**UNIVERSITY OF LJUBLJANA**
**FACULTY OF ECONOMICS**

MASTER'S THESIS

# EVALUATION OF BUSINESS INTELLIGENCE SYSTEM USABILITY

Ljubljana, September 2014 ELVIS POROPAT

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# INTRODUCTION

The reality in businesses nowadays is the easy access to big amount of data that is being transferred into information. Reliable and useful information provide a competitive advantage in turbulent waters on all fields of business activities. Information is the foundation for all important business decisions. That means that on the informational foundation entire business structure is based. Information is needed at each stage of business operations, from enterprise's entrance into the market, its growth, and throughout its every day strategic responses to the market's demands.

Due to the almost limitless processing power and storage capabilities, it is relatively easy to provide sufficient amount of information. Information is in many organizational structures often so accessible, that employees are confronted with saturation and overflow of it, on a daily basis. For that reason we should be aware, that it is extremely difficult to capture, access and process the right information at the right time. This can quickly become impossible, if we are about to prepare the information from billions of terabytes of data (The solution for limitless processing power, storage and RAM, 2011).

For several years now, Business Intelligence (hereinafter: BI) products are, with their increased functionality, trying to help the day-to-day users and "super users" in organizations, to make the best decisions. These knowledge workers, as IT staff, power users, executives, functional managers and last but not least the occasional Information customers, such as business partners and data consumers, are for sure gaining all the needed information. But unfortunately in more and more cases even some additional, so called ballast information. This excessive and unnecessary information must be sieved out, refined and merged into useful piece of information. However, due to bad information management and presentation, the users stated above do often confront with numerous problems. These problems are mostly connected with the usability of the delivered information (Ballard, Farrell, Gupta, Mazuela, & Vohnik, 2006, p. 84).

The presented study is trying to review, how the users throughout the organizational structure, from IT users, business users – top and middle management, and also less IT skilled internal enterprise and casual users in MLEs are finding and assessing the usefulness of the implemented BI system at their daily activities and operations. The BI systems are in modern organizations indispensable, especially when providing sufficient amount of data and information within the operational, tactical and strategic planning. The BI solutions are dispersed through numerous organizations and businesses that differ from each other. For that reason the market is also offering many different Information system and BI tools. These solutions allow users to present almost an endless variety of outputs through all kinds of transmitters. The quality of BI systems nowadays is measured through the eyes of providers and is being evaluated by the diversity of outputs that these tools can efficiently provide. Unfortunately, saturated and in many cases even frustrated, users can often find themselves lost in diversity of outputs, such as reports, dashboards, scoreboards, key performance indicators (KPIs), etc. From that point of view, it does not mean that the BI solution, that gained high rankings on the providers' scales is at the same time also the most useful one, and that the client will receive its full value. As already stated, there are many other important quality attributes that should be also taken into the consideration. System usability, being perceived from the user point of view, is one of the most important ones. It is at high importance, how easy and how quickly the user can perform basic tasks with the given system solution. Furthermore, if the user returns to the system after a period of time not using it, it should be easy for him, and also not time consuming, to establish proficiency. In the end, one of the important usability indicators is users' final satisfaction. It is worthless, if the user is not pleased with the system solution. If the user doesn't find the solution usable, consequently in most scenarios he is avoiding using it and is not producing the expected and desired results. For that reason, I would like to present the BI system usability framework. This will allow me to test, measure and evaluate the BI usability (Ballard et al., 2006, pp. 78-82).

Information is a foundation for every business decision. It does not matter if a decision is a common and daily made one, or if it is a crucial business decision. Employees from each level of the organization are involved in decision making. In the process of empowerment every employee is expected to take several decisions on a daily basis. This means, that employee must deal with a vast amount of data and information, because this helps him find the most optimal decision. This process goes on continuously at every given moment. In order to take some of employees' burden from its shoulders, and to achieve better results, organizations are introducing BI products. BI products are meant to improve efficiency by alleviation the user's data management. The vast quantity of data and information, that is being gathered, leads to the information tools being mostly specialised, or at least adjusted, for each organizational role. Because of modification, and data management procedures, users that are producing important outputs like diagrams, explanations, lists, models, architectures, prototypes and so on, may not find it easy or even meaningful to take advantage of such products. And when the more experienced users do not find it comfortable to use BI tools, it is useless to expect, that they will lead, and effectively encourage the use of BI tools by less experienced users.

