Information Assets and their Value
Wilco Engelsman
w.engelsman@student.utwente.nl

ABSTRACT
This paper presents the results from a literature study on the value of information. I have reviewed the information, accounting and business literature to find economic attributes of information and information valuation attempts. There is at least some consensus on a number economic properties and identifying information as an asset to the organization. Also a number of valuation attempts have been made using classical economical measuring methods, some of them adapted to use the special properties information has. At the end of the paper I propose a conceptual framework in which information could be valued or at least researched.

Keywords
Value of information, information as an asset, measuring information, information assets, information commodities, proposed methods for valuing information, cost of information, information resource, valuation of knowledge, knowledge, knowledge assets

1. INTRODUCTION
Information plays a crucial role in today’s organizations. It is seen as a valuable component, but few organizations have actually realized the full potential of their information assets. Information located in different parts of the organizations are often believed to be of immense value. Although they actually don’t have any measurable financial attributes. Knowing the actual value of the information assets within organizations can lead to a better understanding of the more valuable and less valuable information. It could also serve as a cost justification for large IS investments. Previous studies have attempted to develop methods to give information a more concrete value. Although none of them seem to be in practical use today.

With this paper I wish to do a literature review to determine the key concepts used in valuing information. What and how information should be valued and if any of the reviewed methods are applicable to be used as a measuring instrument.

2. RESEARCH QUESTIONS
With this paper I wish to find an answer to the following research question.
- What is a possible framework to start measuring the value of information?

In order to answer the primary research question, I have formulated sub research questions. These need to be answered in order to determine the current status of information as an intangible asset and its actual value to the organization.

- How does the literature define the concept of information and its value?
- How does the literature define information assets and how to identify them?
- What methods are available in measuring the value of information?

The theoretical significance of these research questions is to create an understanding what information should be measured, what attributes make information valuable and how information can be valued.

The practical significance of these research questions is to eventually develop a method to value information in financial terms. This method can be used to gain a better awareness of the importance of information and cost justification for implementing large new information systems.

The end result of this literature review will be a clear definition of key concepts in valuing information, a possible framework in which information should be valued, a model that shows in what areas further research is required and the gaps in the current literature in the field of information valuing.

2.1 METHOD OF RESEARCH
In order to try and answer my research questions I conducted a literature review of the IS, accounting, economics and business literature to establish a firm foundation to advance the knowledge in valuing information and to identify the gaps in the current literature on this topic [WW02].

I have used a number of search engines to search through the literature: Web of Science, JSTOR, Scopus, Ingenta, Business Source Elite and Google Scholar.

I have used the following keywords and combinations of these keywords: value of information, information asset, measuring information, information assets, information commodities, valuing information, cost of information, information resource, valuation of knowledge, knowledge assets. These keywords produce a number of results. In order to process these results, I have mostly concentrated on peer reviewed articles. These articles are then divided in three major concepts: characteristics of information and information attributes, information assets or commodities and information valuation models. The inclusion criteria are based on relevance of the article, peer reviewed and the journal where it is published. The relevance of the article is based on reading the abstract and scanning the article itself if it matches any of said concepts. After reading and accepting the article I have used web of science and Google scholar citation indexes to search forward and backward to capture as much on that topic as possible.

Exclusion criteria for the search results mainly cover two subjects: 1) mathematical and probability models on the value of information 2) value of Information Systems or Information Technology

The key goal of this research is not to summarize or synthesize all studies on the value of information. I’ll disregard extreme mathematical models derived from information theory and probability theory. The goal is to get the key concerns that different authors identified and derive a common conceptual strategy. This conceptual framework is not intended for
practical use. It is more a guideline for further research and consensus on this topic.

3. LITERATURE REVIEW
In this chapter I will discuss the synthesized material on information valuing. I will discuss information as a concept and it’s valuable properties, information assets and models (views) for information valuing.

3.1 Concept of information
What is information? In an article by Jennifer Rowley she summarizes [Row98] some of the concepts of information. She mentions that information, knowledge and data are related, as shown by a definition from the field of computer science by Senn [Sen90]. Information is data presented in a form that is meaningful to the recipient. Another definition is provided by Curtis [Cur89] Information is data processed for a purpose. Another popular view on the nature of information in the computer science literature is the view by Buckland [Buc91], called information as a thing. Information as a thing can have different forms (e.g. text communication or an object) [GS04]. Buckland points out that in order to communicate knowledge it must be expressed or represented in some physical way, for example as a signal, plain text or communication. With information as a process Buckland means that information is an action, to inform or be informed by someone. There are many other views on information, but it is out of the scope of this paper to discuss all of them. Throughout this paper I will treat information and knowledge as interchangeable items in terms of its valuation. Gunnarsson & Jokull M. Steinarrossen [GS04] mention that there is some confusion in the use of these terms but most authors agree that knowledge is the definitive result of the capture of data and when context and purpose is applied to data information is produced.

