected to money but also when it is not.

In a practical sense, a stakeholder in the Web Observatory may choose a data-to-data exchange with another stakeholder. For example if a company provides data to an academic institution, rather than sell it to another company. In this case the potential dividend of money is foregone in preference for a different type of exchange. ROI for the actors in the exchange still needs to be calculable. Being able to calculate a value for a dataset in terms of other data, rather than money, then becomes important. Via this method it is entirely possible to talk about the value of a dataset in terms of the value of several smaller datasets - yet still maintain the ability to translate this value into a financial one if a data - money exchange has taken place using one of the datasets in the past.

8. An Example of Identifying Value

To back up this theoretical discussion of valuation we include an example of work we are currently conducting with an ad-serving company, one of the partner organisations in the Web Observatory project.

Switch are an ad-serving company, their clients send data regarding each page request to Switch who then run an auction for advertisers who bid for the right to serve an advert impression on the page. Primarily the transaction is then a series of pieces of data contained with each page request. These include, IP addresses, geo-location, browser types and a range of other information. Each request is then augmented with third party data.

Whether or not the price paid for the user is an accurate reflection of the true value of the exchange is dependent on the transaction meeting the conditions of minimal (or calculable) transaction costs and complete information possessed by both parties in the exchange. Although we cannot know if these conditions are met for every transaction, we can infer if they are more or less likely to have been met over large numbers of transactions from an understanding of how the price paid for the user was arrived at.

The advertiser in this case will always have the incentive to bid as low as possible to win a given user, thus maximising their return on investment. If only one advertiser bids for a user it is difficult to tell if this is because they are bidding the fair price they believe the user is worth, or undervaluing the user in the hope they win due to a lack of competition in the market. If, however, several advertisers bid on a user over an extended period of time, we can assume that the competitive pressure will drive the price up to something close to the true value of the user the advertiser is willing to pay, whilst still being able to achieve high enough return on their investment to warrant the purchase.

By analysing the Switch marketplace for occasions when this type of competitive pricing occurs it is possible to isolate some types of information that are more valuable than others. Figure 3 shows the quartile average cost paid per user for a major UK publisher, a client of Switch who trades their user base on the Switch exchange over the course of a day. We have included only the cases where competition was present in the bidding process. We can see that the knowledge that a user is in an urban area is worth less in the market than the knowledge a user is in a rural area.

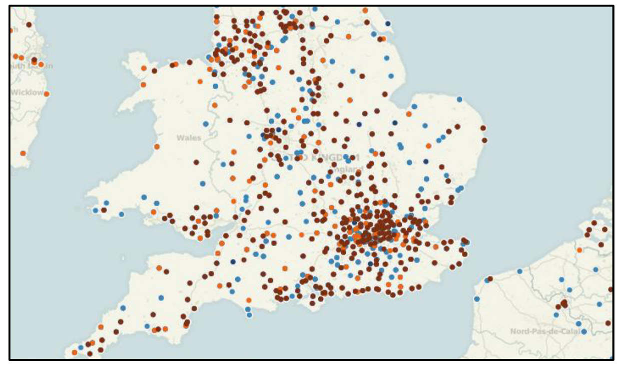

Figure 3: The quartile average cost paid per user for a major UK publisher, where light blue is the highest and dark red the lowest.

Figure 4 shows the same data but this time the average value paid for a user with a particular browser type. Again we see systematic differences in the price paid for a user. Users with Safari browsers are worth approximately 20% more than those using Internet Explorer, for example.