It seems that BI vendors are becoming more and more aware of the problem of lack of the BI usability. It can be even stated, that they are constantly looking for different approaches in order to improve the usability of the BI. Despite these efforts, in too many occasions, we can still hear customers' complaints, about the need of reducing IT workloads. So where is the problem (Imhoff, & White, 2011, p. 18)?

It is not new that the leading companies in the field of BI are developing solutions with the purpose of solving the BI usability problem. Unfortunately, the quality of the products being delivered to the customers is still being assessed from an economical point of view. From this point of view, a good and well assessed BI product provides quick and easy access to quality data and information at any time, regardless of its location. Furthermore it also provides easy data sharing, both, within and outside of the organization. Additionally it provides a tool for understanding data, and its transformation into information for effective usage. (Klaves, 2003, p. 2) All these indicators are being presented in connection with economic value that they bring to the organization. As it can be seen from the stated above, there is some awareness of the need to involve in, and develop the usability of BI systems. Unfortunately, despite the awareness, there still is a lack of research being done on this field.

Majority of these systems are further on being evaluated by clients' and vendors' top management and IT developers. These two groups of employees basically assess the system by its technical performances. The system receives a good grade if it meets the clients' top management technical requirements, and if performs flawlessly. This means that it allows all the necessary functions, that are important when data is being manipulated, and that these functions are working without errors. In the recent years, it is also desired, that the system allows some kind of modular assembly. It is wished that, when it is possible, the system can be modularly built. In this case, the customer only buys the needed parts of the system. This again becomes important, when we are economically evaluating the system. An evaluation like this takes into consideration only the economic factors that affect an investment's value. Economical assessment is important when we are considering the current and expected future values of an investment like portfolio, labour costs, and similar indicators. Unfortunately, these factors work only for this kind of evaluation and just partly reflect the reality.

In order to show the real value of the BI systems, we need to make another evaluation. This usability assessment will still go hand in hand with the economical and performance evaluation. Next to that it will show the real picture of the BI system contribution towards the business goals. Evaluation of the BI system usability from the user, task and system point of view, with the economical and performance evaluation, will show us the real BI system contribution and its comprehensive assessment.

The evaluation that includes the end user's point of view is important. This is important because the users are the real customers of the BI system. If the final users do not use the BI system in the proper way, or even refuse to use it, then the system is useless. With this work I would like to find out, how easy the users find the system to use and handle with. Even more, the employees that are well acquainted with tasks that needs to be performed, and are fully aware of efficient functioning of the system solution, can present handful of proposals, or even some minor problem solutions. Next to that, it would be interesting to explore the methods for improving ease-of-use as early as during the processes of designing and implementing, and later on, during the BI system usage. In order to do the BI usability assessment, it is necessary to obtain some quality components that will at each stage help to study the usability of the BI and help to assess its overall quality (Nielsen, 2012):

- Learnability, or how easy it is for users to accomplish basic tasks the first time they encounter the system;
- Efficiency, or the assessment of the users that have once learned the system, of how quickly they can perform tasks;
- Memorability, or the assessment of users that return to the system after a period of not using it and finding out, how easily they can re-establish proficiency;
- Errors means evaluating of how many errors do users make, how severe the errors are, and how easily they can recover from the errors;
- Satisfaction: How pleasant is it to use the system?

The presented quality components are being brought out from usability evaluations of Operational Information Systems (hereinafter: operational IS). As Popovič, Hackney, Coelho & Jaklič (2012) explain, there are typical differences between operational IS and BI systems, that need to be considered. As it is being stated, we can only partially rely on studies that were carried out in the field of enterprise IS and decision support systems, when making researches in the field of BI systems.

The processes carried out with the operational IS are being more structured than in BI systems. The operational IS are being process orientated. In order to execute these processes efficiently we need a quality data. If quality of data is not being assured, the processes are not efficiently executed, or their execution can be even stopped. These processes are also obtaining integrity, meaning that they are not changing much. This means that we can implement a formal structure that will support these operational processes. This feature also makes the operational system more mandatory to use. The users need to perform certain tasks, in the operational IS, in order to finish their work. On the other hand there is a BI system, which is being data orientated. The BI system is not using only the data, that is being used within the processes, that the operational IS uses. In addition to this data, the BI system is also using some additional data sources. All these data is then being transformed into information and later on into knowledge. This can be explained in the process of preparing some analysis or presentations with the BI system. Before preparing these outputs, the BI system user doesn't know all the data sources that will be needed. In some occasions there is some data missing in the available data sources. This data has to be provided from different data sources. Even if there is all the data available in the available data sources, the BI system user still has to find it, and maybe he doesn't know where to look for it. This are the reasons that the methods for identifying information needs within the BI system can't be as established as in the operational IS (Popovič et al., 2012, pp. 730-732).