3.2 Economics of information
In order to determine how information can be valuable or adds value, some economic attributes of information can be found in the literature. I have divided these economics of information into three main concepts, information as a resource, attributes of information and information value.

3.2.1 Information as a resource
Burk and Horton identify the following nine basis similarities between information and other traditional managed resources [BH88].

- Information is acquired at a definite measurable cost.
- Information possesses a definite value, which may be quantified and treated as an accountable asset.
- Information consumption can be quantified.
- Cost accounting techniques can be applied to help control the costs of information.
- Information has identifiable and measurable characteristics.
- Information has a clear life-cycle: definition of requirements, collection, transmission, processing, storage, dissemination, use and disposal.
- Information may be processed and refined, like raw materials are converted into finished products.
- Substitutes for any specified item or collection of information are available and may be quantified as more or less expensive.
- Choices are available to management in making trade-offs between different grades, types and prices for information.

The above similarities are not always applicable on information, in the sense that information always has one or more of the above similarities, but never the whole list, except for simple administrative information [YB01].

Moody & Walsh claim information has only one similarity with traditional managed resources (or assets). Information has a cost and a value [MW99].

3.2.2 Attributes of information
In the literature a number of different attributes of information can be found. Cleveland summarizes the qualities of information [Cle82], although I was not able to find the article, his findings are cited in [EB91], [Rep86] and [Mos92].

- Information is expandable, it increases with use.
- Information is compressible, able to be summarized.
- Information can substitute for other resources.
- Information is transportable virtually instantaneously.
- Information is diffusive, tending to leak from the straightjacket of secrecy and control, and the more it leaks the more there is.
- Information is sharable, not exchangeable. It can be given away and retained at the same time.
- Information is human. It exists only through human perception.

What Cleveland calls qualities of information, Moody and Walsh call “laws of information”. They argue that there are 7 laws of information which influence the value of information.

- Information is infinitely shareable; information can be shared between any number of people, business areas and organizations without loss of value to each party. Sharing of information increases its value. Replicated data leads to no additional value.
- The value increases with use; information has no real value on its own, it is only valuable when people use it. Unused information is a liability.
- Information is perishable; like most other assets, the value of information tends to depreciate over time. The speed at which it loses value depends on the type of information.
- The value increases with accuracy; In general, the more accurate information is, the more useful and therefore valuable it is.
- The value of information increases when combined with other information; Information becomes more valuable when it can be compared and combined with other information.
- More is not necessarily better; In most cases, the more of a certain resource you have the better. With information it can be the opposite. The biggest problem in most organizations today is not the lack of information, but the overabundance of it.
- Information is not depletable; most resources are depletable, the more you use, the less you have.
- Information is self-generating. The more you use it, the more you have. This is new information is often created as a result of summarizing, analyzing or combining different information sources together.

Skyrme summarizes ten different value adding aspects (or attributes) of information. These aspects refer to increasing user experience and usefulness of the information needed. These ten aspects are consistent with various information quality
frameworks as well as information refining methods and
taxonomy procedures that can increase information value
through reuse [GS04] [Sky94].

- Timeliness: Information is perishable. Different
  information has different half lives (‘sell by dates’).
- Accessibility: Easy to find and retrieve - no long-winded
  searches, good ‘hits’
- Usability: Ease of use; user can manipulate to suit
  application
- Utility: Is suited and usable for multiple applications
- Quality: Accurate, reliable, credible, and validated
- Customized: Filtered, targeted, appropriate style and
  format; needs minimum processing for specified
  application
- Medium Appropriate for portability and ongoing use
- Repackaging: Reformatted to match onward use
- Flexibility: Easy to process; can be used in different ways
- Reusability: Can be reused; ideally extra use should refine
  its quality; the more people that can access and use, the
  better.

Nichols mentions in order for information to be valuable, it
must possess the following qualities. Relevance, timeliness,
availability, comparability, objectivity, sensitivity, quality
[Nic69].

Arrow discusses the special properties of information [Arr96],
including those that give rise to increasing returns. Increasing
returns can occur for other reasons than information. But with
information, constant returns are impossible. Repeating a given
piece of information adds nothing. On the other hand, the same
piece of information can be used over and over again, by the
same or a different producer. And this leads to implications that
are hard to understand. For example, information can be used
for producing a certain item. It is used once, and for all items.
The same information is used regardless of the scale of
production. This is an extreme form of increasing returns.

