Radboud University Nijmegen
Faculty of Science
Institute for Computing and Information Sciences

Information value in a decision making context

A case study and definition of a measurement model

Author
Joep Top
Student No. 4055268
joeptop@student.ru.nl

Internal supervisor
Prof. dr. ir. Th.P. van der Weide
th.p.vanderweide@cs.ru.nl

External supervisor
K. Matthijsen, MSc
kjell.matthijssen@CompanyX.nl

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Abstract

To perform better than the competition, companies need to make effective decisions. This requires valuable information and *Business Intelligence*. Currently there is a lack of research on information value, therefore this research defines and evaluates a measurement model to measure information value. The model is based on theory and practical experiences at the energy company CompanyX. By knowing the value of information and its foundation, information can be improved and can provide better support in decision making. The model is concise, clear and broadly applicable, though it should be adapted to the organization to get the most out of it. Also the right balance has to be found between measurement speed and measurement quality.

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1 Introduction

1.1 Motivation

The energy company CompanyX would like to have a better perception of the value of information products, such as reports. Information products are created from various data sources and provide insight into how the organisation is performing. CompanyX owns much raw data which offers many information product opportunities. Unfortunately, creating information products requires resources and therefore it is desired to estimate the value of information products. Developers of information products are also curious how much value they are adding to the company. By knowing the value of information products, a better assessment can be made to what extent an information product can be used for making decisions within the organisation.

1.2 CompanyX

To define and evaluate a model for measuring the value information products, this research takes place at the energy company CompanyX. In general, CompanyX is a company that provides energy to households and businesses.

1.2.1 The Energy market

The main activity of an energy company is buying and selling products and services in a form of energy. Basically, everyone with buying and selling skills can start an energy company. This leads to much competition and energy companies can no longer distinguish themselves by just the energy price. Presently they have to make a distinction based on the experience, for instance by: being green, giving consumer interesting energy usage information or supply them with innovative (energy) products. It is important for energy companies to make the right decisions so that they can be as efficient and as effective as possible. Therefore they need valuable information.

1.2.2 CompanyX's goal (left out to protect CompanyX's privacy)

1.2.3 CompanyX's background (left out to protect CompanyX's privacy)

1.3 Relevance

Currently, there is still a lack of research and case studies on measuring the value of information products. In literature the problem is comparable to measuring the value of business intelligence (BI). “Measuring the business value of business intelligence in practice is often not carried out due to the lack of measurement methods and resources.” (Popovič et al., 2010). A case study from Pirttimäki et al. (2006) on Measurement of business intelligence in a telecommunications company also stated that additional case studies on the subject are desired.

1.4 Research goal: A model to measure the value of information products

The goal of this research is to create a measurement model, which can be used to determine which information products are valuable. Information products are required to support decision making and when knowing the value of the information product, a better assessment can be made whether an information product should or should not be created. By having a better insight into the value of information, BI managers also have a better capability of achieving their goal, which is to increase the benefits/costs ratio (Pirttimäki, Lönnqvist, & Karjaluoto, 2006).

The measurement model will be used to provide input for business decisions in the BI and IT landscape of CompanyX. In the past information products are often associated with costs only and not with benefits. This makes it also difficult to convince management to invest in business intelligence.

This research is a case study on the measurement of business intelligence and consequently fills the gap in literature mentioned earlier. The measurement model fits the energy company CompanyX and might also be helpful for other organisations.

1.5 Problem statement and research question

There is a need for a measurement model to measure the value of information products from a practical and scientific perspective and currently there is none. By creating this model the following research question will be answered:

How to measure the value of (business intelligence) information products at the energy company CompanyX*?*

Before answering this question the following sub questions need to be answered:

- What is business intelligence?
- What is information?
- What makes information valuable?
- How to determine and present the value of information?

1.6 Research method and structure

This thesis contains a case study and a definition of a model to measure the value of information products. The case study contains a comparison of theoretical and practical findings, where theoretical findings originate from a literature review and practical findings originate from a qualitative and quantitative research approach at the energy company CompanyX. Interviews are held at different business units to review the current situation regarding information value and its context: business intelligence. Questionnaires are used to find out what information value criteria are most important for the organisation. By combining the findings from theory and practice, a practical model to measure the value of information can be defined. After it has been defined it will be tested and evaluated.

This is described in this thesis using the following structure:

1. Introduction
2. Description of the business intelligence context CompanyX vs. literature
3. Theory of information value vs. CompanyX regarding information value.
4. Definition of a practical model to measure information value, including evaluation.
5. Discussion
6. Conclusion

2 Context: What is business intelligence (BI)?

2.1 Business intelligence in terms of Data, Information, Knowledge and Wisdom

Before going into detail about business intelligence, the relevant terms data, information, knowledge and wisdom will be defined first.

In the business world, information is defined as facts or details about a person, company or product etc.[1]. The difference between data and information is that information interpreted, organized, structured or presented as being meaningful or useful[2]: information is data with a context. Ackoff (1989) describes information in relation to data, knowledge and wisdom. This relation is often quoted in literature (Rowley, 2007) by using the DIKW pyramid (Figure 1):

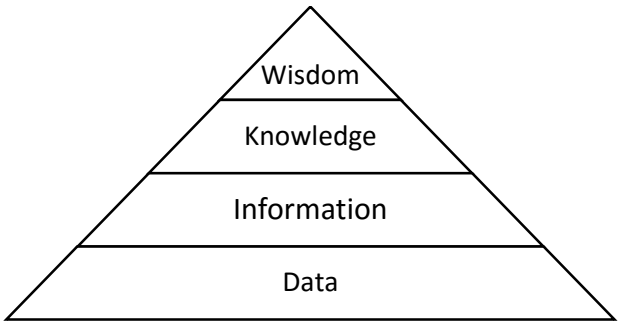


Figure 1 DIKW pyramid, Rowley (2007)

Knowledge can be described as a mix of information, understanding, capability, experience, skills and values (Rowley, 2007). Wisdom can be described as the ability to think and act using this knowledge[3].

When applying the DIKW pyramid in a business context, the process of leveling up from data to wisdom could be described as business intelligence, mainly because business data has the potential to result into business knowledge and wisdom.

2.2 Business intelligence in literature

2.2.1 Origin of business intelligence

The term business intelligence became popular for business and IT communities in the 1990s (Chen, Chiang, & Storey, 2012). Its definition can vary in the business and academic world and therefore clarification is required.

2.2.2 Description of business intelligence

Based on literature research on the definition of business intelligence, Lönnqvist & Pirttimäki (2006) stated that the term business intelligence is about:

[1] http://dictionary.cambridge.org/dictionary/business-english/information
[2] http://www.diffen.com/difference/Data_vs_Information
[3] http://dictionary.reference.com/browse/wisdom

1. Relevant **information and knowledge** describing the business environment, the organisation itself, and its situation in relation to its markets, customers, competitors, and economic issues.
2. An organized and systematic **process** by which organisations acquire, analyze, and distribute information from both internal and external information sources significant for their business activities and for decision making.

Business intelligence can also be interpreted as: competitive intelligence, market intelligence, customer intelligence, competitor intelligence and strategic intelligence (Pirttimäki, Lönnqvist, & Karjaluoto, 2006). Ghazanfari et. al (2011) mention that business intelligence can be viewed from a managerial and technical perspective. The managerial perspective sees business intelligence more as a process. The technical perspective considers business intelligence as a set of technologies, algorithms and tools that supports this process.

2.2.3 Goals of the information produced by business intelligence

Lönnqvist & Pirttimäki (2006) see business intelligence as a "managerial philosophy and a tool that is used in order to help organisations to manage and refine information and to make more effective business decisions". Improving the support on decision making is the most important goal of business intelligence and this is mentioned in many other descriptions of business intelligence (Williams & Williams, 2003, 2010; Pirttimäki, Lönnqvist, & Karjaluoto, 2006; Lönnqvist & Pirttimäki, 2006; Arnott & Gibson, 2005; Ghazanfari, Jafari, & Rouhani, 2011; Popovič, Turk, & Jaklič, 2010; Isik, Jones, & Sidorova, 2011).

According to Williams and Williams (2010) "Business decisions are generally classified as strategic, tactical or operational, although in practice the distinctions can be blurred". In short, they make a distinction between the extremes: the operational and strategic decisions (Table 1).

They also recommend not to focus on the nonstrategic parts of the business: "To have a profit impact, BI investments must be directed at management processes and/or business processes that have the greatest impact on profits." (Williams & Williams, 2010)

Operational decision making	**Strategic decision making**
• Lesser importance	• Greater importance
• Frequent, short life	• Long life (several years)
• Day-to-day business activities	• Enterprise scope

Table 1 Operational vs. Strategic decisions (Williams & Williams, 2010)

2.2.4 Characteristics of business intelligence

In practice, business intelligence is found to be individualistic and ad hoc (Williams & Williams, 2010). This means that people work hard to do everything possible with the data and time available, without having time for extensive scenario analysis and assessment of alternative courses of action. BI applications are too easily installed and change management activities are underfunded, which is a shared problem in the BI industry (Williams & Williams, 2010).

Currently, the trends in business intelligence are Big Data and Business Analytics (Chen, Chiang, & Storey, 2012). Big Data is the "term describing the storage and analysis of large and or complex data sets using a series of techniques including, but not limited to: NoSQL, MapReduce and machine learning" (Ward & Barker, 2013). Business Analytics is about the underlying mathematics of business intelligence. It is getting more advanced, having the potential to create more valuable information.

Major vendors of information systems such as Microsoft, Oracle, and SAP are increasing their commitment and investment in BI (Watson & Wixom, 2007). Companies using their systems could benefit from this, though they can be bottlenecked from their own business intelligence infrastructure.

2.3 Business intelligence at CompanyX

2.3.1 Description of business intelligence

Business intelligence for CompanyX can currently be described as the process of creating, delivering and consuming information products like reports that view how the company or market performed in the past. Opinions differ in the type of information product; some agree that business intelligence is more about advanced information products that include: optimization, forecasting and finding correlations. Other employees do not mention this specifically. A few employees admit that currently most information products are not very advanced, but that they are moving to more advanced information products with better analytics. In practice this means that many reports are still static and there is less integration. CompanyX requires (improved) business intelligence in operational decision making without requiring too much analysis capabilities. For tactical and strategic decision making, improved insight in company performance and progress is required. Also drilling down capabilities to zoom in to more details.

2.3.2 Goals of business intelligence and its information products

CompanyX uses information products for operational and strategic/tactical decisions. Examples of operational decisions can be about fixing errors or customer contact. Tactical/strategic decisions are for instance about improving efficiency of certain processes: what to digitalize, what to change in customer contact and how to tackle bad payers.

A simplified process of business intelligence and decision making is presented in Figure 2, where the arrows describe the relations between the objects in chronological order.

1. This model starts with the process of creating information from data. In the past, this process was complex, because the **BI/IT infrastructure** was decentralized and had less integration.
2. Then the created **information product** is interpreted and used by an employee.
3. The employee makes a **decision** or gives advice to a decision maker who then makes a decision.
4. The ultimate goal of the information products is to create business value, which means that the BI process can also be seen as a value chain. So for information value, business value should not be ignored.

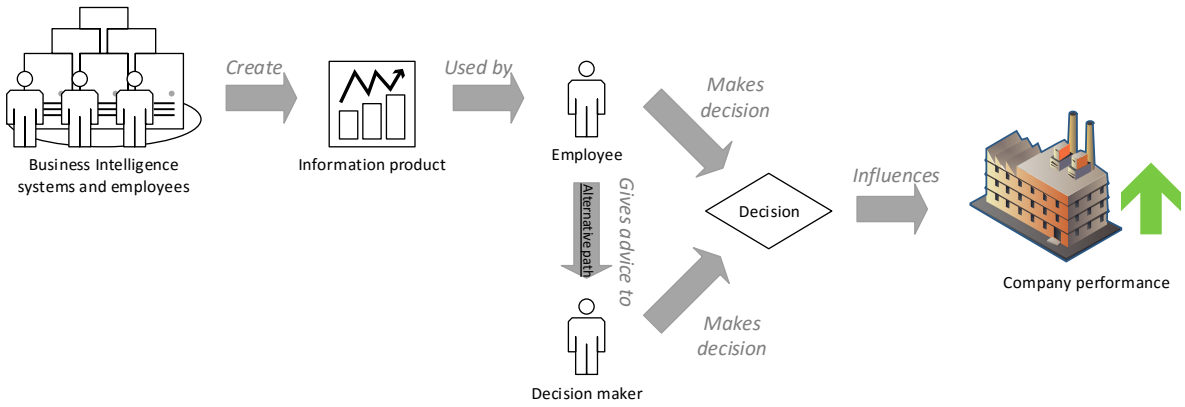


Figure 2 Simplified process of business intelligence, information and decision making

2.3.3 Characteristics of business intelligence

Currently, CompanyX's business intelligence environment can be characterized as:

- Costly
- Inefficient (change process)
- Complex
- Decentralized and distributed
- Isolated technical environments
- Much redundancy
- Limited data integration
- No single version of facts
- Same sources are used multiple times in extraction
- Not able to support future business intelligence capabilities
  - E.g. Big Data, visualization and a sandbox mode

2.4 Business intelligence: Literature vs. CompanyX

2.4.1 Description of business intelligence

In general, CompanyX's employees agree with the second interpretation of business intelligence from Lönnqvist & Pirttimäki (2006) that business intelligence is about the process. A very small part of the interviewed employees tend to interpret business intelligence as described by the first interpretation. They interpret business intelligence as being the result of the process: the business information or knowledge.

CompanyX also uses more specific terms for business intelligence. CompanyX's marketing unit for example uses the term Customer Intelligence, when emphasizing on the commercial focus of business intelligence.

The definition described by CompanyX mainly focusses on the managerial approach, which seems logical because interviews were mainly held with managers and not with technical employees of the IT department.