The difference presented between the operational IS and BI system indicate that the quality components, that are being used to evaluate the usability of the BI system have different relevance, than the ones, that are being used to evaluate operational IS.

Knowing and improving these quality components at all phases of a BI system design, implementation and its usage, can make a significant difference in overall contribution of the BI system in the organization. It is important, that the BI solution is built User-Centered. If the solution cannot do or deliver what the user wants and needs it doesn't really matter whether if it is easy to use or not. On the other hand it is also no good, if the solution can hypothetically do what the user wants, but he or she can't make it happen because the system is to rigid and difficult to deal with.

The main purpose of the work presented is testing and presenting some proposals of how to detect, measure and on this basis improve the usability of BI solutions for Medium to Large Enterprises (hereinafter: MLEs).

Next to presenting the findings, I would like to propose improvements in the field of the BI usability assessment. On one hand, I wish to introduce some proposals to the BI software vendors. They could take the proposals into consideration, while implementing the BI system, and involve some proposed improvements into their already developed BI systems. On the other hand, the results could be also presented to the users of the Information Technologies (hereinafter: IT), like directors, managers and employees in IT and other departments that are being connected to BI and are familiar with the use of BI systems. These users deal with the reporting and BI systems regularly, and should also have the key role when implementing the BI system into the organization. With the User-Centered design (hereinafter: UCD), we could improve the quality, transparency, velocity and diversification of an individual's work and its workspace. With the help of this study, the users of the BI systems should become more aware of the benefits, potentials, etc., but also of restrictions and drawbacks of the systems, that are being used to provide all the information.

The methods, which are intended to be used in order to prepare this work are based on the study of theoretical foundations from the fields of IS and IT. To be more specific, the focus is going to be on the scientific field that explains the importance of the data and information for business decision making. At the same time, there will be incorporated knowledge gathered from literature that was presented by foreign and domestic authors, journals, discussions. Finally also sources published on-line will be used.

Based on the literature review I will develop a BI usability model. In order to do this, I will have to study the field of usability, and what are the important components of it. Since the BI system is a part of IS I will also need to study IS. On this basis I should be able to propose a BI usability model.

In order to obtain an optimal research result it is important, that there are used several data collection techniques. As already mentioned, in the previous paragraph, there will be used available information that is being obtained from different resource types. In this process, the better rated and newer sources will have a higher priority, and will be more likely taken into consideration when preparing the work. Content analysis will be helpful to tabulate the frequency of some characteristics found in the material. Based on the literature review, coupled with the knowledge gained from the case study, a comprehensive list of questions will be provided. These questions will be providing a guidance for written questionnaire. Before issuing the questionnaire, the questions will be discussed with two BI experts. This will be done, because I would like to eliminate unnecessary questions, and improve the questions used to be as understandable as possible.

To prepare an objective BI system usability evaluation, there needs to be taken into the consideration the intangible benefits that are difficult and sometimes even impossible to quantify. An important part in assessing the intangible benefits in the field of BI system usability is the user. The user comes in contact with the BI system whenever he wants to perform a task. For that matter, there will also be included non-participant observation of user behaviour. This should help to present the importance of the UCD (Gibson, Arnott, & Jagielska, 2004, p. 296).

Before issuing the written questionnaire, the list of questions will be discussed with the mentor and with BI professionals. The questions need to be discussed in order to eliminate the unnecessary ones. Unnecessary questions are questions that are not touching the subject. The questions that will be used in the questionnaire also need to be discussed, in order to make them as understandable as possible to facilitate the work of the respondents. Further on, the goal is to adjust the questions in a way. that they will ask about the BI system specifications, which differ from other solutions in IS. Finally, this will be also done to eliminate any unnecessary uncertainty that might occur. For this purpose I will perform pilot verification of the questionnaire. This will be done with two interviews. The first interviewee will be from the BI system provider side, and the second from the BI system customer side. The outcome of the interview will be then discussed with the mentor and then the final version of questionnaire will be prepared.

When the final version of the questionnaire will be prepared, the written version of the questionnaire will be administered. The questionnaire will be focusing on end user characteristics, system features, task variables connected with the characteristics that are used to evaluate usability. This analysis research will help to ascertain some issues that the user confronts when using the BI systems. The web-based survey will use a rating method, as well as a checklist, in order to make it easier to complete and collate the behaviours and pre-dispositions to the BI systems usability.