When discussing these different attributes of information,
Oppenheim et al studied the practical effects of these attributes.
They concluded that accuracy and timeliness of information are
the most important information attributes [OSW04].

3.2.3 Information value

Repo [Rep86] [Rep89] divides the value of information in
philosophical value and practical value and only concentrates
his further research on the practical value of information.
Practical value is further divided in value in use and exchange
value. The value-in-use describes the value of information from
the information users and use viewpoint. The exchange value is
needed to compare values either in comparison with the values
of information channels, services or products in information
need situation, or in a marketing situation for determining the
price for a piece of information.

According to Repo [Rep86] the value-in-use of information can
only be stated by the user of information while he is performing
his knowledge-work task and from the results of the task. In
order to avoid subjectivism, the basis for determining the value
of information even from an information use viewpoint has to be
in the knowledge-work itself. Measuring the value-in-use of
information in practice is a demanding task. Objective value-in-
use is often impossible to measure in full, only some indicators
may be available from individuals how the information
influenced the task and the results.

In his study five types of information where identified: task
information, domain information, problem information,
problem solving information and outcome information. The
final concluding remarks from his study are:

- One should speak of the value of information at the user
  level only in terms of value in use. Because the value-
giving situation of information products and services is a
need-oriented situation, there is a need for expected value-
in-use studies. The talks about use values in money terms
makes it easy to mix value-in-use with exchange values.
Only seldom is it possible to derive exchange values from
objective value in use in full.
- The organization, or the community more generally, gives
  the framework for knowledge work and it operates with
  exchange values. There are seldom real measurements for
  such a concept as the value-in-use of information at the
  organizational level should we only speak of the exchange
  values of information products, services, systems and
  channels?
- One should not mix a user’s viewpoint and a community’s
  viewpoint when determining the value of information and,
  on the other hand, the value of an information service or a
  product.
- Different kinds of information and knowledge have
  varying values for a user of information: domain, problem
  and problem solving information are the most interesting
  ones when determining the value-in-use. Also the
  information use context has major importance here.
- Specification of the exchange values of information
  systems and products is an issue entirely different from
  specification of the value-in-use of information-the
  exchange values deal with information production and
  transfer and market, not with the use.
- There is no sense in trying to count the total value of
  information; different viewpoints and observation levels
  mean different emphasis.
- When an organization measures the value of information in
  some particular situation, it has to ask the information
  user’s opinion about information needs and study the
  information-use contexts here the examples of the use
  values are the most useful tools available at present. In
  finding the most cost-effective information products,
  services, systems and channels, one needs exchange value
  considerations in the information markets.

In 1989 Repo performs [Rep89] another literature review on
the value of information. He concludes that economic probability
theories on the value of information were far from successful
and recommends more classical economic ways of valuing
information. Furthermore he gives a point of reference for
looking at types of information separately while valuing
information.

He keeps reminding that according to his ideas the studies on
valuing information should be done in two different directions.
1) The exchange value of information products using classical
economic measures; 2) The value-in-use of information should
be studied using the cognitive approach which takes the user,
the use and the effects of the use of information into
consideration.

Cronin and Gudim [CG86] [EB91] argue that it may be too
simplistic to actually speak just about information, in discussing
its resource qualities. Information has the features of a hidden
property good. Its value may not be fully appreciated until well
after the time of use. Eaton and Bawden extend on this topic by
stating that information is not readily quantifiable. It has no
intrinsic value. And the value depends on its context and its use
by particular users on particular occasions. The value of
information to its users is impossible to determine in advance.
Furthermore the value of information does not change with time in any predictable manner. But overall they conclude that information is a resource, in the sense that it is of vital importance to organizations, by virtue of its importance to the individuals within them. But it is qualitatively different from others.

According to Yates and Bawden [YB01] the valuation of information and knowledge will never be an easy task. It will be particularly problematic. This is due to the Eaton – Bawden paradox [Ho10]. The Eaton – Bawden paradox is the view that information cannot be managed, including the valuation of information, like any other resource, without doing violence to those attributes of information which make it an inarguable resource, in the sense of being a dynamic force for innovation and progress. They do still believe that information, despite the Eaton and Bawden paradox, can be valued in financial terms. The way forward is likely to lie in an acceptance of the paradox, and the devising of sensitive means of managing and valuing information and knowledge which do not do violence to the essential nature of these entities.

In principle there are two ways in which information resources may be valued. Firstly valuation for an external audience, as a way of demonstrating the contribution of information to the overall value of an enterprise. Secondly valuation for an internal audience, as a way of encouraging better use of information assets [YB01].