2.4.2 Goals of the information produced by business intelligence

Both in literature and at CompanyX, the goal of business intelligence is to support decision making within management and operational processes.

2.4.3 Characteristics of business intelligence

The individualistic and ad hoc approach mentioned in literature could have been one of reasons of the much redundancy and the no single version of facts. A centralized infrastructure with improved data

governance and more data integration can tackle those problems. This also offers better opportunities for future business intelligence capabilities. Though mayor vendors are improving the BI capabilities the information systems, it is for organisations important to improve their data governance and IT infrastructure first. Though it might be important for CompanyX to quickly and easily deploy BI applications, it could have been the reason for the inefficient change process.

The BI characteristics from the past are mainly about the transformation of data to information. For information value, it is also important to consider the effects of the information: the decision making process.

2.5 CompanyX future plan of business intelligence: The BI-roadmap

CompanyX is currently experiencing a mayor change in business intelligence, mainly to support future possibilities and to tackle the negative characteristics mentioned in chapter 2.3.3.

In the future, CompanyX requires more real time information, improved (scenario) forecasting and the ability to explore new markets and products. Big data is also a hot topic for CompanyX and this trend is being confirmed in literature as well (Chen, Chiang, & Storey, 2012). Besides storage and analysis, Big Data is also about the retrieval of the data according to CompanyX. A typical example of Big Data at CompanyX is the issue of managing the large amount of data provided by smart energy meters of millions of consumers at the same time. Besides using business and market data, CompanyX also thinks about the possibilities of utilizing data from external sources like social media, satellites and CBS (central bureau for statistics).

The plan: the BI-roadmap, started with both business and IT drivers (Table 2).

Business driver: BI business value	IT driver: BI optimization
• Support on competition; secure margin and volume • Support on innovation; develop new margin opportunities • Support on marketing; powerful sales and marketing	• Reduce IT and support costs • **Increase quality of information** • Increase BI capabilities • Adequate compliance support

Table 2 Business & IT drivers

The BI-Roadmap includes the following requirements:

- ➔ BI support on *Farm*: operational excellence improvement needs to be supported
- ➔ BI support on *Grow*: more and better customer, product, partner and channel insights are necessary
- ➔ BI support on *Innovate*: Big Data, visualization and market- and energy analytics capabilities will be needed

The main difference between the new and the previous architecture is that the new architecture improves **data integration** and removes complexity. Each Business Unit should now only require one centralized information sytem with its own required data sources. Integration between bussiness units is still possible, but a higher level.

A **Data Governance Repository** ensures data integrity, for instance by checking if data matches the standards, definitions and business rules.

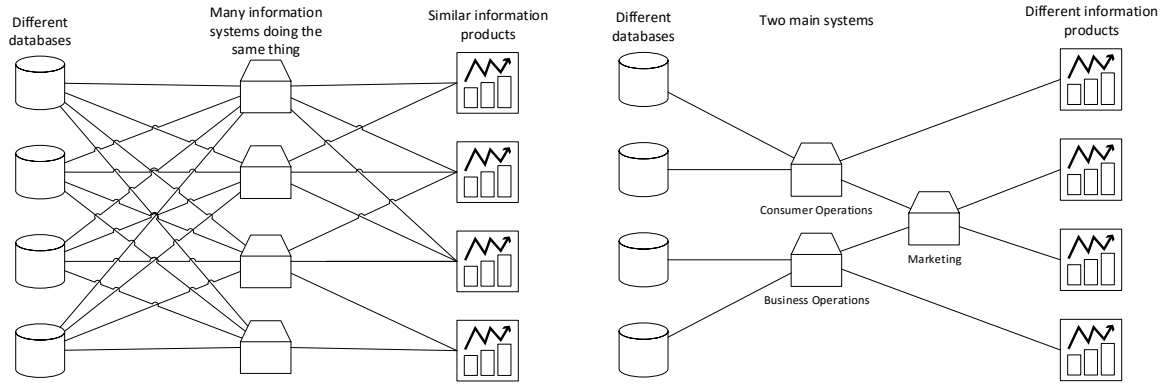


Figure 3 Example of the current (left) and future BI infrastructure (right)

2.6 Conclusions on business intelligence

CompanyX mainly sees business intelligence as a process of creating, delivering and consuming information from internal sources or market research. Besides this definition, business intelligence can also be seen as the information or 'intelligence' resulted from this process. This is important, because this means that there is a difference between the value of information products and the value of business intelligence. Nevertheless, according to literature and CompanyX, the goal of business intelligence is decision making and CompanyX hopes to improve the support on this.

Learning from literature and CompanyX, business intelligence can create problems such as complexity and redundancy. It is important to tackle these problems and CompanyX tries to do so with their BI roadmap, including important aspects such as centralization and data governance.

The BI Roadmap does not include a model to measure the value of the individual information products. Before developing a measurement model, it is important to research how information value can be defined and how this fits with CompanyX.

3 The value of information

3.1 In general: Information usability

3.1.1 In literature

Kelly (1993) states that value is created as a result of *utilising* the information (or intelligence). Information is utilized for instance when it improves operational processes and management processes (Williams, 2003). Information is *used* for decision making, which means that the **usability, usefulness or utilization** of an information product is an important benchmark for its value. Because usefulness and utilization are very similar to usability, there is no distinction made between them in the definition. They can be described as the extent in which the information is usable and useful.

Information has to be valuable for the organisation, therefore it is also possible to look at the business value that resulted from the decision where the information was used. To make this measurable, it is important to know what the goals of the organisation are. Business value is for instance associated with finances, customers or organisational developments (Simmons, 1996). Pirttimäkki et al. (2006) also explain that value for an organisation is often associated with profit.

Besides value for the organisation, Pirttimäkki et al. (2006) also describe that the value for the user is important. They describe that value for the user is typically assosiated with perceived usefullness, supporting the fact that value is associated with usability. According to Wixom and Todd (2005), perceived usefulness is significantly influenced by information satisfaction.

According to Frøkjær et al. (2010), usability consists of three independent aspects, namely: **effectiveness**, **efficiency**, and **satisfaction**. Effectiveness and efficiency can be measured quantitatively and can be related to financial value for the organisation. For satisfaction, it is more complex because it is not tangible. When the satisfaction is low for instance, it is not clear what the reason behind this is. To find out the reason, satisfaction should be divided into sub-criteria. Another difficulty is that satisfaction is qualitative and subjective.

These aspects are also mentioned in the ISO/IEC 25010: 2011 standard as quality characteristics for software and computer systems. The ISO/IEC 25010: 2011 standard also mentions the characteristics: **Freedom from risk** and **Information context coverage**. It is assumed that the information with a high freedom from risk and high context coverage, is more valuable for the organisation.

Over time, usability has been characterized using different characteristics. Cheikhi, Abran & Suryn (2006) gave an overview of literature and ISO standards from 1993-2003.

Dix et al. (1993)	**Nielsen (1994)**	**ISO 9241 (1998)**	**ISO 9126 (2001)**	**Abran et al. (2003)**	**ISO 25010 (2011)**
Effectiveness Efficiency Satisfaction Learnability	Effectiveness Efficiency Satisfaction Learnability	Effectiveness Efficiency Satisfaction	Understandability Learnability Operability Attractiveness Usability compliance	Effectiveness Efficiency Satisfaction Learnability Security	Effectiveness Efficiency Satisfaction Freedom from risk Information context coverage

Table 3 Usability characteristics: different sources over time

The usability criteria from ISO 9126 are very different and feel incomplete compared to the other sources. Scholtz et al. (2013) solves this problem by combining usability criteria from ISO 9241 and ISO 9126 (except usability compliance). They did not yet include the successor of ISO 9241, namely the ISO 25010 standard.

To make this research complete, the characteristics used by Scholtz et al. (2013) and the newer standard are being combined. Also, a very different usability criterion that can be used is added, namely: '**Fun-to-use**'. This criterion was used in research on the usability of user interfaces (Haan, Veer, & Vliet, 1991) and might also be valuable.

In the following paragraphs, the usability criteria from ISO 25010:2011 are being described in more detail.

3.1.2 At CompanyX

Business value for CompanyX is very much related to the goals of CompanyX (chapter 1.2.2), and to some extent are similar to the business value examples given by Simmons (2006). One of CompanyX's goals is "appealing to work for", making the user and organisational perspective on information value both important to evaluate (Pirttimäki, Lönnqvist, & Karjaluoto, 2006). Overall, the financial value for the organisation is made explicit when this is possible and required. Value for the user on the other hand is generally not made explicit because it is time consuming.

3.2 Information usability: Effectiveness

3.2.1 In literature

Effectiveness is about the actual effect the users can achieve by using the information product for a decision. If the decision resulted into business value *because* of the information, then the information is effective. To identify if a decision resulted into value, it is required to monitor finances or other business goals (using other information products). **Extra income** can be measured for instance by evaluating the extra sold services or products. A company can also evaluate the costs that can be saved when using information products **saved costs**. An empirical study on 50 Finnish companies found that that most companies do not consider time and costs savings as the primary benefits when investing in business intelligence (Hannula & Pirttimäki, 2003). But a company can save costs for instance by evaluating the 'seven wastes' defined by the Toyota production system (Ōno, 1988) on: Transportation, Inventory, Motion, Waiting, Over-processing, Over-production, Defect.

business intelligence can offer intangible benefits (Arnott & Gibson, 2005). Therfore, the effectiveness is difficult to measure or estimate. The **indirect relation** between information and business value is also one of the challenges that make the value of information difficult to determine. Moreover, confounding variables could also influence business value.

It is possible to ask the user if the information product was effective. Davison (2001) for instance asks the user to rate the **certainty of making the right decision with and without** the information. Knowing this, the indirect relation between the information product and business value is clearer. When the decision maker is totally dependent on the information, then the financial value of the decision and the information product can be seen as equal, when ignoring the costs for using, building and maintaining the information product.

3.2.2 At CompanyX

CompanyX is a commercial company and therefore is mainly interested in the financial effects. In contrast to the case study of Hannula and Pirttimäki (2003), CompanyX *does* consider time and costs savings as one of the primary benefits in business intelligence. Cost savings are mainly short term

oriented, while extra income is better expressed on the long term. Determining these effects can be challenging, unless the information product is a business case that already calculates what income or cost savings can be created. Business cases on phone call reduction are for instance created to make cost saving decisions.

Besides financial effects, the effects on CompanyX's goals (chapter 1.2.2) are also important. They are related in a way, because the business goals should result in enough financial effect to survive.

The effect on customer satisfaction can be for instance determined by using customer satisfaction data from the customer surveys. The effect on employee satisfaction can be for instance determined by using the satisfaction data from the employee surveys.

3.3 Information usability: Efficiency

3.3.1 In literature

Information efficiency is mainlly about saving time and effort. This is quantifiable by measuring the involved system activities, which were also measured in a case study on measuring business intelligence (Pirttimäki, Lönnqvist, & Karjaluoto, 2006). It includes measuring time and number of clicks when using an information product, though the number of clicks often is not what is important to users: What's more important is "whether or not they're successful at finding what they're seeking" (Porter, 2003).

3.3.2 At CompanyX

CompanyX's dashboard environment captures for each information product per user: the used time and used number of selections. Then it calculates the avarage time and number of clicks used for an information product. It is not commonly used as a measure of qualilty, but it is used for detecting information products not beeing used at all. Currently, the number of information products in the dashboard environment is limited, meaning that the usage data is not available for each information product.

3.4 Information usability: Freedom from Risk

3.4.1 In literature

Since ISO 25010 (2011), freedom from risk has been introduced as a characteristic of usability. The changed definition of usability means that freedom from risk is not been commonly used in usability research. Freedom from risk is the degree to which the information product "mitigates the potential risk to economic status, human life, health, or the environment". According to a literature overview on software ecosystems by Fotrousi et. al. (2014), freedom from risk furthermore includes the related concerns of security, reliability, maturity, availability, and other related guarantees.

Creating information products can also introduce risks. To make these risk visible, Williams and Williams (2010) suggest using a BI risk/opportunity map (Figure 4). Though the map is mainly used for the larger BI projects, it might also be useful to evaluate smaller projects involved in new information products. Project A and B can be for instance information products with a great potential to deliver business value. In general, the risk is calculated by multiplying the risk **probability** with the risk **impact**[4], though these factors can be challenging to determine.

[4] https://technet.microsoft.com/en-us/library/cc535373.aspx

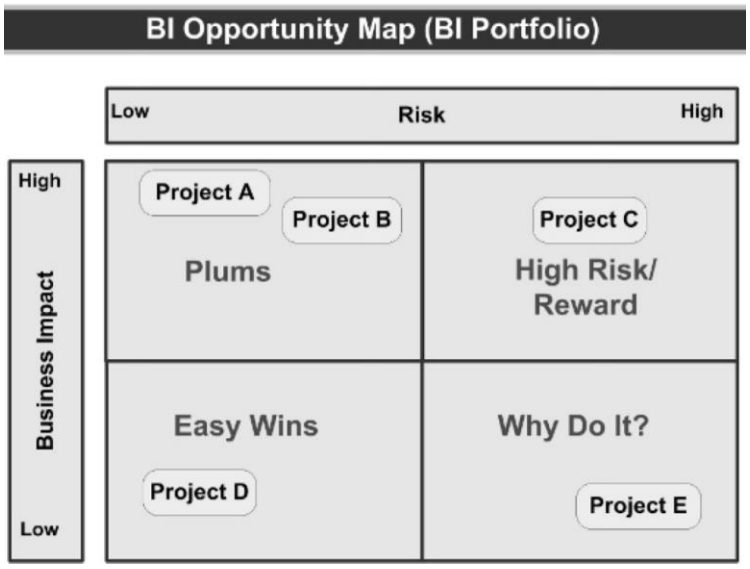


Figure 4 BI opportunity map (Williams & Williams, 2010)

3.4.2 At CompanyX

The aspect: *freedom from risk* is very valuable for CompanyX in the context of creating information products. For example: Information products that deal with compliancy often have a higher priority compared to other information products, because these information products can prevent CompanyX from receiving expensive fines.