In order to present a more complete picture of the BI system usability assessment, the study includes mapping and scaling. Since the visualization is an indispensable tool, mapping is very useful. To find and present certain variables that cannot be seen by respondents, there scaling will be used.

In order to make an evaluation if the proposed model is valid or not, I will use Structural Equation Modeling (hereinafter: SEM). This technique is being used for testing and estimating relations. Further on, I will use Partial Least Squares (hereinafter: PLS) regression analysis, firstly to select suitable predictor variables, and later on to find which relations between dependent variable and a set of predictor variables are more important than others. The variables included in the model are recapitulated by the variables used to evaluate the usability of IS. Since not all variables, that explain usability of operational IS have the same importance also in the concept of BI system usability, I picked the most suitable ones for my research. I will continue my master's thesis with the hypothesis placement and their explanation according to the proposed research model. Further on I will present data collection and analysis (Abdi, 2010).

In the last part of the presented master's thesis I will present the results of the research. In this part I will conduct an interpretation of the research. In the application discussion I will give research implications from theoretical and practical point of view. Last but not least, I will close the presented work with a conclusion.

# 1 IMPORTANCE OF INFORMATION FOR BUSINESS DECISIONS

In agricultural era, labour was probably the most important if not even a key resource of any organization. Some experts also believe that in the industrial period which followed, capital took place as most critical resource. Nowadays, in the post-industrial era, it can probably be agreed, that information is next to the knowledge and people or employees, one of the basic and most critical resources needed in the modern business world (Sheth, 1994, pp. 3-4).

New-age organizations are suppliers, managers and consumers of enormous quantities of data and information. To achieve their goals, company employees need to make all kinds of decisions on a daily basis. Business decisions that are being made are the choice between two or more alternative problem solutions in numerous, daily presented business situations. In order to make a good decision, decision makers obviously need adequate information. Because the information in decision-making process forms a solid base for decisions, it is crucial to have it. We know four forms of information. Firstly there is known information. This means, that decision makers are aware of it, but they may have or not have the required access to it. On the other side there is an unknown information, where users are unaware of it. Information that the user is unaware of, cannot be considered when making a decision, because no one is aware of its existence. From this it can be seen, that the best combination is known-known information. This means, that the user is aware of the information needed, and that he has the access to it, and can use it when making a decision. The worst combination for decision making is unknown-unknown. This means, that the user is not aware of the information existence and he doesn't possess it (Sheth, 1994, pp. 5-9).

Organizations nowadays are for sure trying to avoid the second combination when the decision maker doesn't know about the information existence and he doesn't possess it. For this reason, gathering, storing, communicating, and using information are some of the essential elements of the organizational operating processes. These elements, and the capability of securing, analysing and retrieving information are the building blocks of organizational intelligence. Organizational intelligence is the capacity of an organization to create knowledge and use it to strategically adapt to the environment. It is similar to I.Q., but framed at an organizational level (Halal, 1997).

Nowadays organizations are also devoting more and more time and attention to the business decision-making. On one hand this must be done because there is an increased tendency in important decisions to be made quickly and without errors. On the other hand, many of these decisions are made by employees that are coming from the lower levels of the organizational structure. These employees confront the problem, and should know best how to resolve it. Finding the best solution is in this way ideally made in the shortest time possible. Because more and more employees are involved in decision making, and are playing an important part in the business process, this process is called empowerment. Bowen and Lawer (1995) are describing the process of empowerment in business world as the need to share information and develop teams that have the power to make decisions. The practical consciousness of the importance of information is also mirrored by research efforts intended to understand and improve the uses of information by employees (Quinn, & Spreitzer, 1999, p. 6).

On the basis stated above it can be argued that IT, which makes it easier or even possible to gather, manage, and present the information, is nowadays playing an important role in the successful business.

## 1.1 Business decision

As in everyday life also in business success comes to the people who get the big or important decisions right. Because business decision making is a crucial part of every business operation, it is at high importance that the right or better decisions are being made in order to provide overall success of the business. The quality of the decision made partly depends, as already stated, from the quality and the quantity of the given data and information and partly from experience and from quality in interpreting of available information. This experience involves consultation, seeking for different views and expertise. Further on, it also involves the ability to admit that one was wrong and changing one's mind. Various technologies exist, which help in making the information clearer and better analysed (Ausveg, 2012).

Even if decision makers are trained to make better decisions, an environment where they won't be unfairly criticised, for making wrong or bad decisions, is rather essential. A climate of criticism and fear stifles risk taking and creativity. That is why it is important, that decision takers receive proper support from their colleagues and superiors.