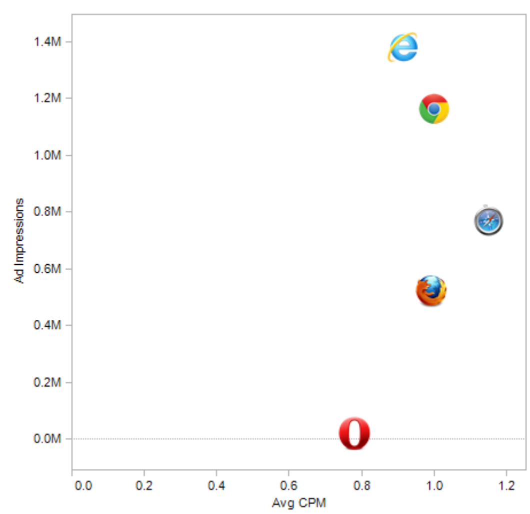

Figure 4: The average value paid for a user by browser type

The page request can then be viewed in economic terms as a dataset as it occurs at a point in time. The value of the dataset is the money the dataset is exchanged for in the Switch market. The motivation for the monetary exchange in this case is that an advertiser wishes to show a person an advert. If we find an instance where a person has no data associated with them then the price bid by the advertiser can be denoted as £x. This is the base value of any ad-serving transaction. If we then find a case where the person has geo-location data associated with them suggesting they live in London (data(L)), the advertiser might bid £y. So the value of that piece of geo-location information becomes £y-£x.

So now data(L) = £y-£x = £z, is the value of knowing a person lives in London has in economic terms. If we then take a case where a public sector organisation has a 1 million user database of geo-location information for internet users in London, there may be privacy concerns preventing the monetisation of this data via the ad-serving market, for example. If the organisation instead decide to offer the data to a university for research purposes then we can still assume the value of this data at the point of exchange will be 1million(£z) or 1million(data(L)), providing our assumptions about transaction costs and information asymmetries still hold.

The university then conduct research that isolates particular behaviours of people living in London augmenting 1million(data(L)) with a further set 1million(data(B)). Then exchange this data back to the public sector organisation for a larger dataset of 45million(data(L)). The return on investment on the part of the university and the organisation would be 44million(data(L)) or 44million(£z), which is the value of the 1million(data(B)) created from the transaction , minus the cost of conducting the research and supplying the data.

If instead the university decide to take the 1million(data(B)) to the ad-serving market then again return on investment can be calculated. In this case 1(data(B)) would be added to the user information in the page request. The value of 1(data(B)) in this transaction them becomes the rate the advertiser would pay for a page request containing data(L)+data(B), minus the original value of £y, minus the cost of conducting the research/1million on the part of the university, minus the cost of integrating the new information into the ad-serving transaction on the part of the ad-server.

9. The Web Observatory as a Data Exchange

If the goal of the Web Observatory is to facilitate data exchange and research, key to its success is showing an ability to provide value to its stakeholders. Stakeholders need to be able to understand how much they gain from participating in the project, why they gained more some weeks than others. Without this, the positive feedback required to motivate further exchange will not be present.

What we present here is a way of valuing data exchange that does not require the presence of money in the transaction, but does remain tied to revenue generation models as they exist online. In order to function there must be a facilitator within the Web Observatory group, or for an additional extension to the Observatory concept to be constructed. Although this falls outside the remit of the Web Science Observatory, an existing stakeholder may be well placed to facilitate these data transactions. This important role would provide a source of information about the value of data resources that all Observatory stakeholders can use to value their holdings, in data or monetary terms, and calculate return on investment.

We propose that in order to facilitate this process a function of Web Observatory should be to provide a set of indices detailing the current valuation of data within the exchange based on a historical record of transactions between stakeholders in the system. Where possible, these indices should include a value in financial terms for all datasets present on the exchange that have been exchanged for money in the past. If this has occurred, it is possible to then extrapolate the value of other datasets using the methodology we outline.

To construct an index we propose using a similar methodology used in the construction of financial market indices. Given a set of initial stakeholders we set an arbitrary index value of 100 index points. We take this value to be representative of the data holdings of all of the initial stakeholders. As datasets are exchanged and augmented we add extra points to the index based using our valuation methodology for valuing data in terms of other data.