CompanyX uses similar maps (Williams & Williams, 2010) to decide how to prioritize the creation of information products. At Business operations (B2B) for instance, they use "Financial Value" instead of "Business Impact" along the y-axis and "Effort" instead of "Risk" along the x-axis. Quantifying the risk can be challenging and costs effort, therefore it is not done explicitly when creating lower effort information products. Moreover, it also slows down the business process. Larger IT and business intelligence projects on the other hand, require a more extensive analysis.

The information itself can also be a risk according to CompanyX. For instance, the information might give an incomplete view of the reality, might contain errors or can be misinterpreted leading to bad decisions. Sensitive and private information should also be treated carefully and when building information products, the required processing power is also taken into consideration. This means that one has to be aware of reliability, security and availability, when it comes to information and the freedom from risk. Apart from the larger projects, the risk of information products is not quantified, but is implicitly dealt with. The reason for this is because it is not possible or requires too much time.

3.5 Information usability: Context coverage

3.5.1 In literature

Similar to *freedom from risk*, information context coverage was recently introduced in ISO 25010 (2011) as well. It is the degree in which the information product can be used in different contexts. It is quantifiable for instance by counting the different users of an information product.

3.5.2 At CompanyX

As mentioned in chapter 3.3, CompanyX's dashboard environment registers the information usage for each user. This means that the amount of contexts where an information product is used in could be measured. Otherwise, there are also other ways of finding out who is using the information products.

3.6 Information usability: Satisfaction

3.6.1 In literature

Satisfaction is one of the criteria that needs more clarification. If a user is satisfied with the information, it is not clear on what aspect of the information the user is satisfied with. This means it is not clear on how to improve the information.

Criterion name	**Description**
Information quality	
Completeness	*The degree to which the system provides all necessary information*
Accuracy	*The user's perception that the information is correct*
Format	*The user's perception of how well the information is presented*
Currency	*Represents the user's perception of the degree to which the information is up to date*
System quality	
Reliability	*The dependability of system operation*
Flexibility	*The way the system adapts to changing demands of the user*
Integration	*The way the system allows data to be integrated from various sources*
Accessibility	*The ease with which information can be accessed or extracted from the system,*
Timeliness	*The degree to which the system offers timely responses to requests for information or action*

Table 4 Wixom and Todd (2005) Criteria related to Information Satisfaction

According to Wixom and Todd (2005), the perceived usefulness (or usability) of information is significantly influenced by the information satisfaction. They found that the most important input criteria for measuring information satisfaction are **accuracy** and **completeness** through information quality. The **reliability** and **accessibility** are most important through system quality.

Wixom and Todd (2005) indicate that when decisions are more operational, aspects like timeliness will possibly play a more important role. Their criteria for information quality were selected because they are widely used, representative, and relevant to the IT. They mention the list is not extensive, meaning that other criteria can be relevant. Eppler (2003) for example found seventy typical information quality criteria and developed a framework outputting sixteen criteria which should cover all aspects of Information quality (Table 5).

Criterion name	Description
Comprehensiveness	*Is the scope of information adequate? (not too much nor too little)*
Conciseness	*Is the information to the point, void of unnecessary elements?*
Clarity	*Is the information understandable or comprehensible to the target group?*
Correctness	*Is the information free of distortion, bias, or error?*
Accuracy	*Is the information precise enough and close enough to reality?*
Consistency	*Is the information free of contradictions or convention breaks?*
Applicability	*Can the information be directly applied? Is it useful?*
Timeliness	*Is the information processed and delivered rapidly without delays?*
Traceability	*Is the background of the information visible (author, date etc.)?*
Maintainability	*Can all of the information be organized and updated on ongoing basis?*
Interactivity	*Can the information process be adapted by the information consumer?*
Speed	*Can the infrastructure match the user's working pace?*
Security	*Is the information protected against loss or unauthorized access?*
Currency	*Is the information up-to-date and not obsolete?*
Accessibility	*Is there a continuous and unobstructed way to get to the information?*
Convenience	*Does the information provision correspond to the user's needs and habits?*

Table 5 Eppler's (2003) criteria and descriptions

It is important that criteria are clearly defined, because they can be interpreted differently, especially when comparing literature. In literature, different criteria can have the same definition, while similar criteria can have a different definition. By comparing Wixom and Todd's criteria to Eppler's criteria for instance, the following can be concluded:

- Wixom and Todd (2005) do not make a distinction between **accuracy** and **correctness**: "accuracy represents the user's perception that the information is correct".
- **Interactivity** (Eppler, 2003) and **flexibility** (Wixom & Todd, 2005) are similar, both are about the ability to adapt to the (changing) demands of the user.
- **Completeness** and **comprehensiveness** are similar, because both are about "providing all necessary information" (Wixom & Todd, 2005), "not too much not too little" (Eppler, 2003).
- **Format** and **clarity** are almost similar. According to Wixom and Todd (2005) "Format represents the user's perception of how *well* the information is presented", while clarity represents the user's perception of how *clear* the information is presented.
- **Security** and **maintainability** are not used by Wixom and Todd (2005). According to the ISO/IEC 25010:2011 standard, these criteria are important for developping software and computer systems. Information is created and managed *within* these software and computer systems. Therefore, security is not really related with *information* value. The maintainability of information products on the other hand, *can* be valueable from a developer or organisiational perspective.
- Wixom and Todd (2005) only include the criterion **timeliness**: which is about fast response to actions ánd information requests. The response to action is similar to Eppler's criteria: **speed**.
- **Integration** is not very well supported by the model and is not considered as one of the important quality criteria according to Eppler (2003). It is still assumed that integration creates higher quality information, because by integrating more sources, information is better balanced and more objective.
- Criteria that have been used by both Eppler (2003) and Wixom and Todd (2005) are: **currency** and **accessibility**.
- New criteria are: **applicability, consistency**, **convenience**, **traceability and conciseness.**

Popovič et al. (2010) used eight of Eppler's criteria for measuring the maturity of business intelligence systems, namely: comprehensiveness, clarity, conciseness, consistency, correctness (or accuracy/ precision), convenience, traceability, and interactivity (or flexibility).

Criterion name	Description
Accuracy / precision / correctness	*Information should be precise and close to reality. Also information should be free of distortion, bias, or errors*
Consistency	*The information should be free of contradictions or convention breaks*
Applicability	*Information should be able to be applied directly*
Clarity / format	*Information should be well, understandably and clearly presented to user*
Comprehensiveness / completeness	*The scope of information should be adequate. There should be not too much nor too little information*
Conciseness	*The information should be to the point and should void of unnecessary elements*
Convenience	*The information should correspond to the user's needs and habits*
Currency	*The information should up-to-date and not obsolete*
Traceability	*The background of the information should be traceable, such as the used data, author(s)*
Accessibility	*The information should be continuously accessible without not to many obstructions*
Flexibility	*The information should be able to adapt to (the changing demands of) the user?*
Integration	*The system should allow data to be integrated from various sources*
Reliability	*The system operation should be reliable*
Timeliness / Speed	*The information should be processed and delivered rapidly without delays. The information should also match the user's working pace*

Table 6 Most important criteria joined from Eppler (2003) and Wixom & Todd (2005)

Davison (2001) also used similar criteria for measuring the satisfaction of information, though these criteria are not as complete. He recommends using a survey to measure satisfaction criteria on a five-point Likert scale. It is not uncommon to measure satisfaction and business intelligence using surveys with a five-point Likert scale: Isik et al. (2011) for example use a five-point Likert scale to measure the satisfaction of business intelligence and Ghazanfari et al. (2011) evaluated business intelligence characteristics also by using a five-point Likert scale.

To verify the value of a new information product, the survey should be filled in by a decision maker (Davison, 2001), though take into account that "Decision makers are normally very busy and may be discouraged by a long, time-consuming survey.". Therefore, Davison's survey only includes three questions regarding the three most important satisfaction criteria, fits on one A4 page and Davison furthermore empathizes that the survey should be adapted to fit the decision maker's style. A case study from Pirttimäki et al. (2006) is one of the first papers on measuring business intelligence in practice. By annual user surveys and instant feedback using Davison's criteria, they measure the satisfaction of information.

Besides satisfaction, Davison (2001) asks how certain the user is in making the right decision before and after consuming the information product. He also asks the user to estimate the value of the information product impact.

3.6.2 At CompanyX

At CompanyX it is not common to measure the user/employee satisfaction of information products quantitatively. Though when a user/employee is not satisfied (s)he can give qualitative feedback by sending a message or scheduling a meeting.

CompanyX's dashboard environment offers the opportunity to give qualitative feedback by putting a note on a preferred location on the dashboard, though this functionality is not commonly used.

3.7 An overview of the usability criteria

Table 7 is an overview of usability criteria and description.

Criteria	Description
Effectiveness	*The contribution of the information to the goals of the information and the organisation.*
Efficiency	*The efficiency in using the information*
Information context coverage	*The degree in which the information product can be used in different contexts and multiple times*
Freedom from Risks	*The degree in which the information can mitigate potential risk*
Satisfaction	*The degree in which users are satisfied with the information(sub-criteria)*
Attractiveness	*The capability of the information product to be attractive to the user*
Fun-to-use	*The amount fun in using the information*
Learnability	*The capability of the information product to enable the user to learn its use*
Maintainability	*The information should easily maintainable*
Operability	*The capability of the information product to enable the user to operate and control it*
Understandability	*The capability of the information product to enable the user to understand whether the information is suitable, and how it can be used for particular tasks and conditions of use.*

Table 7 Overview of usability criteria

The theoretical model (Figure 5) presents the criteria that contribute to information value and describes the criteria "satisfaction" and "effectiveness" in more detail. The weights of all criteria can be different in an operational or strategic decision making context.

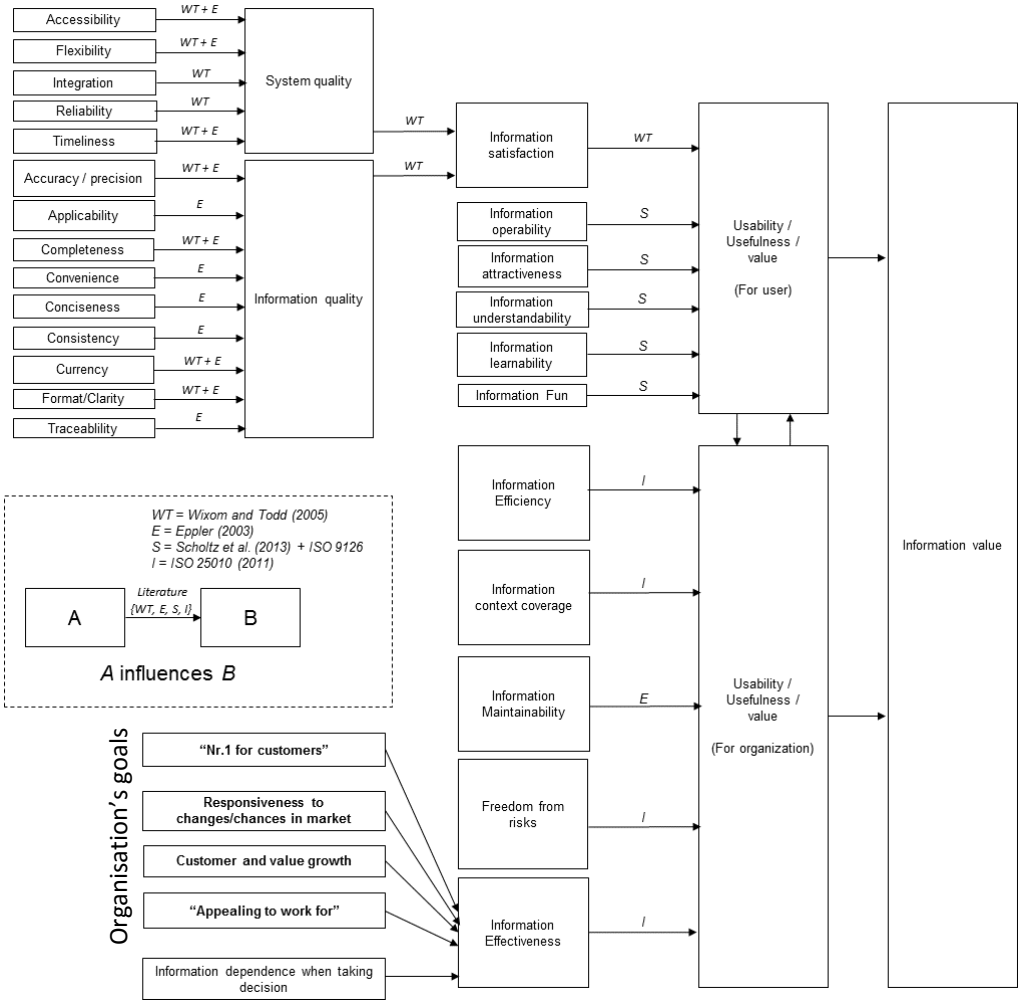


Figure 5 Extensive model on information value

3.8 Increasing the usability of information and its costs

3.8.1 In literature

The creation and improvement of information products within an organisation requires resources. Davison (2001) makes a distinction between the fixed costs and the variable costs, where the variable costs are the costs associated with the output. Negash (2004) describes costs in more detail:

- Hardware costs: already installed vs. not-installed hardware
- Software costs: packages, subscriptions, market data/information
- Implementation costs: training, maintainance
- Personell costs: salary and overhead, space, computing equipment, and other infrastructure for individuals required when peforming and supporting BI (IT)
  *"A sophisticated cost analysis also takes into account the **time spent reading BI output** and the **time spent searching** the Internet and **other sources** for BI"* (Negash, 2004)

For the larger projects on business intelligence and creating information products, Williams and Williams (2010) also recommend a BI readyness assesment, process engineering (how is BI used in the business context?) and change analysis (what changes are required?).