Business decisions are taking part at all business levels. At the top end of business structure, the board of directors are making the strategic decisions. These decisions are usually about the investments and directions of future growth. Managers are making more tactical decisions, about optimal contribution of their departments to the overall business goals. Finally also ordinary employees, from the bottom layers of a hierarchical organizational structure, are expected to make some decisions. These so called operational decisions are basing on the conduct of their own tasks and improvements to business practice. In order to make the process of empowerment work for the organization, it is necessary that an organization has careful recruiting, good training and enlightened management (Bowet, 2012; Griffin, & Media, 2012).

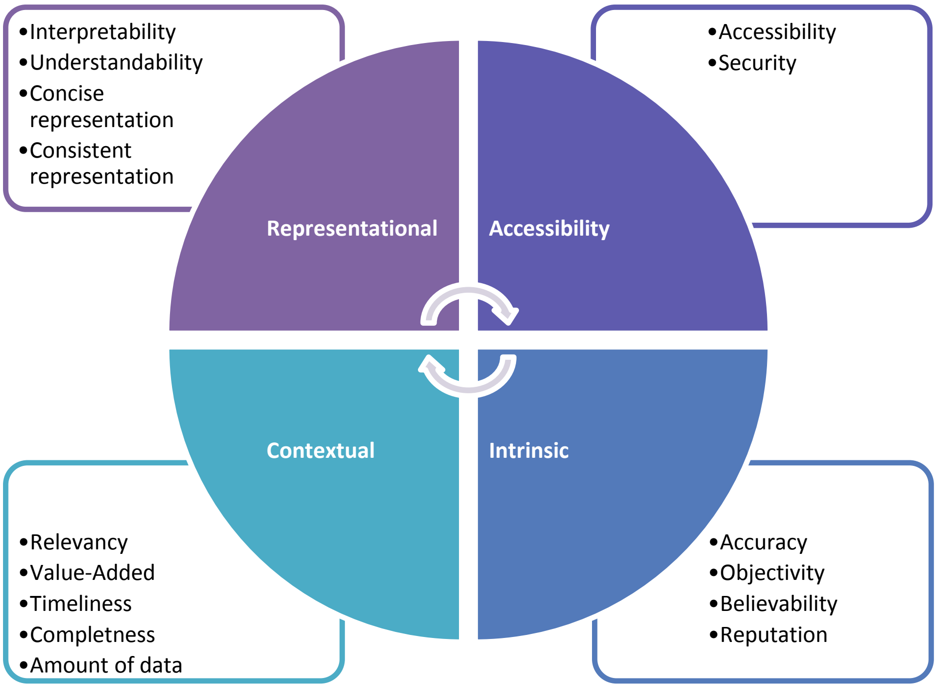
## 1.2 Data and information quality

There is usually more than one way to the give a correct answer to a certain question. Querying and answering questions can be done using data and information that is being retrieved from different sources, internal and external ones, and is being used in different combinations. For instance, we possess many different sources that hold slightly different data and information about one product. None of these sources contain wrong, or even misleading data. Even more, they are rather potentially interesting for a global query requiring. Executing all possible combinations is probably in relevant cases infeasible, also when using specialised BI system, and would be economically unjustified. That is why, we must choose between logically equivalent sources. This can be also done with the help of the BI system. Usually this selection takes into consideration the quality of information that comprises criteria, such as timeliness, completeness, accuracy, etc.

Amidst the increasing information availability, the quality of information is becoming more and more important factor, for the effectiveness of BI systems and individuals, who must reveal the quality information. The quality of information produced is not only an issue that involves IS architects, graphic designers and technical authors. This issue primarily, and most importantly concerns managers that take decisions and relay on the given information throughout the organization.

Wang and Strong (1996) have, in a conceptual framework for data quality model, empirically identified fifteen information quality criteria that are defining information quality. These, as data and information consumers - people who use information - define as most important quality criteria, are classified into four main categories; Accessibility, Intrinsic, Contextual and Representational information quality criteria (Knight, & Burn, 2005):

*Figure 1*. Conceptual framework for data quality




Source: Y. R. Wang, & D. Strong, *Beyond Accuracy: What Data Quality Means to Data Consumers*, 1996, p. 20.

An information source, or a query plan achieves certain scores in each of these criteria. We are processing these scores to calculate a total information quality score, and we are using them to rank the sources and plans. On the basis of this ranking we put in action only the best plans with the best sources disregarding the others. The data and information quality is also effecting the IS and its usability. It is important that within the IS we are dealing with the quality data, that will assure the correct outputs. At this point it is once again necessary to highlight the difference between the operational IS and the BI system.