A finding by Wilkins et al [WWY97] seems to collaborate the statement of the different values of information/knowledge in the use of its context. They argue that valuation of knowledge assets is treated differently by corporations, venture capitalists and commercial bankers, by their unique requirements and needs.

According to Thomson [Tho01] the value of information is not a function of the information itself, but rather of measurable attributes of the information. Assigning value to information is a substitute for assigning value to the area the information covers. He also mentions accuracy and timeliness as important attributes of information [GB04].

According to Porter [PM85] information is used to gain competitive advantage over competitors by enabling delivery of cheaper or more highly differentiated products. Information gives an added value and substitute for labor or capital investment. Information is also no longer seen as a cost based activity, an activity to support other activities. Currently information is seen as an important source of value creation [Sam98].

Finally Oppenheim et al mention the value of information is usually based on cost, but it is a general mistake to only quantify its value based upon the cost. Information which costs little can be of great value, the value depends on its context an use, as mention earlier [OSW01].

### 3.3 Information assets

According to Moody and Walsh information satisfies the definition of an asset much better than an employee or customer, which all three are commonly referred to in the literature as intangible assets. Where the company does not own employees and customers but information is owned. Information is an intangible asset with relevant attributes of having service potential and being able to give economic benefits to its owner, but not possessing the physical form of an object [MW99].

In order to qualify as asset information should have the following characteristics [MW99]. It should have service potential or future economic benefits. It should be controlled by the organization and is the results of past transactions.

Information meets all these requirements.

#### 3.3.1 Identifying information assets

One of the publications on information as an asset was by Nigel Horne [Hor98]. He mentions a booklet he produced to describe an information management guideline for information assets. This booklet contains seven steps, but only the first step is relevant for the scope of this paper. This first step is the identification of information assets and the classification into those of value and importance that merit special attention and those that do not. This booklet is based on one of the major reports about information assets; the Hawley Report. They defined information assets as data that is or should be documented, and that has value or potential value [Haw94]. They have also identified commonly used information assets, but there is no consistency in the identification of information assets within companies. Information assets include market and customer information, product information, specialist knowledge and information for operating in a particular area, business process information, management information, human resource information, supplier information and finally accountable information.

All these assets identified may have attributes that impact on the effectiveness of an organization. A first step must be to define the context in which to identify attributes of information assets. Diverse interest groups will have diverse information needs and uses. Each group contributes information and uses information contributed by others [OSW01].

In a more empirical research study, Oppenheim et al [OSW03] concluded that the academic world and the business world have a different view in identifying the attributes allocated to information assets. They found a strategic role for information assets in planning and control, managing internal and external operating environments, providing organizational direction and momentum in decision making. Attributes were described in terms of the inherent qualities of information assets and in terms of the information asset as a resource in itself. This suggests that executives at such senior levels in an organization expect quality and accuracy in their information assets as given. They see information assets and their attributes as having a role in improving the effectiveness of, and decision-making processes in, their organizations. The absence of economic attributes suggests that the recognition of the ‘value of information’ is still the prime area of difficulty and one which will not be easily solved. As a result of this study, they refined the list of information assets of the Hawley report into a more concrete and workable list. E.g. Customer information, competitor information, product information, business processes, management information, people management, supplier information, legal information and finally organizational information.

In another research study by Oppenheim et al [OSW04] about information assets they mention a formal definition: information assets comprise resources that are or should be documented which promise future economic benefits. One of the major problems they encountered in valuing information assets was the ability of information to change value in particular situations and contexts or particular individuals. There was a need to measure information within particular contexts.

In an earlier study by Glazer [Gla93], the term meaningful information is introduced. Meaningful information is grouping of otherwise discrete forms of information into an organizational pattern. The challenge for organizations that want to adopt formal information measurement procedures is the identification of the relevant patterns or the appropriate level
at which to aggregate individual items of information. He does not actually use the term information asset, but the term meaningful information can be seen as a synonym here.

3.3.2 Managing information assets

Gunnarsson & Steinarrossen [GS04] summarized an article by Skyrme [Sky97] to strategically manage information assets, in order to fulfill the requirement of having “the right information, in the right place, in the right format, at the right time”. According to Gunnarsson & Steinarrossen, Skyrme further recommends that organizations should adopt the principles of IRM, typically used for monitoring valuable tangible assets, to intangible assets like information because of the increasing value of information and lack of management in many organizations.