3.8.2 At CompanyX

At CompanyX similar costs are described and quantified, but generally only for the larger projects. As part of change analysis they for instance quantify the "Costs to Change". CompanyX also makes a distinction between fixed costs and variable costs. The costs are not difficult to calculate according to CompanyX's IT department, which is also mentioned by Davison (2001).

- **Fixed costs**
  - IT Infrastructure: CPU, memory, storage etc.
  - Licenses
  - System administrators
  - Generic costs: CIO office, workplaces etc.
- **Variable costs**
  - Working hours required for creating and maintaining information products, measured in: FTE (fulltime-equivalent)

3.9 Conclusions on the value of Information

Information value for the user or organisation can be described by using the usability of the information. Usability can be characterized in many ways. For CompanyX, the most important characteristic of ISO/IEC 25010: 2011 is probably **effectiveness**, because it describes the actual effect of the information on business value and CompanyX's goals. To find out if the usability criteria efficiency, satisfaction, context coverage and freedom from risk are also important, a more extensive analysis is required (see chapter 4.1). This also applies to other usability criteria mentioned in older ISO standards and by Scholtz et al. (2013).

When evaluating information products, the efficiency, effectiveness, context coverage can be measured by using quantitative data. The other criteria are mainly qualitative and subjective. To measure all criteria quantitatively surveys with Likert scales are required for instance.

Assessing the value of future information products can be challenging because the information cannot be used yet. When creating information products it is recommended to keep the usability criteria in mind. For some criteria it is possible to measure their value by making estimations.

4 Defining a model to measure information value at CompanyX

To develop a model for measuring information value at CompanyX, first the most important criteria for CompanyX are selected (chapter 4.1). Then an overview of the different information products used for decision making is given (chapter 4.2), to be able to define a more practical model (chapter 4.3). Finally the model will be tested and evaluated in practice (chapter 4.4).

4.1 What measurement criteria are most important for CompanyX?

4.1.1 Method to find most important criteria

To know what criteria from literature are most important for CompanyX, a survey was held on twelve key employees with different backgrounds. All usability and satisfaction criteria from the theoretical model were rated for an operational and strategic decision making context, because Wixom and Todd (2005) stated that the importance of some criteria could differ between these contexts. The survey tested each criterion on a five-point Likert scale. Using a Likert-scale seemed to be a valid method, because this was also used for measuring satisfaction and business intelligence in other research (chapter 3.6), and it is quickly filled in by respondents. Besides a Likert-scale, employees were also asked to always select the three most important criteria.

4.1.2 Survey results

The results of the survey explain what usability and satisfaction criteria are most important for CompanyX. The results are presented in four graphs, where a higher bar length equals a higher score. The first two graphs present the most important usability criteria (Figure 6 and Figure 7). The second two graphs present the most important satisfaction criteria (Figure 8 and Figure 9). The results from the Likert-scales are very close to each other (Figure 6 and Figure 8), so triangulation by ranking is useful in this situation and (Figure 7 and Figure 9).