Operational IS is being used in operational business activities. Its intention is to support the operational business processes. Operational IS can be for instance involved in the production process of a product so it assures the correct flow of activities, materials and other resources needed. Handling these operational tasks, and having the right data and information, is at vital importance in order to produce a quality product.

On the other hand there is a BI system. This system is also used daily, but not so routinely in comparison with operational IS. The tasks that are being performed with the BI system are different from those being performed with the operational IS. The most obvious difference is when using the BI system to make more aggregated assessments or predictions. If we take a look at example presented in the previous paragraph, operational IS is being used in the production process, where it is important to have the correct data, and information in order to make a product. If not all the data is correct we might produce a bad product, or maybe not produce it at all. But if we want to know or produce a presentation about monthly production of this product, we need more aggregated data. The fact is, that some product might not be produced because of the bad data used in the operational IS. But this data is not so critical when the data is being aggregated in order to make a presentation about monthly production via the BI system.

From the stated above we can see that quality data and information is important for the IS. The quality data has a direct and an indirect impact on the usability of the operational IS. But the quality of data doesn't play the same role in the BI systems and its usability. For that matter I am in next paragraphs describing the quality criteria, that is being used when defining if the data and information are a quality one or not. But this criteria is not being used in the proposed model that evaluates the BI system usability.

Next to accuracy and objectivity Intrinsic IQ also includes believability and reputation of the information. At this point accuracy and objectivity alone are not sufficient for data to be considered of high quality. Contrary to the traditional development view, "new age" data consumers also consider believability and reputation as an integral part of intrinsic. This intrinsic data quality encompasses something more than the accuracy and objectivity dimensions that IS and BI professionals strive to deliver. This means that information producers and custodians should also ensure the believability and reputation of data (Kahn, Strong, & Wang, 2002. pp. 187-189).

A contextual criterion argues that information quality must be relevant, timely, complete and appropriate in terms of amount, so as to add value (Kahn, Strong, & Wang, 2002. p. 186).

Representational IQ emphasizes the importance of the format of the data that must be concise and consistent. The data must also be meaningful, which means, that it is interpretable and easy to understand. For example, currency figures in the context of a U.S. database are typically in dollars, whereas those in European databases are likely to be in EUR. This type of context belongs to the representational IQ, instead of contextual IQ, which deals with the data consumer's task (Lee, Strong, Kahn, & Wang, 2001. p. 137).

Information systems professionals and also information producers recognize the importance of accessibility. Accessibility of information is a quality that emphasizes the importance of computer system that stores and provides access to information. This means, that the system must be accessible, but at the same time secure and must present information in a way, that it is interpretable, easy to understand, and easy to manipulate with (Lee et al., 2001. p. 135).

The information quality should be taken into consideration as soon as during query processing, if not even earlier. This inclusion is very important in a scientific and also in a statistical context. There are many relevant data sources where the quality of data and information varies. Selecting the right data source/s is essential. Poor information quality can have considerable social and economic impact – Garbage-In-Garbage-Out. Furthermore, scientific databases are very sensitive regarding timeliness and accuracy of data. This is being reflected in a quickly outdated results, and data of varying quality (Orr, 1998, pp. 1-5).

# 2 BUSINESS INTELLIGENCE

We live in the era where information is power. In any business enterprise, it is important, that everyone has the crucial information which they need in order to accurately and effectively fulfil their business obligations. If a business wants to deal with frequent and quick market changes, and if it wants to be successful and quick in decision making process, it needs to understand BI.

## 2.1 BI defined

In the world literature we can find many definitions of BI. At this point I am in a chronological order presenting just few of them. These definitions, that I find rather important, were selected because the definitions or their authors had a certain influence, in the years when they were presented.

- Gartner, the world's leading information technology research and advisory company, defines BI as an umbrella term, that includes the applications, infrastructure and tools, and best practices that enable access to and analysis of information to improve and optimize decisions and performance (Business intelligence BI, 2012);
- International Business Machines Corporation (hereinafter: IBM) defines BI as software, that allows business users to see and use large amounts of complex data (Timely data analysis with a high-performance, integrated data warehouse, 2012);
- Williams S. and Williams N. (2007, p. 2) in the book; The Profit Impact of BI, define BI as combination of products, technology, and methods to organize key information that management needs to improve profit and performance;
- Tvrdikova (2007, p. 165) describes the basic characteristic for BI tools and states that BI tool has the ability to collect data from heterogeneous source, to possess advance analytical methods, and to support multi users' demands;

These four definitions, that I consider most interesting, and also most of the other definitions which can be found in the literature, are primarily focusing on software and technology components. If we want to completely evaluate the usability of BI platforms, we should, next to those two components, consider the human evolvement in the concept of BI.