To begin with we will not know if the relative values of different types of data. So for each type of data we require a separate index. As the holdings of this type of data increase we would simply increase the index points by the percentage increase. As data begins to be exchanged we can then have meta indices holding the shared valuation across different types of data. As the Observatory system expands to include datasets valued in monetary terms we can allow that value to percolate through the index valuing other datasets which, to this point, only have been valued in index points.

Another important role of Web Observatory is to facilitate transactions. To do this the Web Observatory project needs to also incorporate systems to reduce information asymmetries and transaction costs that prevent, or miss value data exchange.

10. Data Quality

Through developing our understanding of value in a data exchange the debates about provenance or data quality can be re-phrased in terms of information asymmetries at the point of exchange. Meta-data concerning the quality or provenance of a dataset is only as necessary if there are likely implications for the valuation of the dataset in exchange.

As an example, if a dataset of 1 million lines of geo-location information trades at £10, including provenance information about 1 incorrect record increases the value of the dataset by £10/1,000,000. This piece of provenance information is then clearly not very valuable so there is little reason to store it. Being able to value the data properly allows for these decisions to be made based on the implications for the valuation of the Observatory system as a whole.

11. Facilitating Exchange

We can also frame our understanding of data standards, storage and functionality of Observatories in terms of the cost of data exchange. Again, understanding a datasets valuation in exchange, use of a format that allows it to be exchanged more easily reduces the cost of the transaction and thus increases the value of the data. If this value is calculable, in the way we have outlined, the decision to provide a number of formats is purely based on the return on investment generated by increasing the value of the data. By providing an index of data values as exchanges occur, Web Observatories can then inform stakeholders where the areas of the largest return on investment would be when looking to reduce transaction costs.

12. Discussion and Conclusions

In this paper we began by highlighting issues surrounding data quality and management pertinent to the creation of Web Observatories. Key to this is the ability to link the motivation for exchanging and improving datasets to return on investment for stakeholders in Web Observatory projects. We then described different form of revenue generation models as they exist online and highlighted the disassociation of the data exchange transactions from the revenue generation models that fund data or content exchange.

In order for Web Observatories and the web in general to maintain self-sustaining growth geared towards increased data exchange, it is imperative that the value of data exchanges can be framed in terms of measurable return on investment. Whatever metric is used to value return on investment it need not be a financial value in itself but must be translatable into one. Otherwise, the funding of exchange systems like Observatories will remain fundamentally detached from the value created in the exchange. This necessarily biases the behaviour of stakeholders in these systems away from creating value through data exchange and towards maximising revenue via other means.

We then show how it is possible to value purely data – data exchanges in a way that is ultimately translatable into monetary terms, but also flexible enough to find other units to measure the exchange that may be more appropriate for certain transactions. By using a proxy price for data – data exchanges derived from an existing revenue generation model, it is possible to show return on investment in data exchanges without the need for money changing hands.

Bringing the discussion back to data quality and management, with a proper valuation system for data exchanges it is possible to frame these issues in terms of return on investment. Instead of calling for perfect criteria for data labelling we argue that the market should decide what is the appropriate set of criteria based on the implications for return on investment for including such criteria. Similarly we argue that the facilitation of exchange through data standards should also be viewed in terms of the cost of converting datasets to a particular standard over the likely implications for return on investment elsewhere in the system. Therefore we are suggesting that there is a the need for an assessment of the current DQ methods and standards in place from a sample of Observatories with a view to creating a Web Observatory complied methodology, vocabulary and DQ processes that can be standardised to benefit the community.

We also perceive an essential part of the infrastructure of Web Observatories to therefore be a type of market index that records the terms of data exchanges. We show how using private sector partners it is possible to link the value of data to existing revenue generation models. This type of valuation is essential in tying data exchange to its funding and thus providing positive feedback loops stakeholders in Observatory projects can exploit to generate return on investment.

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