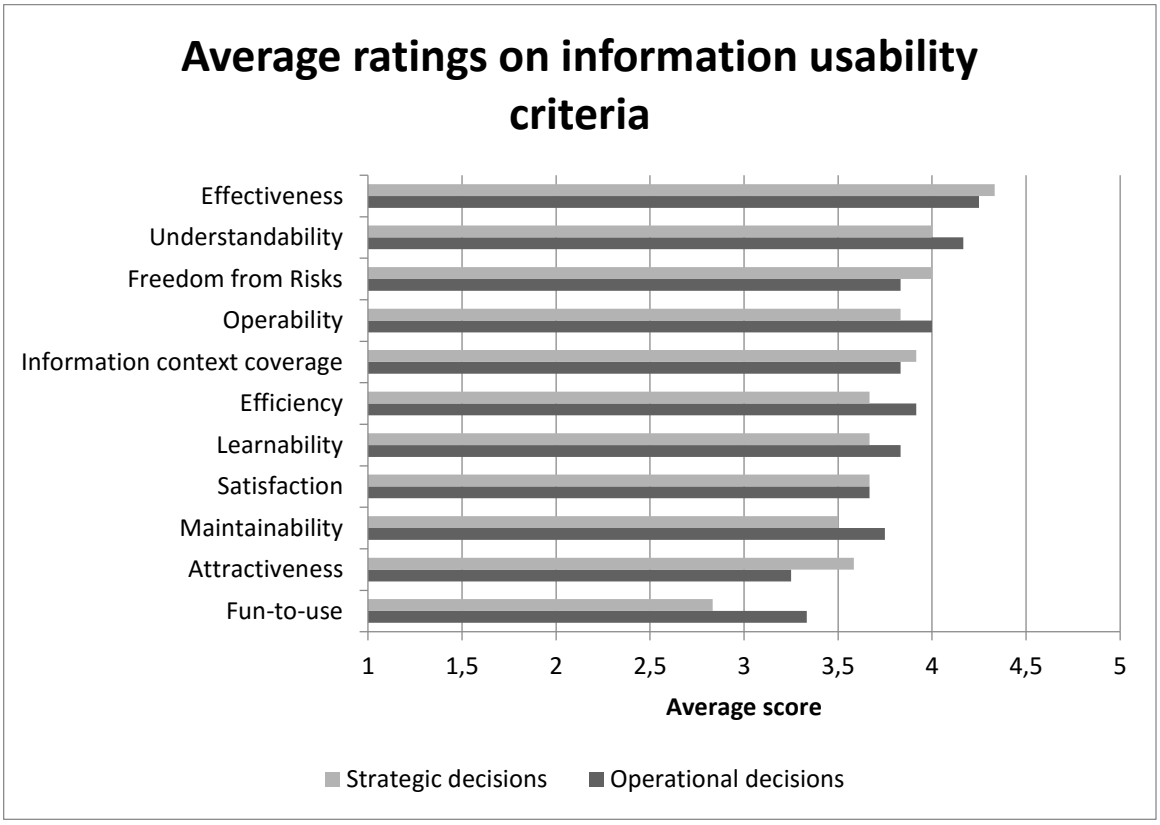


Figure 6 Average ratings by CompanyX on information usability criteria

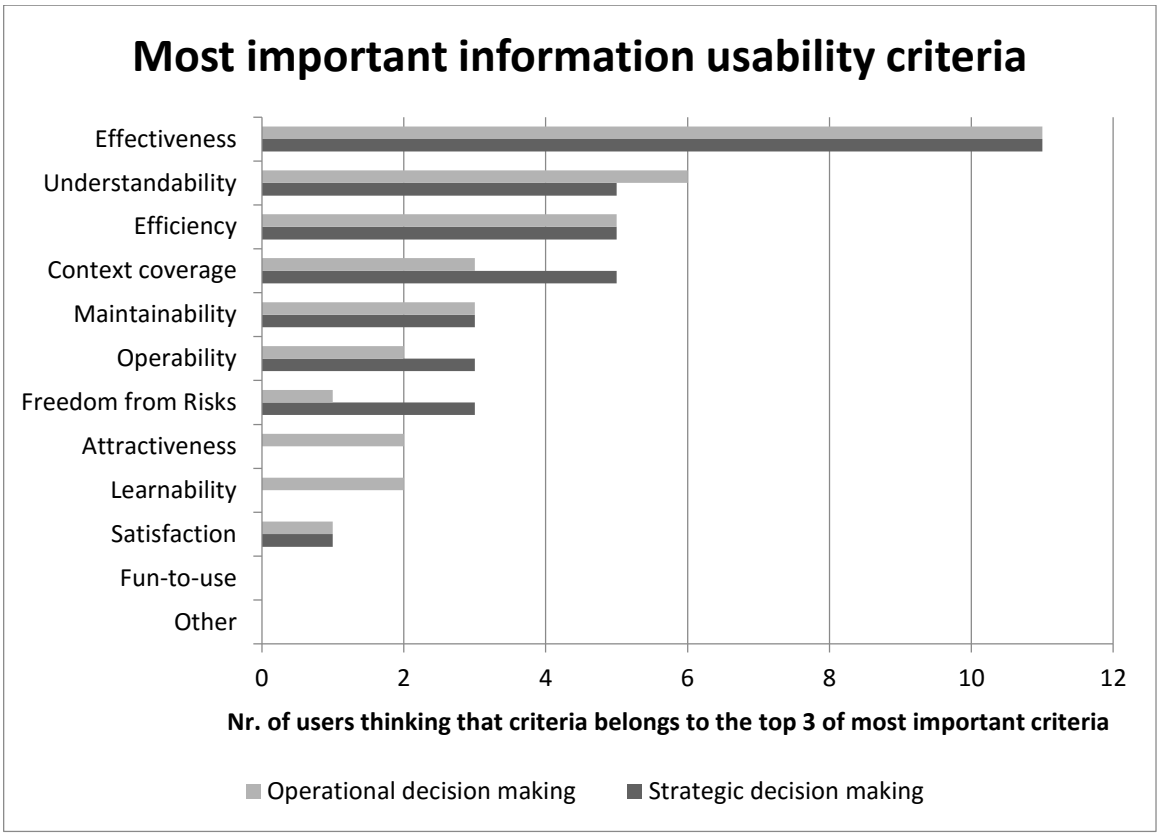


Figure 7 Most important information usability criteria for CompanyX

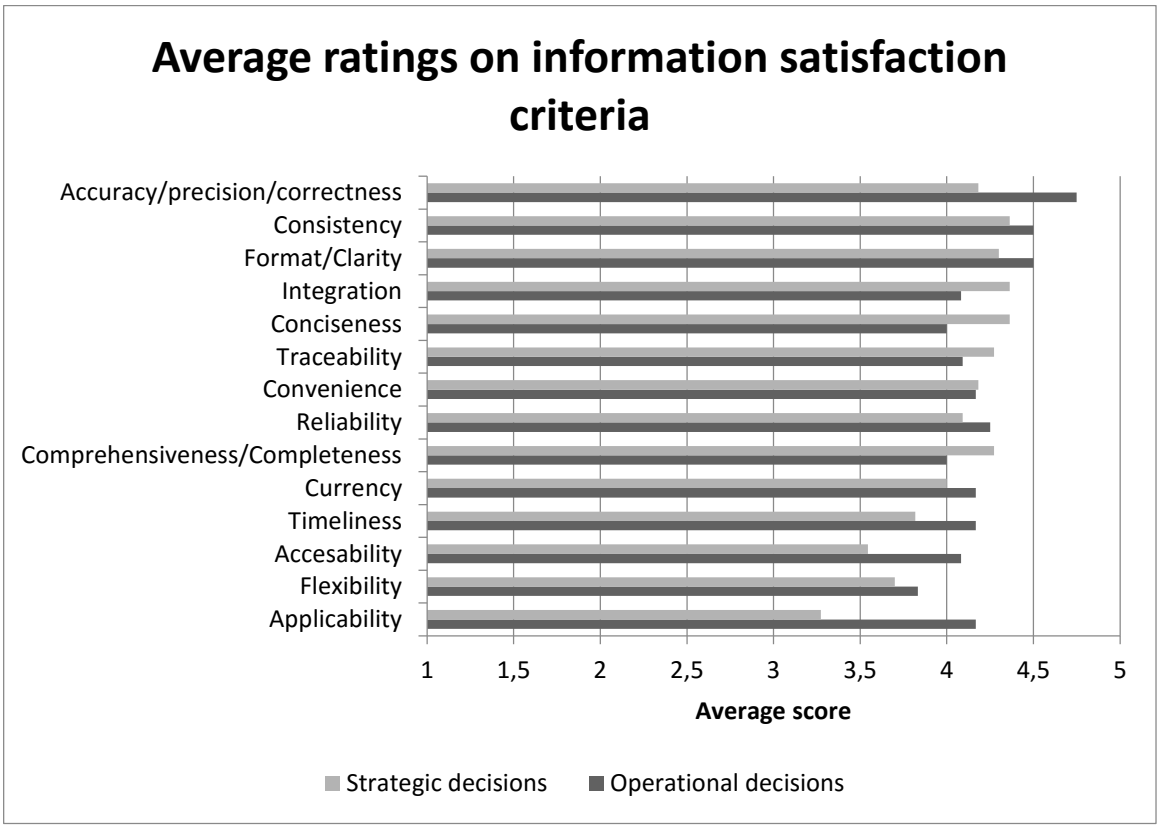


Figure 8 Average ratings by CompanyX on information satisfaction criteria

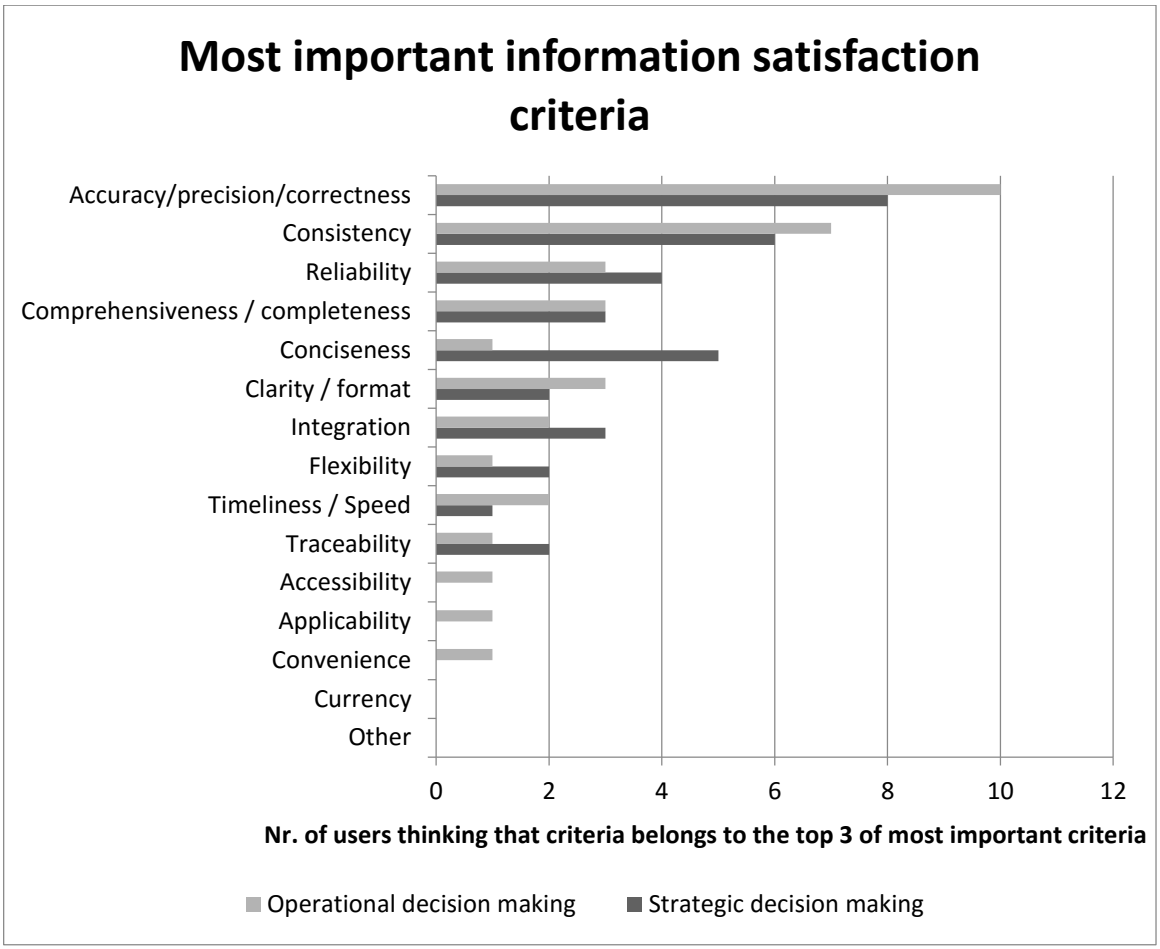


Figure 9 Most important Information Satisfaction criteria for CompanyX

4.1.3 Results conclusion

Concluding from this survey, the most important measurement criterion of information value for CompanyX is the information **effectiveness** (in creating business value). To make its definition more clear, it will be devided into three sub-criteria, namely: the effectiveness to decision making, the effectiveness compared to an alternative and the effectiveness to the organisation's goals. Another important criterion for CompanyX is the **understandability** of information. The **context coverage** and **efficiency** are reasonably important as well.

For measuring information quality and satisfaction, **accuracy** is the most important criterion for CompanyX, which is also concluded by Wixom and Todd (2005). **Consistency** is an important criterion for CompanyX too, which means that the information should be free of contradictions or convention breaks. This is very much in line with accuracy and therefore it is unnecessary to evaluate this criterion separately.

With a rounded average score of three, the criterion **Fun-to-use** is considered to be the least important criterion compared to the other criteria, although it is still moderately important.

There is little difference between the importance of the criteria in the operational or the strategic context. The main differences in the average score between the criteria in operational and strategic decision making are between the applicability (+0.9), accessibility (+0.5) and accuracy (+0.5). The timeliness and efficiency are only slightly more important in operational decision making. Wixom and Todd (2005) expected that especially timeliness would differ when making decisions in an operational context.

Now that the most important criteria are known, an CompanyX-focused model (Figure 10) can be created, distilled from the theoretical model (Figure 5). Though Freedom from risks was not selected very often as one of the three most important criteria, it is still included, because the interviews highlighted that information products that mitigate risks receive higher priority than information products that don't.

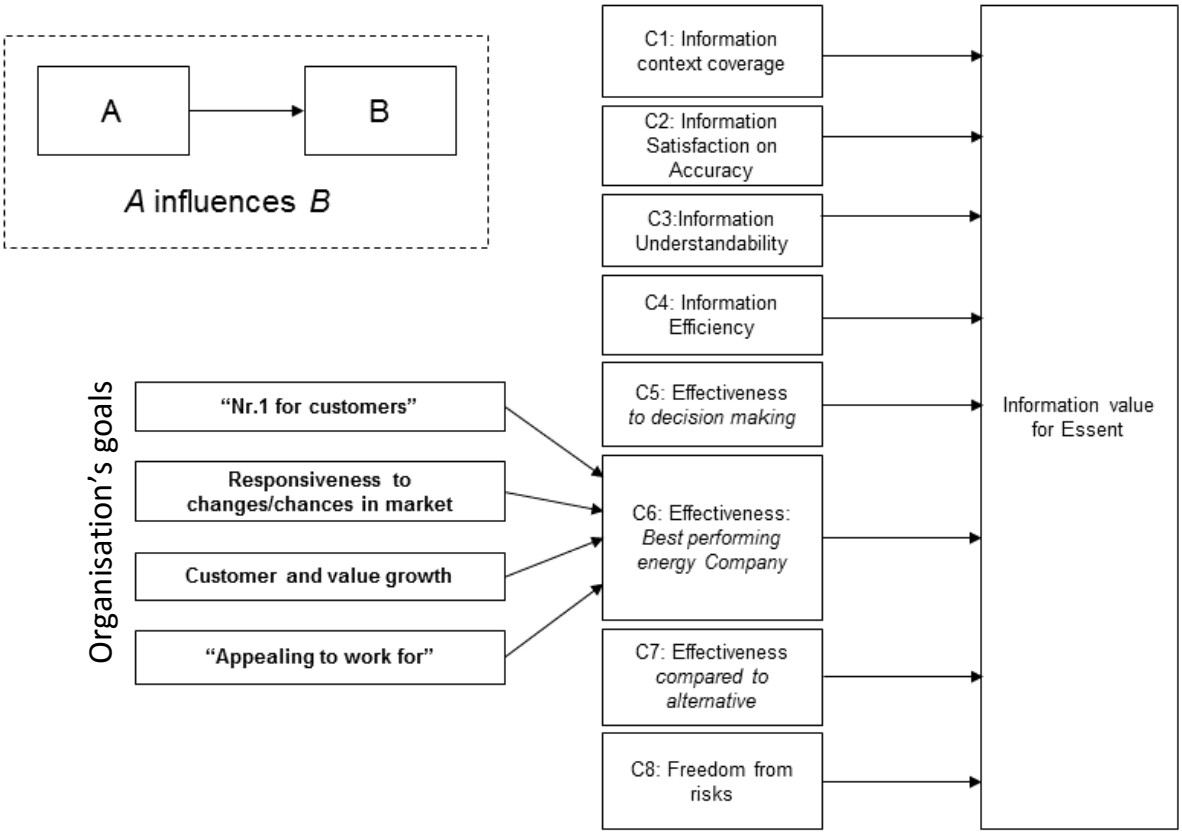


Figure 10 CompanyX-focused model: what is most important for CompanyX?

4.2 Overview of CompanyX's different type of information products

4.2.1 Types of information products

Currently, CompanyX owns much information products that ought to be used for operational and strategic decision making, including:

- Reports (on churn rates, financial overviews, complaints, customer satisfaction, performance indicators (KPIs) etc.)
- Business case calculations
- Lists or query results

These information products are mainly in a spreadsheet or dashboard format. Paragraph 4.2.2 and paragraph 4.2.3 describe the difference between these two formats.

4.2.2 Spreadsheets

Spreadsheets are used when the information is specific and needs to be created quickly. Visual representations can also be implemented quickly if necessary. Spreadsheets are mainly useful when not often used. They can be created manually or by using a tool.

When a spreadsheet report already exists, employees often remain using this instead of creating a new report in the Dashboard environment, because it is usually cheaper and they are accustomed to the report. The downside of spreadsheets is that they have higher management costs and are more prone to errors.

Spreadsheet files accessed through email, network storage or through the intranet web application platform (SharePoint). Though it is technically possible with the web application platform to evaluate what users opened or downloaded a file, it is not used.

4.2.3 Dashboards

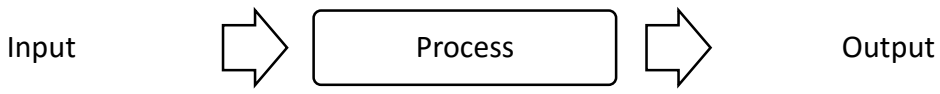
A dashboard is a type of report that is presented in a web environment. The information is linked to a database, allowing the information to be constantly updated. The main goals of having a dashboard is to provide a concise overview, user friendliness and faster data processing capabilities.

A report is being built in the dashboard environment when it is frequently used and when the data requires a visual representation. The user also has the possibility to apply different filters on the data to view the information from different perspectives. The usage of a dashboard is being logged by default. This offers the opportunity to easily monitor the usage of specific dashboard reports.

4.3 Practical measurement method

Now that CompanyX's information products and their most important usability criteria are known, a method to evaluate information products in practice can be created. The evaluation is suited for existing information products and for future information products before they are being built. Typically, a measurement method consists of three main phases:

1. Input: the data input for information value
2. Process: the calculation of information value using the input
3. Output: the presentation information value



4.3.1 Input

The most broadly applicable way of measuring the input is by using an evaluation form. The goal is to gather as much valuable data without requiring too much time of the information product user. Just like information products, the form should be understandable, efficient and effective. The evaluation form should also be applicable in many contexts. Table 8 is the form design, including the set of important criteria C in column 1, where $C = \{c_1 \dots c_8\}$. Column 2 describes how to measure each criterion and column 3 shows the corresponding form questions, which could be described as $q(C)$, where for example $q(c_2) = \{q_4\}$ and $q(c_6) = \{q_{11}, q_{12}\}$. The form can be found in Appendix 2.

Column 4 indicates if the form question can also be used for future information products.

Criteria C	**How to measure in practice?**	**Form Question Nr.**	**Can also be measured or estimated for future information products**
c_1: Context coverage	Count the decision makers or advisors which are users of the information. Count manually or by using log information (from the Dashboard environment or the web application platform).	**	Yes
c_2: Accuracy satisfaction	Ask most important users of the information on a Likert scale: *How satisfied are you with the accuracy of the information?*	q_4	No
c_3: Understandability	Ask most important users of the information on a Likert scale: *How do you rate the understandability of the information?*	q_5	No
c_4: Efficiency	From most important users: 1. Extract usage time from the Dashboard environment log information, or 2. Ask: *How much time do you normally spend each time on using the information product?*	q_2*	No
	Ask most important users: *How much time is minimally required to comprehend the contents of the information product?*	q_3	No
c_5: Effectiveness to decision making	From most important users: 1. Extract number of uses a week from Dashboard log data, or 2. Ask: *How many times a week do you use information product?*	q_1*	Yes
	Ask most important users of the information on a Likert scale: *How dependent are you on the information product?*	q_6	Yes
	How certain are you in making the right decisions using the information product?	q_8	Yes
	How certain are you in making the right decisions without using this information product?	q_{10}	Yes
	What decisions are being made using the information product and what is the impact of these decisions?	q_7	Yes
	Are you able to make the same decisions without having used the information?	q_9	Yes
c_6: Effectiveness compared to alternative	*If there is no information product, what is the alternative?* *And how much time saving does the information product produce in contrast to this alternative.*	q_{11} q_{12}	Yes
c_7: Effectiveness to the organisation's goals	Ask the most important users of the information product: *To what goals of the organisation does this information product contribute?*	q_{15}	Yes
c_8: Freedom from risk	Ask most important users: *Can the information help prevent important risks for the company?* If so, ask on a Likert scale: *What is the total risk?*	q_{13} q_{14}	Yes Yes

Table 8 How to measure criteria in practice?

* When evaluating a dashboard, Q1 and Q2 can also be measured using log information instead of asking the user.

** There is no question in the form to measure the context coverage, this should be measured manually or by using log data gathered by the dashboard environment.

4.3.2 Process data

To find the value of an information product, the input of the form and additional input needs to be processed. Let P be the set of information products. For each information product p, let U be set of users that use information product p, and let R be the set of respondents that filled in the form. Then let $Resp(q,r)$ be the answer to question q, given by respondent $r \in R$. The answers to the questions are numeric except for q_7, q_{11}, q_{13} and q_{15}:

- The answer to q_7 and q_{11} does not have to be processed.
- The answer to q_{13} is a string value containing "yes" or "no": $Resp(q_{13},r) = \{"yes", " no"\}$.
- The answer to q_{15} is in binairy vector where each element of $Resp(q_{15},r)$ represents a company goal with a value 0 or 1.
    - Value 0, if respondent answered that the information does not contribute to the company goal.
    - Value 1, if respondent answered that the information does contribute to the company goal.

  The results are in the following vector: $Resp(q_{15},r) = (\{0,1\},\{0,1\},\{0,1\},\{0,1\})$.

For each criterion ($c \in C$), the answers of the respondents need to be processed (Table 9). In column 2, one or multiple answers of a respondent ($Resp(q,r)$) are used to calculate a criterion score of an individual respondent: $Score(C,r)$. By using the average or maximum of the individual respondent, the total score ($Score(C)$) for a criterion can be calculated using, see column 3.