For that matter, I am obligated to present some alternative BI definitions that include human evolvement. These definitions are being presented in a chronological order;

In the article “Building Effective Intelligence Systems for Competitive Advantage” from the year 1986, authors present BI in a rather interesting way. Ghoshal & Kim (1986, pp. 49-58) argue that BI refers to a managerial philosophy, as a tool used to help organizations to manage and refine business information with the objective of making more effective business decisions.

Cindi Howson, an independent consultant and author/Co-author of four important books from the field of BI says, that; “Business intelligence allows people at all levels of an organisation to access, interact with, and analyse data to manage the business, improve performance, discover opportunities and operate efficiently” (Definition of business intelligence, 2008).

Inmon, Terdeman, & Imhoff (2000) write about the BI as a discipline of understanding the business abstractly and often from a distance. Further on, they argue that with BI, you can see the “forest and the trees”. This is an analogy used to express focusing on the details of a situation (the Trees), and seeing the Big Picture (the Forest).

BI can be defined as combination of operational data with applications and technologies that are being used to present complex and competitive information to planners and decision makers. It is important, that business analysts are having the right access to the right data or information. This is being needed to make better business decisions at the right time. Only when this condition is ensured, knowledge workers can understand the capabilities available in the organization, market trends and future directions, the technologies and also the regulatory environment in which the organization is operating. With the BI platforms being mission-critical and integral to an enterprise’s operations; enterprise-wide or local to one division, department, or project; or centrally initiated or driven by user demand, the actions can be performed on a certain base, instead of primarily relying on intuition (Business Intelligence (BI), 2013).

These definitions for BI demonstrated that BI systems are including multiple initiatives in order to measure, manage and improve the performance of employees, teams and processes. For this reason nowadays BI systems can give every employee access to the data required in order to make informed decisions. Next to that the BI systems have also the flexibility needed so that the employees can work the way they do.

## 2.2 Information systems, business intelligence and their evolution

The term usability evolved from the psychology of human factors and its focus on users and “user friendly” products. Usability is a measure of the quality of a user's experience interacting with a product. It is about users' ability to do what they want and need with the product or site (Bevan, Kirakowski, & Maissel, 1991).

BI usability can be determined by a software ease of use. It can be defined by factors such as the familiarity of the design, attractiveness, comfort, level of interaction, permitted response time, etc. From those factors it can be seen, that BI usability is a quality, that many IS possess, but unfortunately also many lack. It can seem hard to know, what makes something usable. If you don't have a breakthrough usability paradigm that actually drives sales, usability is only an issue when it is lacking or absent. Fortunately there are also customary and reliable methods for assessing, where design contributes to usability, and where it does not. These methods also help to judge what changes to make to designs, so a product can be usable enough to survive, or even thrive in the marketplace (Rubin, & Chisnell, 2008, p. 3).

What is today known by the name BI and its usability, has an origin and evolution that should be looked at, in order to introduce the concept of BI system usability (BI USABILITY: evolution and tendencies, 2011).

BI was introduced into the field of computer science as early as 1958, by a German computer scientist Hans Peter Luhn. For that reason, today we cannot talk about BI as a new technology. Even more, we also cannot talk about BI as an integrated solution for companies, within which the business requirement is definitely the key factor that powers technology innovation (The History of Business Intelligence Part 2, 2011).

In the sixties, IS were basing on files that almost totally depended on hardware limitations. The main goal of these systems was data storage and its treatment. But the storage systems - at that time storage systems were tapes - highly hindered the possibility of information management. Only when the first hard drives, that allowed direct access, came to the surface, it was possible to process data in order to obtain the information.

In this first time period, IS interacted with system users in a very precarious way. Systems consisted of consoles that displayed a series of options textually. Users had to select and generally present as many screens as options available. After choosing these options, the user obtained printed information, summaries and detailed lists.

In the 1970s the database management systems (hereinafter: DBMS) and the relational model presented by Edgar Frank Codd arise. This was a big step forward in this field. Until the presentation of the DBMS and relational model, the database structures were mainly based in network models, hierarchies, or just simply in structured files. The predominant characteristic of these databases was inflexibility and physical relations between entries (Sumathi, & Esakkirajan, 2007, pp. 67-68).