- It is important that managers understand the role and impact of information on the organization. Whereas information can add value to products and services as well as improve quality of decision-making and reduce risks.
- Establish a clear assignment of responsibility of an organizational wide Information Resource Management Initiative (IRM). Because the responsibility of developing value from information resources falls often short when governance is not apparent.
- Institute policies for how to utilize information resources throughout its lifecycle. Pay attention to ownership, information sharing and integrity. Make policies consistent with the organizational culture.
- Identify information resources, their users, usage and importance. Further identify the information cost, value and sources. Classify information by key attributes. Classify knowledge and make knowledge maps i.e. inventory over what the organization knows.
- Employ data mining, information refining and knowledge editing methodologies and techniques. Using technologies based on intelligent agents can help in the data mining process, but topic experts are needed to repackage relevant material in a user-friendly format through basic content analysis.
- Refining information methods techniques are examples of commercial methodologies that are not widely used by organizations, but can be highly valuable.
- Institute an effective information management strategy through the development and implementation of appropriate technological systems. These systems can be e.g. intranets, groupware and collaborative technologies for more widespread sharing and collaborative use of information as well as advanced text retrieval, document and content management and knowledge management expertise systems among others.
- Promote a culture for sharing information through expertise systems and communities.

3.4 Information valuation methods

The final part of this review mentions the actual valuation attempts made in the literature. It is interesting to see that the valuation attempts differ as soon as the context of the valuation changes.

3.4.1 Valuation in risk perspective

One of the approaches uses valuation in a security risk management context [Poo00]. From these reasons, it is possible to discover effective and defensible techniques of both a quantitative and a qualitative nature. The overall purpose of an information valuation for risk management is to assess the appropriateness for controls and the sufficiency of budgets for Information Security Management. When management does not know the value of the information assets in the context of information security controls, the cost of controls overshadows the value of the information assets. Poore mentions that valuing information depends to a large extent on the purpose of the valuation therefore as such information can have several values [Poo00] [GS04].

Valuing information from a risk perspective differs from other valuation methodologies in Poore’s view where one or more of the following conditions are most likely the motivating factors for the valuation: exclusive possession, utility, cost of creation or recreation, potential liability, convertibility and operation impact.

He mentions information can be valued both qualitative and quantitative. Quantitative valuation of information assets, information has positive value when it is accurate, timely, useful, permitted and rare. It may be a liability when the contrary is true. If the negative value and the positive value of a given set of data were described on an interval, the absolute magnitude of the interval would represent the value of the data for purposes of security risk management.

For example, if the value to the organization were five units and the potential liability if inappropriately released were minus seven units, the value would be 12 units. If an unit is $10,000 the total value would be $120,000. He also mentions not all information can be valued quantitatively. Some aspects are best done qualitatively. Reasons for this include the potential for misuse of misunderstanding of the quantification. He gives three distinct topics for qualitative valuation, life safety, political sensitivity and criminality.

Gunnarsson & Steinarrossen [GS04] used this model in a valuation attempt in risk perspective. They concluded that the effort to value information is not entirely problem free, although at least theoretically it should be possible to value information. The most important question here is how relevant the valuation is and to whom it has value. This was one of the deciding factors when valuing information.

3.4.2 Historical Cost Valuation

Moody & Walsh argue [MW99] the most workable approach seems to be the historical cost method, because of its reliability ease of collection and general applicability. It can be used for all information. The method “as is” is not sufficient to value information, so they proposed the following modification. This modification incorporates the laws of information they defined.

- Cost of collection should be used as the baseline for measurement of value for operational data. This should be standardized by using a standard data entry cost for each data item.
- Management information should be valued based on the cost of the processed used to extract the data from operational systems.
- Data which is collected redundantly should be considered to have zero value to avoid double counting.
- Unused data should be considered to have zero value, this can be determined via data usage statistics.
- The number of users and the number of accesses to the data should be used to multiply the value of information. When information is used for the first time it will be valued at cost of collection. “Each subsequent use will add to the value. This allows the historical cost of the information to be modified in the light of its use in practice and reflects the cumulative nature of its value across different users.
- The value should be depreciated based on the shelf life of information.
• The value should be discounted by its accuracy relative to what is conserved to be acceptable. In practice, this would probably have to be done based on perceptions of accuracy, because of the cost of empirically measuring accuracy.

3.4.3 Usage over time valuation
Ying Chen [Che05] presents a method to value information according to its usage over time. This is a simple, effective and tangible model since it relies on measureable metrics and observable facts. The main context for this method is to differentiate information values for Information Lifecycle Management (ILM).

The approach is based on two fundamental principles: Information value is realized and reflected through its usage and information value changes over time. The valuation model is derived from two measurable and observable metrics: usage and time. The model captures both the information value changes over time and the value differences among information.