Criteria C	**Score for Respondent r** $\boldsymbol{Score(C,r)}$	**Total score** $\boldsymbol{Score(C)}$
c_1: Context coverage		• Let t be the ultimate target number of users. $Score(c_1) = \begin{cases} \frac{\lvert U\rvert}{t} & if\ \lvert U\rvert \le t \\ 1 & if\ \lvert U\rvert > t \end{cases}$
c_2: Accuracy satisfaction	$Score(c_2,r) = \frac{(Resp(q_4,r)\ -1)}{4}$	$The\ average\ score\ of\ the\ respondents$: • Let $nr(C)$ be the number of respondents that filled in all question answers ($Resp(q,r)$) corresponding to the criteria C. $Score(c_2) = \frac{1}{nr(c_2)} \sum_{r \in R} Score(c_2,r)$
c_3: Understandability	$Score(c_3,r) = \frac{(Resp(q_5,r)\ -1)}{4}$	" "
c_4: Efficiency	$Score(c_3,r) = \begin{cases} 1 & if\ Resp(q_3,r) \le Resp(q_2,r) \\ \frac{Resp(q_3,r)}{Resp(q_2,r)} & if\ otherwise \end{cases}$	" "
c_5: Effectiveness to decision making	$Score(c_3,r) = Max(D_1,D_2)$ $D_1 = \frac{(Resp(q_6,r)-1)}{4}$ $D_2 = \begin{cases} 0 & if\ Resp(q_8,r) \le Resp(q_{10},r) \\ \frac{(Resp(q_8,r) - Resp(q_{10},r))}{4} & if\ otherwise \end{cases}$	" "
c_6: Effectiveness compared to alternative	• Let m be the target amount of minutes in the answer: $Resp(q_{12},r)$ $Score(c_6,r) = \begin{cases} \frac{1}{m} Resp(q_{12},r) & if\ Resp(q_{12},r) \le m \\ 1 & if\ Resp(q_{12},r) > m \end{cases}$	" "

c_7: Effectiveness to the organisation's goals	$Score(c_7, r) = Resp(q_{15}, r) \cdot \omega$ Where ω is the vector$(\omega_1, \dots, \omega_4)$ assigning weights to each of the components of the result vector $Resp(q_{15}, r)$. $\sum_{i=1}^{n} \omega_i = 1$ $Resp(q_{15}, r) \cdot \omega = Resp(q_{15}, r)_1 \cdot \omega_1 + \cdots + Resp(q_{15}, r)_4 \cdot \omega_4$	" "
c_8: Freedom from risk	$Score(c_8, r) = \begin{cases} 0 & if\ Resp(q_{13}, r) = "no" \\ C_8 = \frac{(Resp(q_{14}, r) - 1)}{4} & if\ Resp(q_{13}, r) = "yes" \end{cases}$	$The\ maximum\ score\ of\ the\ respondents$ $Score(c_8) = \max_{r \in R}(Score(c_8, r))$

Table 9 Criteria score calculation

Combing the total scores of each criterion, the value score for an information product p can be calculated using $ValueScore(P)$. By using weights (w), the organisation can give priority to the different criteria.

$$\sum_{c \in C} w_c = 1$$

$$ValueScore(P) = \sum_{c \in C} w_c * Score(C)$$

Scores are not always meaningful and sometimes tangible and accountable values are required, like monetary value or time. This is especially required for commercial companies like CompanyX. Some of the input from the form can be used to provide this. It is for instance interesting to know how much efficiency exactly is required expressed in minutes. It is also valuable to know how much time the information product actually saves on a weekly basis. *Time is money*, so if requiring the financial value, the amount of money that is or can be saved can be calculated by using the extra scores in Table 10 as input.

Extra score E	**Score for Respondent r** $\boldsymbol{Score(E, r)}$	**Total score**
e_1, Efficiency: Lack of time a week	$Score(e_1, r) = \begin{cases} 0 & if\ (Resp(q_3, r) \leq Resp(q_2, r) \\ Resp(q_1, r)((Resp(q_3, r) - Resp(q_2, r)) & if\ otherwise \end{cases}$	$The\ sum\ of\ the\ score\ of\ the\ respondents$ $Score(e_1) = \sum_{r \in R} Score(e_1, r)$
e_2, Effectiveness: Time saved weekly	$Score(e_2, r) = Resp(q_{12}, r) * Resp(q_1, r)$	" "

Table 10 Additional score calculation

The extra efficiency score: *Lack of time a week*, is composed from the number of uses a week by a respondent ($Resp(q_1, r)$) and the time that is saved each time the respondent uses the information compared to an alternative ($Resp(q_{12}, r)$).

The extra Effectiveness score: *Time saved weekly*, is composed of the minimum time that is required to comprehend the information to be able to put it to good use ($Resp(q_3, r)$) minus the actual time that users spending on the information ($Resp(q_2, r)$). To put it in a weekly perspective it is multiplied by the number of uses a week ($Resp(q_1, r)$). Note that the users with sufficient time require 0 minutes (there is no negative amount of minutes possible!).

The form also included a small amount of qualitative feedback. The most important one is the answer to the question: What decisions are being made using the information product and what is the impact of these decisions. This and the "Effectiveness to decision making"-score give a good overview of the added value of an information product.

4.3.3 Output: the presentation information value

When the input of the form is processed, it has to be presented in a way the added value of an information product is evident. By visualizing the value of an information product it can be compared quickly to other information products, which can be useful when finding the information product to focus on. Knowing the value of information products does not necessarily mean the information is valuable for the organisation. If the information product is no longer used for instance, the value for the organisation is none. Therefore it is important to consider all individual criteria scores to get a view of the value of the information and to know what criteria to focus on when improving the information product.

Figure 11 shows an example of how the value of information products can be presented using a stacked bar chart. The length of the bar represents the ValueScore of an information product (P). The length is formed by the sum of the weighted scores of each criteria ($\sum_{c \in C} w_c * Score(C)$), where the sum of these weights is 1 ($\sum_{c \in C} w_c = 1$). By using a stacked bar chart the weighted score of each criteria ($Score(C)$* w_c) is visible by its length, the unweighted score of a criteria is displayed inside a bar.

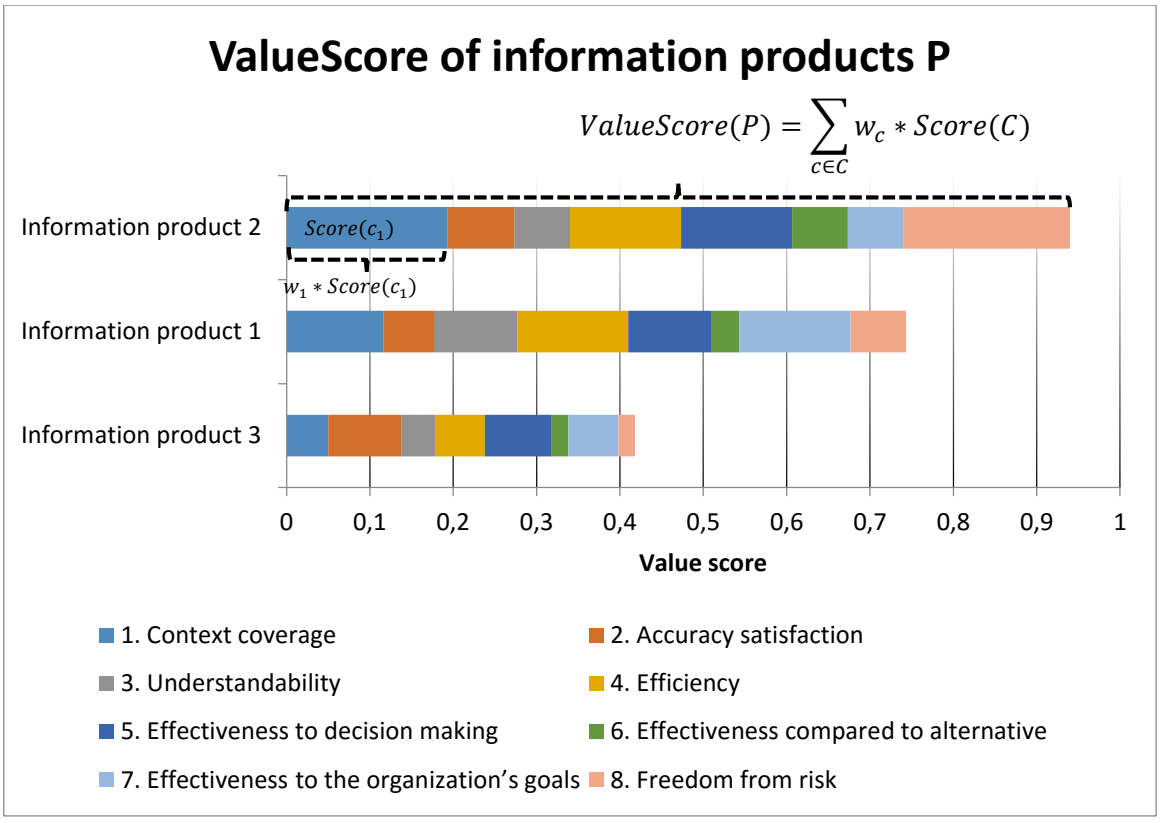


Figure 11 Bar chart on the value of information products

Apart from "context coverage", the score for each criteria ($Score(C)$) is the average or the maximum of the individual user score as mentioned in Table 9. The value of an information product can also be presented by paralleling the scores of the individual respondents, like in Figure 12. In this way it is possible to trace how the score for a criteria ($Score(C)$) is composed and how much each user contributed to this score. If for instance only one user provides a low score, he or she could be invited for an appointment for instance, to find out the reason behind this low score. This requires the evaluation form to be not anonymous, which might be a problem for some organisations where the privacy of the employees is very important. When anonymous, employees might provide different answers.

Figure 12 also presents the value of an information product using a stacked bar chart. The length of the bar represents a RespondentValueScore for an information product (P). It is formed by the sum of the weighted scores of each criteria ($\sum_{c \in C} \widetilde{w}_c * Score(C,r)$), where the sum of these weights is 1 ($\sum_{c \in C} \widetilde{w}_c = 1$). By using a stacked bar chart and equal weights, it is immediately clear what criteria affect the user's individual score. The view of a single information product (P), like in Figure 12, offers the opportunity to additionally present the unprocessed qualitative feedback form the respondents: $Resp(q_7, r)$, and if required even their other comments.

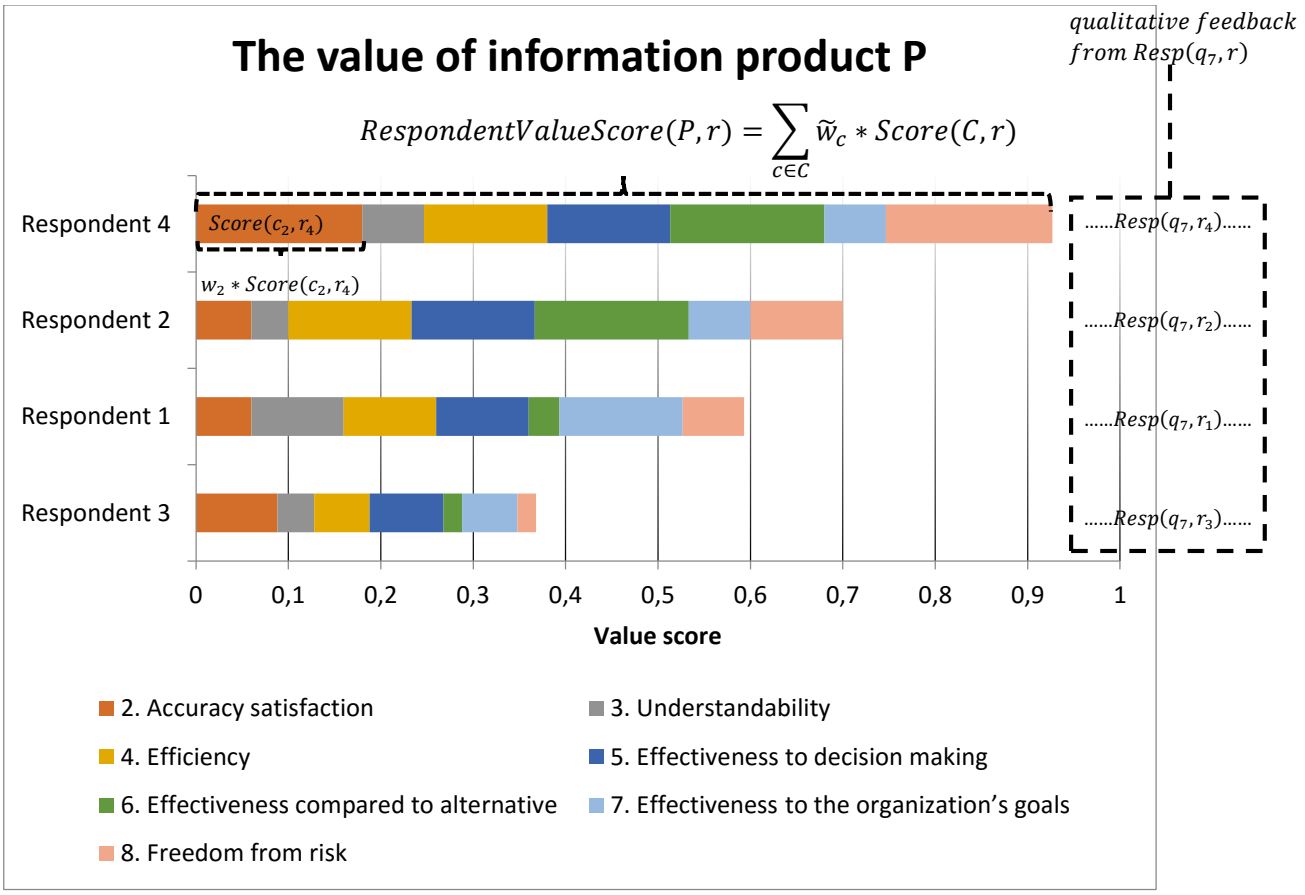


Figure 12 The value of a single information product

As mentioned earlier in 4.3.2, tangible values such as time are also required. To make time visual and comparable, an ordinary bar chart could be used like in Figure 13, though there are more representations possible. The length of the bar ($Score(e_2)$) in Figure 13 represents the time that is saved every week because of the information product. It could also be viewed on an individual respondent level ($Score(e_2, r)$), though a total value from the summed individual scores might be more valuable. It is also valuable to know what the alternatives are, they could be for instance presented on the right side of the graph in Figure 13.