The baseline model assumes that the past usage history serves as an indication of the importance of the information for the present time. It indirectly infers the information value at present time by factoring two key aspects of information usage, i.e., the recency and the degree of the information usage. A piece of information is more valuable if it is used more recently and it is used more heavily than others. The model must combine both recency and degree of usage aspects with strong bias towards one aspect or another. It must consider the tradeoffs between the two. To eliminate bias, they normalize the recency and degree of usage factors in to a common value scale, between 0 and 1.

By combining both recency and usage allows the model to capture information value changes over time and the differences among information.

This model is only a first step. It actually doesn’t define the financial value of information, but it generates a scale which information is more valuable. The author did mention incorporating cost factors in one of the next steps in completing the model.

3.4.4 Utility value of information
In 1991 Glazer proposed a conceptual framework for measuring the value of information [Gla91] [Gla93]. He valued information in the context of “marketing” and as result information can be seen to be a function of information’s role in facilitating exchange. And at the same time, for economic users of information such as the firm, the meaning of information is clearly related to the measure of its value. He clearly mentions that measuring the value of information has been problematic.

The unit of analysis is the transaction, which we define to be the exchange between a firm and the consumer of goods or services for money. However, a key component of any transaction is that, beyond the exchange of goods for money, information is also exchanged.

The key problem is that the value of information is context-dependent and multidimensional. But nevertheless he identifies three value components

• Given the information, revenues from subsequent transactions are greater than they otherwise would be;
• Given the information, costs of subsequent transactions are lower than they otherwise would be;
• The information itself is marketed

So, the value of information belonging with a given transaction is the sum of the profits that result from increased revenues and reduced costs from future transactions that are in turn a function of information collection along with the transaction and the profit from the sale of the information itself.

In similar fashion it is possible to calculate the value of information for upstream transactions between the firm and its suppliers. Here the role of the information is to reduce the cost of the inputs that go into the firm’s products and services. And finally the value of information associated with exchanges within the firm. Here the goal is generally the reduction in Production / operations costs.

The three measures of the value of information associated with different types of transactions can be aggregated to give the total value of the firm’s information.

The function of a valuation framework that is oriented toward the information itself is to ensure that the firm has the incentive to identify such opportunities by demonstrating the intrinsic sources of economic value that reside in its information.

Glazer recognizes how valuing information resources can contribute to the information and business strategy and assist in deciding what particular focus and commitment to have [GS04] [Gla91] [Gla93].

3.4.5 Valuation of knowledge assets
Wilkins et al proposed a method to value knowledge assets [WWH97]. According to Yates – Mercer and Bawden the difference between knowledge and information is minimal and therefore it is possible to discuss both in a similar fashion [YB01].

Wilkins et al mention the value of knowledge assets is treated differently by corporations, venture capitalists and commercial bankers based upon their unique needs and requirements. The value of these knowledge assets is the sum of cost based value and the added value summed over all relevant processes in which it is a resource. They identify two contributors to value from this perspective. An activity involved in production of the product adds a certain value to the finished product/ service. When an activity is performed, cost is incurred because the activity consumes resources in production. Therefore, a knowledge asset, which is possessed by a resource and used in an activity, has an associated cost and an added value. To determine the value of a particular knowledge asset the following questions should be answered:

• What is the added value of an activity?
• What is the cost of a resource per activity per product?
• How much of the added value can be assigned to the knowledge asset?
• How much of the cost can be assigned to the knowledge asset?

The added value of an activity or a product is normally not traced for production processes. It is an artifact, a concept that is used to think about management of activities and the assignment of resources. To assign added value to knowledge assets, they need a perspective that captures how value is added to a product. This is a very complicated issue and it is not possible to determine exactly the value that is added to a product or service. To determine the added value of the knowledge asset, one can systematically propagate the requirements of the product that are relevant to the value added, to knowledge asset requirements. With the relevance of each product requirements, and the contribution of each knowledge asset, the portion of the added value of that product that is achieved by the knowledge asset can be estimated.

Since a knowledge asset can contribute to various products, the total added value of the knowledge asset is the sum of the added value in each product/service.
The cost of a knowledge asset can be calculated by determining the cost per product of the resource that embodies the knowledge asset. This cost can be derived from the cost per product per activity of each activity that consumes the resource. This activity is central to this costing approach (activity based costing). The total value is the sum of the added value and the associated cost.

4. DISCUSSION

Information valuation is a topic that is currently, or has been, investigated by a number of authors. After reviewing the literature, I observed the following main concepts in information valuing. These will be discussed by using the sub research questions.

“How does the literature define the concept of information and its value?”

The value of information depends on a number of economic attributes. In the table below I have listed all properties identified by the different authors.