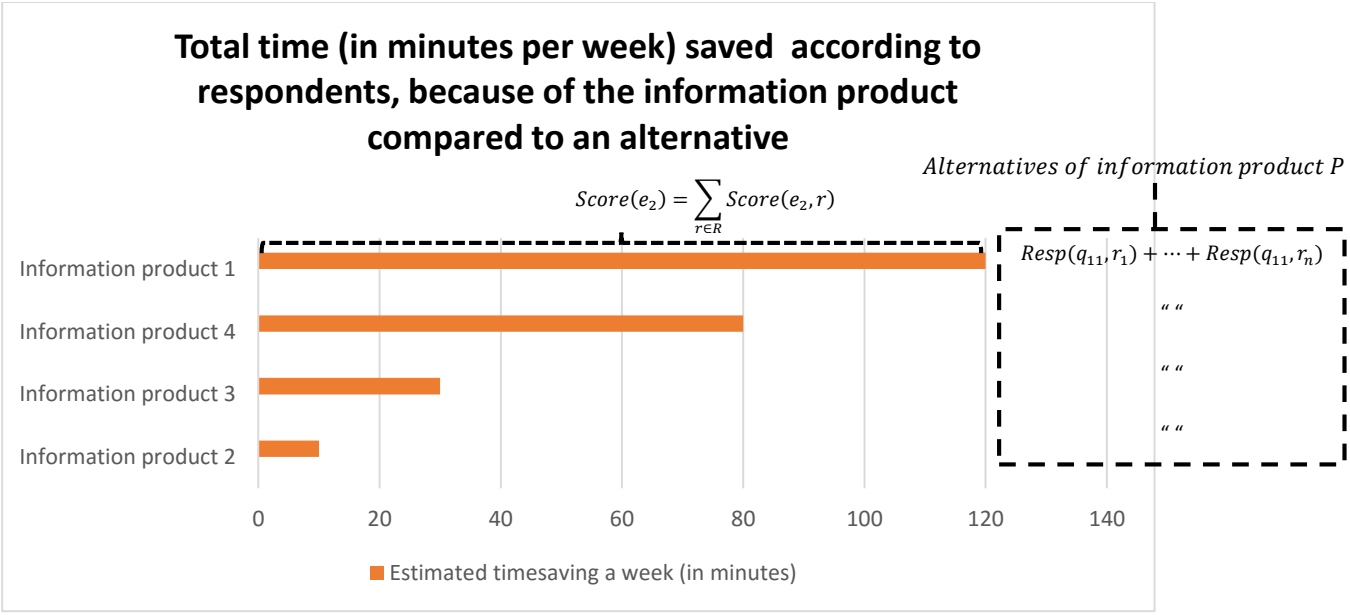


Figure 13 Time saved weekly

Sometimes the information itself is not efficient enough. Not every user is willing to take time in comprehending all the information. Therefore Figure 14 is an overview of the information products that should be more efficient.

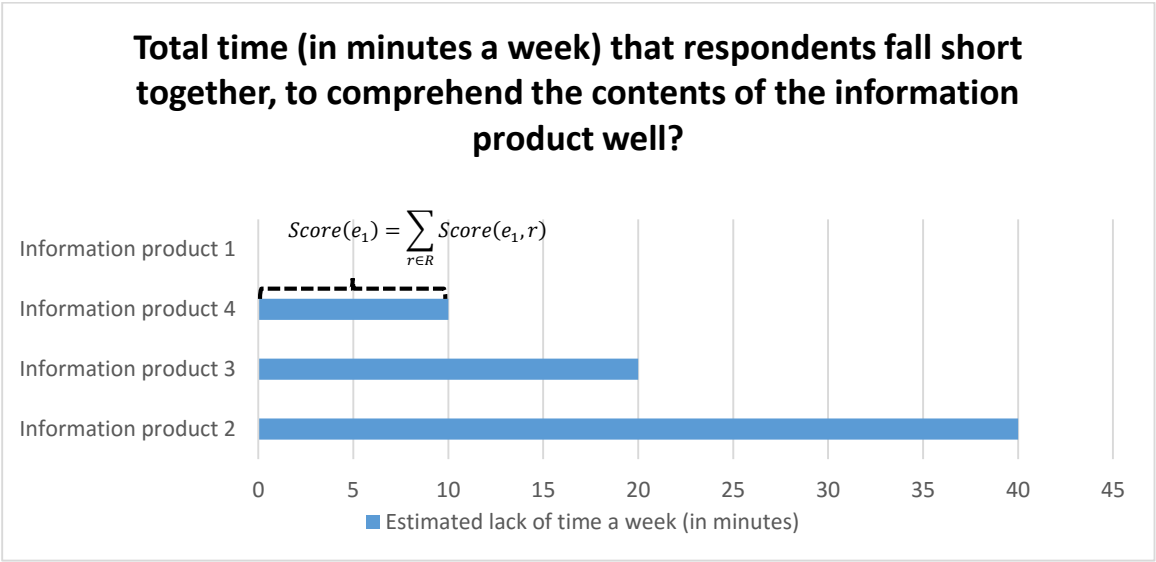


Figure 14 Weekly efficiency required

4.4 Evaluation of information product characteristics in practice.

CompanyX's information products and their most important criteria are identified. Now the defined measurement model can be tested in practice. To do this, three information products are selected: one spreadsheet and two dashboards. These information products are **reports** selected by the Business Process Support department of Consumer operations. For each of the three information products an evaluation form was send to the employees who use the information product according to their function.

The input from the following respondents are processed and presented:

- Spreadsheet 1: 7 respondents
- Dashboard 1: 4 respondents
- Dashboard 2: 5 respondents

Additional input values can be customized to fit the organisation view on value. To test the measurement model in practice these values are used.

- Number of users resulting in maximum score of "context coverage" $t = 15$
- Amount of minutes saved that will result in a maximum score of "Effectiveness compared to alternative" $m = 100$
- Weight vector $\omega = (\frac{3}{10}, \frac{2}{10}, \frac{4}{10}, \frac{1}{10})$
- $Resp(q_{15}, r)_1\ refers\ to\ goal\ 1: Nr.1\ for\ customers$
- $Resp(q_{15}, r)_2\ refers\ to\ goal\ 2: Responsiveness\ to\ changes\ in\ the\ market$
- $Resp(q_{15}, r)_3\ refers\ to\ goal\ 3: Customer\ and\ value\ growth$
- $Resp(q_{15}, r)_4\ refers\ to\ goal\ 4: Appealing\ to\ work\ for$
- Weight vector $w_c = (\frac{1}{8}, \frac{1}{8}, \frac{1}{8}, \frac{1}{8}, \frac{1}{8}, \frac{1}{8}, \frac{1}{8}, \frac{1}{8})$
- Weight vector $\widetilde{w}_c = (0, \frac{1}{7}, \frac{1}{7}, \frac{1}{7}, \frac{1}{7}, \frac{1}{7}, \frac{1}{7}, \frac{1}{7})$
- For each information product P, the number of users U is assumed to be 20

After processing the input using the method from 4.3.2, the output results into the graph in Figure 15. The three reports can be compared based on their value score. Because the weights are equal, the graph can also be used to see on what criteria the report can be improved.

What can be concluded is that Dashboard 1 scores low on the criteria: Freedom from Risk. This means that it is not used to prevent risks for the company, making it less valuable than Dashboard 2 and Spreadsheet 1. Spreadsheet 1 scores lower on efficiency compared to the other two dashboards. This was expected, because dashboards are efficient according to their definition. This does not mean that the spreadsheet does not contribute to the efficiency of the organisation, on the contrary, when looking at the effectiveness compared to an alternative, it is more efficient than the other dashboards. An alternative can be for example the use of other (sub-)reports. This requires more manual work.

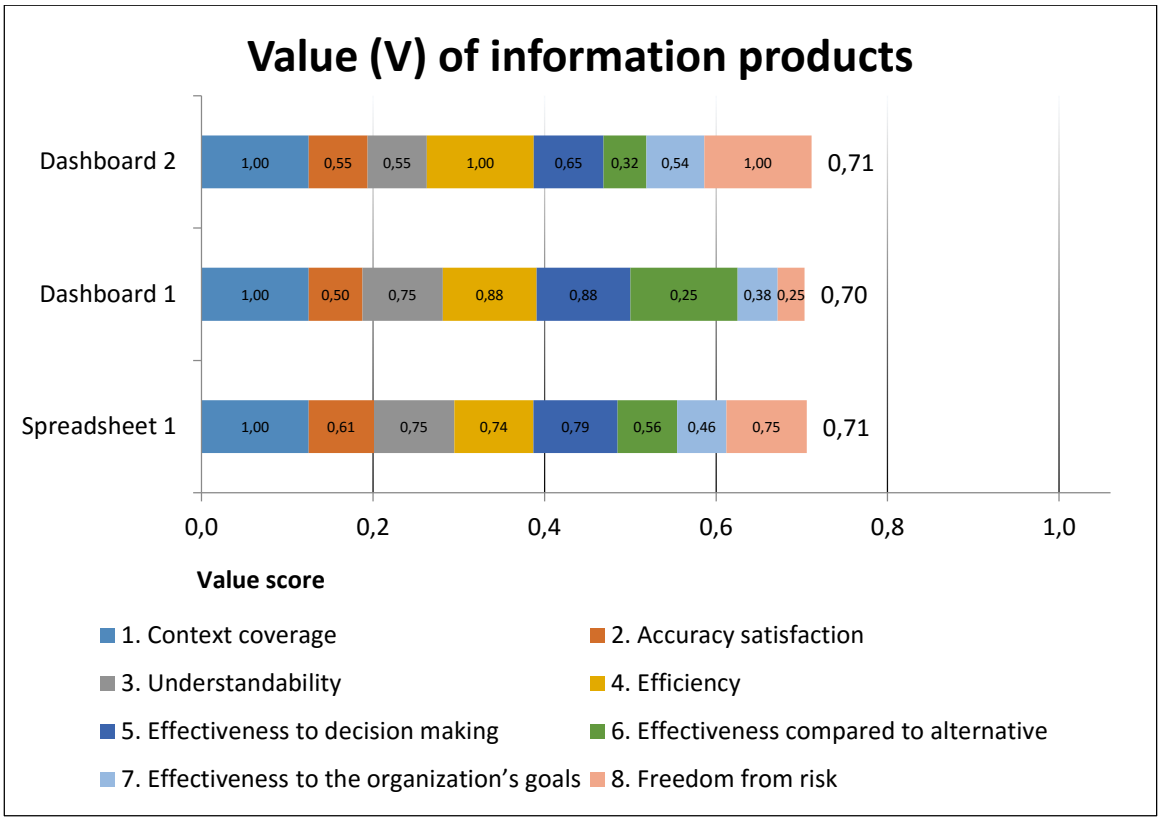


Figure 15 Evaluation of three information products in practice

The time a week that is saved compared to an information product's alternative is displayed in Figure 16. Figure 17 represents the efficiency that is required a week for each information product. In both charts, Dashboard 2 performs best, though the time values are just an estimation by the respondents, making them not completely reliable.

When taking the value score and additional scores into account, Dashboard 2 is the information product with the highest value. To improve this dashboard, the information should be made more accurate and understandable.

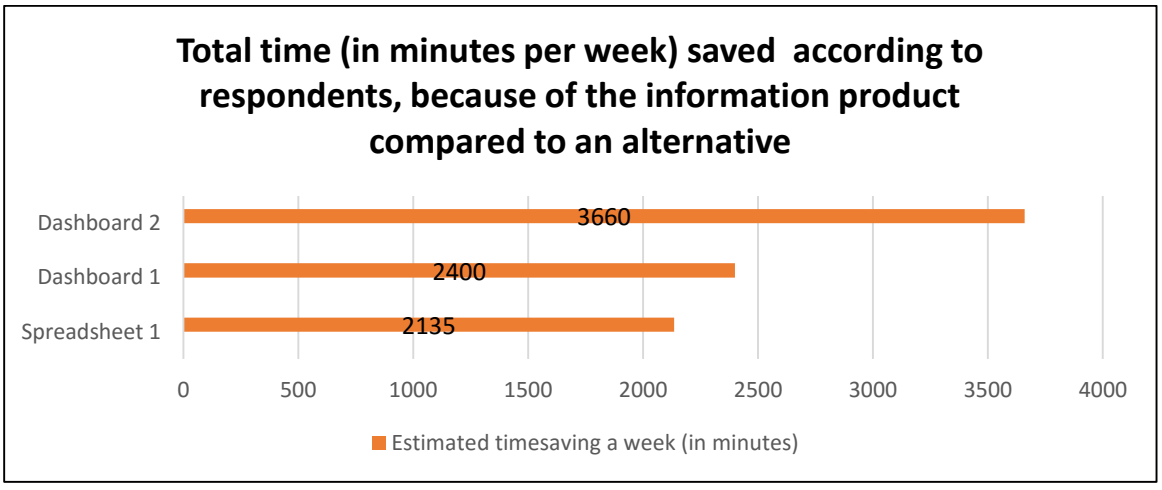


Figure 16 Additional score: time saving

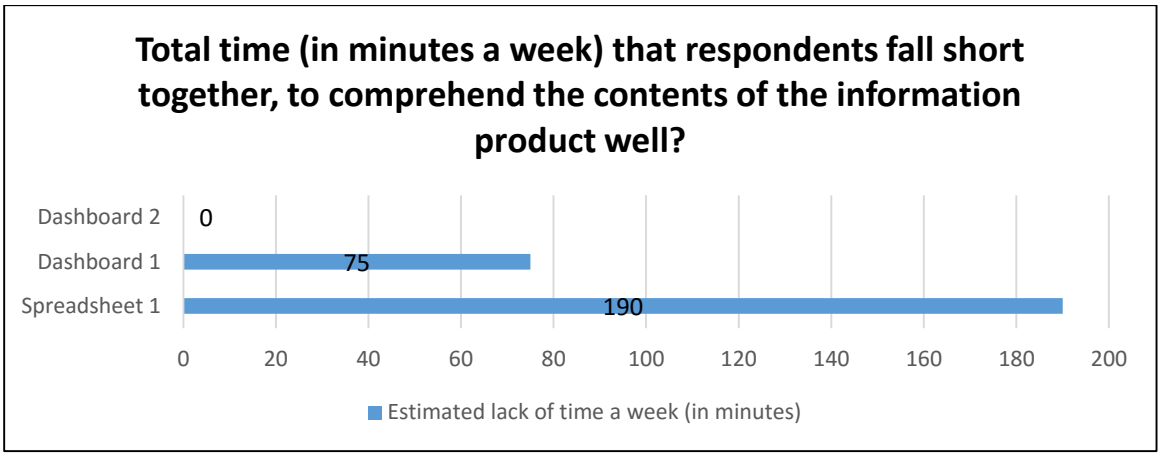


Figure 17 Additional score: lack of time

The additional scores are not only used to see what information product is most valuable. Time is money and by using Figure 16, CompanyX can calculate the money that is saved because of the time saving effect of the information product. Figure 17 can be used for making decisions on improving information efficiency, but it can also be used to make decisions on allowing employees more time for using the information.

In Figure 18, the value of Spreadsheet 1 is presented using the individual scores of the respondents. If wanting to improve the accuracy, it might be helpful to talk to Respondent 4 and 6 first. If wanting to improve the efficiency, Respondent 2, 4 and 7 might offer some valueable feedback. Qualitative comments are not presented on the right side, because of privacy reasons, but they might already include an explanation for the lower score. When improving the information on a criteria such as understandability, it is imaginable to only show improvements to the users with low score on this criteria, because improvements and changes are not necessarily an improvement for users.

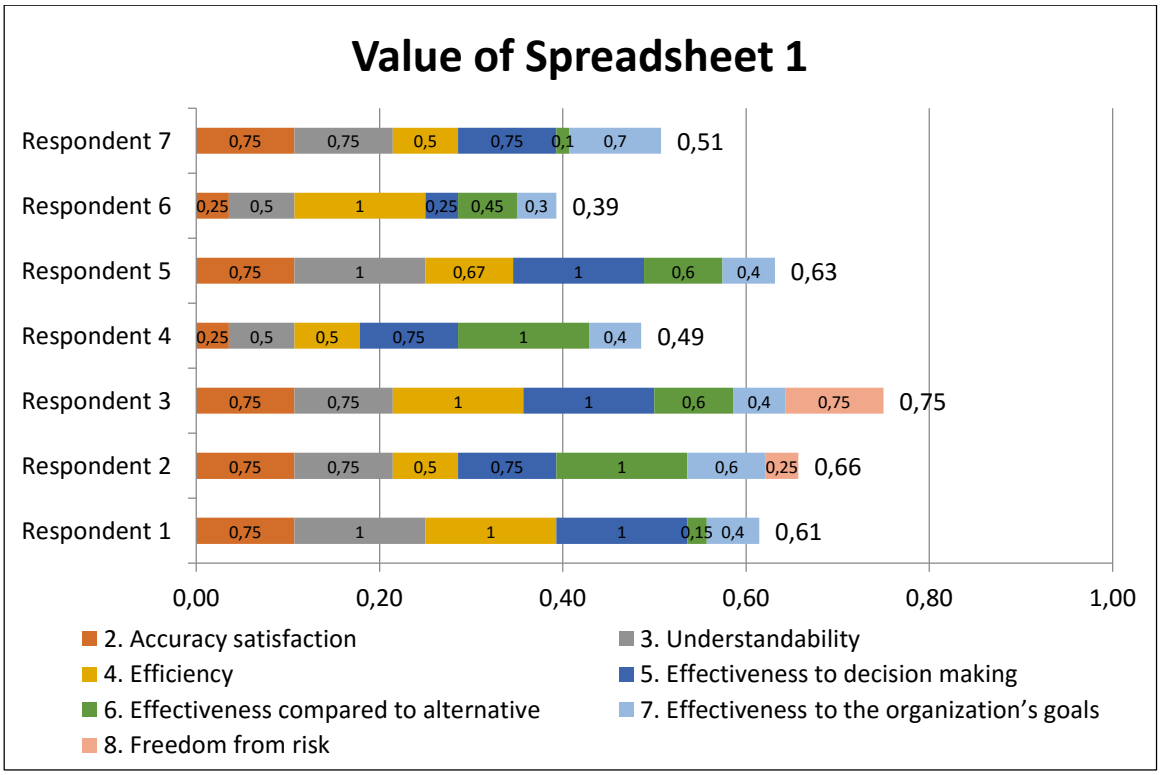


Figure 18 Value of an information product (spreadsheet 1) in detail

5 Discussion and future work

In this chapter different elements of my work are discussed and extended with opportunities for future work.

5.1 The right criteria for the model?

Finding the right usability criteria within a large commercial company can be challenging, because the importance of the criteria can differ within different parts of the company and within different contexts. At the energy company CompanyX, the most important criteria for operational and strategic decision making are determined based on feedback from different key users, but additional field research is required to verify the importance of these criteria. It is faster for an organisation to measure only the most important criteria, but measuring all criteria would be better when requiring a better insight in information value and how to improve the information. It is important to find the right balance between speed and quality.

5.2 Incomplete input

Evaluation forms are used to gather input from the users. With short time available, it is important to create valuable questions. When testing the evaluation form, answers that require time-values might not always be given by the users. Therefore it is important to review output values such as “time saving” and “lack of time” with care. This also applies to criteria scores on “efficiency” and “effectiveness compared to alternative”. It can result into empty scores or scores that are for instance only determined by one respondent. Asking a respondent to give time-related values on a scale from 1 to 5 might be a solution, though this loses the opportunity to convert the time value to a financial value. Asking both might be best, though this results into a longer evaluation form. Therefore the balance between speed and quality is very important for the evaluation form as well.

5.3 The right measurement model for value

The value (score) of an information product and the individual criteria scores can be calculated and presented in different ways. The measurement model uses a way that is concise, applicable and clear. For other methods, additional research is required. Clustering criteria that can be improved and criteria that are only an indicator for value might be an important first step. Then the organisation can decide more quickly what to do with the information product.

5.4 Experienced information users

The measurement model does not take into account the experience of the users. Experience could for instance influence the understandability of the information. To tackle this problem, an extension to the measurement model would be required. An extension could be for instance asking the users to provide their experience with the information. By including the usability criteria ‘learnability’ in the measurement model, this problem might also be tackled.

5.5 Retention of the information value and criteria scores

It is interesting to see what the information value and criteria scores do over time, for instance when the information is improved on certain criteria. If the scores and value have changed, the former answers and scores from the same respondents are no longer relevant for improvement. This does not mean they are not valuable at all. It might still be relevant to maintain a database of the individual respondents’ answers. This allows learning the rating behavior of respondents, creating the possibility to normalize scores, making the output value score more accurate.

5.6 Weighing costs against benefits

This research describes the benefits and costs of creating and improving information. A good addition to the measurement model would be a method that can weigh the costs against the benefits, for instance by using a return of investment formula: $ROI = \frac{(\text{gain form invesment} - \text{cost of investment})}{\text{cost of investment}}$. By providing clear insight into the costs and benefits, organisations can make more efficient decisions if information must be created or improved.

6 Conclusion

This thesis provides a framework for measuring the value of information products that are used (or should be used) in decision making. By measuring and creating valuable information, CompanyX can make better decisions, which are required to survive in the competitive energy market. There is a lack of measurement methods (Popovič et al., 2010) and a method is also required by the business intelligence board of the energy company CompanyX. The problem is a business intelligence problem, therefore it is very important to evaluate the concept business intelligence first, because in literature, business intelligence has different definitions. Pirttimäki et al. (2006) found out that business intelligence can be described as the process of creating information or 'intelligence', but it can also be described as the result of this process, namely the information or 'intelligence' relevant for the business. According to the interviews, CompanyX mainly sees business intelligence as a process. This means that there is a difference for them between the value of information products and the value of business intelligence.

Like business intelligence, the value information can be interpreted in many different ways. For CompanyX, value is mainly financial, which is understandable, because it has to survive in a very competitive environment. In literature, the value of information or business intelligence is not just financial. The value of information could also be described as the usability of information, because value is created as a result using and utilizing the information (Kelly, 1993). The usability of information is included in many research papers and ISO standards, but like BI and information value, it has no general definition. By combining the most recent ISO 25010 (2011) standard and the criteria from Scholtz et al. (2013), the measurement criteria are formed. For one of the criteria, namely satisfaction, even sub-measurement criteria are selected, because satisfaction itself is not tangible enough.

Because there are too many criteria, only the most important criteria for CompanyX were selected. The criteria were selected based on the results of a survey, in which employees rated the criteria on a Likert scale and by letting them select the top three of most important criteria. The latter is better suitable for this situation, because the average results from the Likert scales were very close to each other.

The survey made a distinction between information in an operational and strategic decision making context, but there were no differences between both contexts with respect to the most important criteria. From all criteria, the effectiveness was clearly the most important, which the interviews also showed. Effectiveness can be interpreted as the effect to decision making, but also as the effect to business goals or business value that result from decision making.

Besides effectiveness, other important criteria are: understandability, efficiency and context coverage and freedom from risk. The interviews also revealed that information products that mitigate risks receive higher priority in contrast to information products that don't. The satisfaction of the information was not among the most important usability criteria, therefore only the most important measurement criterion of satisfaction was selected, namely the accuracy. Accuracy is considered to be the most important satisfaction criteria according to CompanyX, confirming the research from Wixom and Todd (2005), where accuracy is indirectly the biggest contributor to information satisfaction. By evaluating these criteria the value of an information product can be determined.

To evaluate an information product, the measurement model requires the input from an evaluation form, because a form is very applicable to practice. Because the measurement model is based on theory and practical experience, trade-offs have to be made between the time required for measuring value and the precision of the value. More questions on the input criteria will improve determining the value the value for example, though it requires more time.

In practice, the questions and answers from the evaluation form that include an estimation of time should be treated carefully, because time can be difficult for the user to estimate and provide. When the input is gathered, a value score is processed and presented in a way, it is clear what criteria are the main contributors to the value and on what aspects the information product can be improved. The score can be compared to other information products to find out which is most valuable. Providing tangible output such as ‘saved time’ or ‘time required’ is useful for an organisation, because it is easier to convert to financial value, though the output should be interpreted carefully as mentioned earlier. The measurement model includes weights and other parameters which makes the measurement model broadly applicable within the energy company CompanyX and possibly also in other organisations. For organisations the challenge remains in finding the right balance between quality and speed of the measurement model.

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Appendix 1: Evaluation form (Dutch)

Evaluatieformulier voor: ...

Wij zijn benieuwd naar de waarde van rapportages (informatie) en deze enquête hoopt hier meer inzicht in te creëren.
Het invullen duurt ongeveer 5-10 minuten.

Alvast bedankt!

Efficiëntie

Hoeveel keer per week gebruik je het rapport ongeveer?

Hoeveel minuten besteed je ongeveer per keer aan het gebruik van dit rapport?

Hoeveel minuten zijn minimaal nodig om de inhoud van het rapport voldoende tot je te nemen?

Kwaliteit

Hoe tevreden ben je met de nauwkeurigheid van het rapport?

	1	2	3	4	5	
Helemaal niet tevreden over nauwkeurigheid	○	○	○	○	○	Erg tevreden over nauwkeurigheid

Hoe begrijpelijk vind je het rapport?
(Het rapport begrijpen en in staat zijn zelf adviezen/beslissingen te kunnen nemen op basis van de informatie)

	1	2	3	4	5	
Helemaal niet begrijpelijk	○	○	○	○	○	Erg begrijpelijk

Hoe afhankelijk ben je van het rapport?

	1	2	3	4	5	
Helemaal niet afhankelijk	○	○	○	○	○	Erg afhankelijk

Beslissingen nemen / advies geven

Het doel van het rapport is om bepaalde beslissingen te kunnen nemen en adviezen te kunnen geven.

Wat voor beslissingen maak je of wat voor adviezen geef je op basis van dit rapport?

Hoe zeker ben je in het maken van de juiste beslissingen MET het rapport?
(of hoe zeker ben je in het geven van juist advies MET het rapport?)

	1	2	3	4	5	
Heel erg onzeker	○	○	○	○	○	Heel erg zeker

Zou je dezelfde beslissingen kunnen maken ZONDER het rapport
(of zou je dezelfde adviezen geven ZONDER het rapport)

- ○ Ja
- ○ Nee

Hoe zeker ben je in het maken van juiste beslissingen ZONDER het rapport?
(of hoe zeker ben je in het geven van juist advies ZONDER het rapport?)

	1	2	3	4	5	
Heel erg onzeker	○	○	○	○	○	Heel erg zeker

Als het rapport er niet zou zijn, wat is dan voor jou het alternatief?

Hoeveel tijdsbesparing in minuten levert het rapport ongeveer op tegenover dit alternatief per keer

uur ▼ : min. ▼ : sec. ▼

Bijdrage aan de organisatie

Kunnen dankzij dit rapport belangrijke risico's voor de organisatie direct dan wel indirect worden vermeden?

Bijvoorbeeld risico's op: economische status, gezondheid, milieu, security, betrouwbaarheid, beschikbaarheid etc.

- ○ Ja
- ○ Nee

Zo ja, kun je op een schaal van 1-5 de grootte van het totale blootgestelde risico aangeven?

	1	2	3	4	5	
Erg klein risico	○	○	○	○	○	Erg groot risico

Aan welke doelen van de organisatie draagt het rapport direct dan wel indirect bij?

- ☐ Eerste keus voor iedere consument
- ☐ Continue groei van klanten en/of waarde
- ☐ Inspelen op veranderingen in de markt
- ☐ Aantrekkelijk om voor te werken

Overige opmerkingen over dit rapport:

Verzenden