Table 1: overview of value influencing attributes

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Cleveland</th>
<th>Moody &amp; Walsh</th>
<th>Skyrme</th>
<th>Arrow</th>
<th>Nichols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportable</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substitute other resources</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible to Summarize</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not depletable</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Timeliness</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Diffusive</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combinable</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Usage</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Shareable</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perishable</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redundancy adds no value</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Human</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reusable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessible</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customized</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium appropriate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formatting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relevance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There a number of economic properties that are highlighted by different authors. Accuracy and timeliness are considered of great importance by both Poore, Moody & Walsh and Oppenheim [Poo00][MW99][OSW01]. Both Moody and Repo mention information has a certain acceptable level of accuracy [MW99][Rep89]. For example space shuttle control information during space flight should be 100% accurate, or it has no value. But customer information used for direct mailing applications can have a much lower accuracy.

Some authors use different terminology in describing essentially the same attributes. Moody & Walsh mention accuracy as a component that influences value, but Skyrme calls it quality of information. Moody & Walsh mention perishable and Skyrme timeliness. Furthermore the attributes compressible and diffusive identified by Cleveland map to the attribute not depletable by Moody & Walsh. Most of the attributes identified by Skyrme promote the using of information. This is essential the attribute that information becomes more valuable when used. The table below shows a summarized list of identified valuation components, by relating the different attributes of the authors to each other.

Table 2: summarized list of attributes

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Cleveland</th>
<th>Moody &amp; Walsh</th>
<th>Skyrme</th>
<th>Arrow</th>
<th>Nichols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible to Summarize</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not depletable</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combinable</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Usage</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Shareable</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timeliness</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Redundancy adds no value</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

Furthermore information valuation depends on two extra dimensions, the audience of the valuation and the context of the valuation. Goldschmidt and Smidt proposed different valuation techniques for different purposes in asset valuation. For instance valuating for internal audiences and external audiences [GS69]. In the case of external reporting they suggest to use historical cost analysis and depreciating the asset based on its shelf life as basis for valuing the asset and for internal use they suggest either concentrating on the income it generates or the present market value.

The value of information is also dependent on the context how the information is used and therefore can have different values at the same time. This property of information is agreed upon by most of the cited authors. This also reflects on the observation by Cleveland that information is human and exists only through human perception [Cle82]. There seems to be at least some support to value information in terms of classical economic valuation techniques and not by
probability, communication theory and information theory models. This was first suggested by Repo in 1989 and it seems to be supported by the valuation attempts of Moody and Walsh in 1999 and the research of Glazer.

Gunnarsson & Steinarsroussen conclude after performing a case study on valuing information in risk perspective: The bottom line is that for valuing information in a successful manner, it requires a complex and extensive operational focus on how information is used, how frequently and how users rank (value) information, within the organization as well as how information affects different organizational functions [GS04].

“How does the literature define information assets and how to identify them?”

Both Moody & Walsh and Oppenheim agree upon the definition of information assets. They both seem to recognize that information is typically an asset to the organization. Moody and Walsh define all information as an asset, but it is more likely that there are different types of information assets within the organization. Repo [Rep86][Rep89] already describes 5 distinct types of information that are available to the organization. Information assets have been identified as early in 1994. The Hawley Report [Haw94] identified a number of information assets known in practice and Oppenheim et al empirically revised the list. Glazer mentions in order to start measuring the value of information you should group certain information into discrete pieces of information that have a certain organizational meaning. In the table below I will try to show the relationship between these terms. I believe that they try to explain the same thing in another level of abstraction. The eight types of information identified by the Hawley Report are just a concrete example of “meaningful information”. The five types of information identified by Repo are a subset of information types, they apply to both all information and in the concrete examples from the Hawley Report.

Table 3: valuable information types

<table>
<thead>
<tr>
<th>Glazer</th>
<th>Oppenheim/Hawley Report</th>
<th>Repo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meaningful information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>customer information</td>
<td></td>
<td>Task knowledge</td>
</tr>
<tr>
<td>competitor information</td>
<td></td>
<td>Domain knowledge</td>
</tr>
<tr>
<td>product information</td>
<td></td>
<td>Problem knowledge</td>
</tr>
<tr>
<td>business processes management information</td>
<td></td>
<td>Problem solving knowledge</td>
</tr>
<tr>
<td>people management supplier information</td>
<td></td>
<td>Outcome knowledge</td>
</tr>
<tr>
<td>legal information organizational information</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Oppenheim et al investigated [OSW04] the assets identified by the Hawley Report and tried to assign the economic properties mentioned earlier to these assets. One of their conclusions was that business companies in the UK did not recognize the same qualities as the scientific literature did. Skyrme recognized the importance of information assets and proposed a way to manage these assets like they are normal tangible business assets. It is interesting to notice that keeping your information assets valuable Skyrme pays attention to most of the recognized economic or valuable attributes of information.

“What methods are available in measuring the value of information?”

The attempts to actually value information or devise a method to value information in classical economical terms are hard to find in the literature. Most of the valuation attempts recognize the mentioned economic properties and use them in the context of the valuation.

It seems likely that the future of information valuing lies in determining the context of the valuation and therefore assigning more or less value to the certain attributes of information. The valuation of information has in principle two different audiences, an internal public and an external public. Both require different valuation techniques [YB01].

Another commonly used practice was not using any of the economic (value adding attributes) of information, but concentrate on the cost of creating and/or focusing on the income it generates. These models where commonly used by Glazer [Gla91][Gla93] and Wilkins et al [WWH97] in their valuation attempts. These are variations on the utility method for asset valuation.

Table 4: valuation methods

<table>
<thead>
<tr>
<th>Authors</th>
<th>Use</th>
<th>Glazer</th>
<th>Moodys &amp; Walsh</th>
<th>Chen</th>
<th>Poore</th>
<th>Wilkins et al</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Utility</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost based</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Usage over time</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Risk aspects</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information specific properties used in the valuation</td>
<td></td>
<td>Usage</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Timeliness</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accuracy</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shareable</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rarity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

4.1 Valuing information

After reviewing the literature and answering the mentioned research questions, I conclude that information valuing depends on a number of main concepts. What information to value (defined information assets), the audience for the valuation, the context of the valuation and what economic attributes of information to include in the valuation.

1) Identify information asset. As a starting point I recommend using the revised list of information assets by Oppenheim et al. They empirically tested the list of information assets of the Hawley Report and made a few minor changes to the list. This list is a more concrete example what Glazer calls “meaningful information” and is good example of groupings of information that fall into an organizational pattern. The five types of information identified by Repo are less suitable to use in a valuation attempt, since they cannot be related to any organizational pattern and are very abstract.

2) A second step is to determine the audience of the valuation. The audience of the valuation comprises an
5. SUMMARY & CONCLUSION

The concept of information valuing has been researched for a number of years. Information is valued as important, but still there is no practical method in use to value information. There are a number of authors who define some value increasing properties of information. But only a handful of these properties are highlighted by the same authors. These are, accuracy, timeliness, usage and information is sharable. Also, there are still very few valuation attempts made and most of them are different from others, this seems to collaborate the most important aspect of valuing information, its context. The identification of information assets has received some attention from science and business, but it concentrated on finding commonly used groupings of information. There is still no framework in which information assets can be identified and used as a basis for the valuation. In short, valuing (or researching this topic) comprises four different steps. 1) Identify information assets, 2) determine the audience for the valuation, 3) determine the context, 4) value information using an existing model 4b) come up with a model that is suitable for this specific valuation context.

6. FUTURE RESEARCH

There is still much unknown about the valuation of information. I was able to synthesize a conceptual framework for the valuation of information, but none of the proposed methods reviewed seem to be in use today. I will propose future research guidelines according to my conceptual framework. The first step is in indentifying the information assets. Oppenheim et al tried to refine the economical attributes of information and determined that all attributes granted to information by science are not valued in practice. One of the first steps could be a action or case study research to confirm or deny this theory. These kinds of research types can also be used to validate the information assets defined by the Hawley Report [Haw94]. I would also suggest to start researching for ways to determine information assets for a situation specific way. It is possible that there is some deviation between industries and different companies. The value of information itself depends heavily on the context and audience of the valuation. The different valuation models [Gla91][Gla93][MW99][Che95][Poo00] seem to collaborate this statement. The literature explicitly mentions the context of usage has a direct effect on the valuation of information, but fails to mention what contexts are available. Determining the context of information valuing should be a next step in researching this topic, this also incorporates assigning the relevant economic attributes in the particular context of the valuation. For example, the model used by Chen [Che05] depends heavily on usage and time, but the models of Poore and Moody & Walsh also use additional properties of information [Poo00][MW99]. This can be done by an initial literature study to determine a few initial contexts and assigning the attributes. This can be tested by a case study and refined by using an action research program. As a final step valuation models have to be created for different valuation contexts.

ACKNOWLEDGEMENTS

I would like to thank my course tutor Daniel Moody for suggesting this interesting topic about information valuation and for his comments on my draft paper.

REFERENCES


[CG86] B Cronin and M Gudim. Information and productivity: a review of research. International