The relational model made an important positive effect on database development. But it took a while, that the first versions of systems were able to support the database creation. At the same time, there were made many improvements in the responses to requirements of data and information. Next to this, there were also made some improvements, that included interactive text interfaces. This meant the ability to present the information per screen, due to the possibility of scrolling. Improvements contributed to better interaction with the user. Unfortunately reports were still static and highly orientated towards transactional information.

In the eighties, the personal computer was more and more available, and the DBMS grow in popularity. In the year 1986, the SQL language was standardized. In this "era" also the idea of a "Data Warehouse" appeared. This concept was later defined by Bill Inmon and Ralph Kimbal in 1992. In the 1989 Howard Dresner redefined the term BI, which firstly appeared in 1958 (BI USABILITY: evolution and tendencies, 2011).

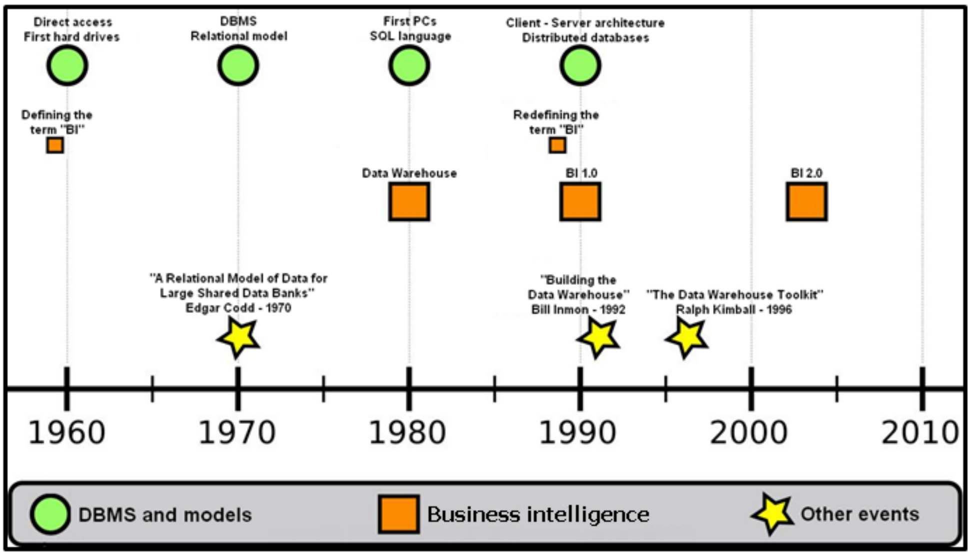
The first Data Warehouse providers in the 1980s emphasized the hardware and the capacity of their DBMS. But they "neglected" the Graphical User Interface (hereinafter: GUIs). This happened, because they left the development of GUIs to the outside programmers and developers. These developers didn't cooperate with each other in order to produce one "general" solution. They instead worked within different companies and organizations. And their main goal was to prepare their own specialised solutions. Because of this, many issues arise. It is argued that the percentage of unsuccessful IT projects at that time was as high as 80 percent. The blame for this disastrous result cannot be pinned only on non-cooperation. The developers of GUIs were used to work with "traditional" transactional and operational systems (hereinafter: OLTP) and relational modelling. These traditional approaches were not successful, because the development and implementation of a Data Warehouse cannot be compared to the OLTP. The GUI developers needed to apply new methodologies, models and tools, that were designed specifically for this new concept. When the interactivity was taken into the account, the improvement was soon notable (Hospodar, & Trevisan, 2008, pp. 6-10).

The new programming languages allowed friendlier and more user-orientated graphic and textual user interfaces. Also the reports could be more personalized and parameterized. The first information graphics like pie graphs and bar graphs were also introduced. And in the late 1980s, the first spreadsheets appeared. Spreadsheets radically changed the interaction between the end user and information, granting the possibility of maintaining an interaction with the data. Spreadsheets offered some, unfortunately still not enough, possibilities. Because of this, piles of redundant and unorganized data were created. This leaded into spreadsheets being introduced into database management only later, when it was possible to process, organize and convert these unorganized data into a datasets that could be used effectively.

In the 1996 the Gartner Group brought up the concept of BI. It was defined as the application of a set of methodologies, processes, architectures and technologies, that are able to transform raw data into a meaningful and useful peace of information. This information is then being used to improve enterprise operation effectiveness and support manager's decisions in order to achieve competitive advantages. In the 1990s organizations were operating with a lot of PCs, personal DBMSs, spread sheets, etc. All of these new approaches provided heterogeneous data and decentralized and unconnected information. The appearance of client-server architecture allowed the development of a new paradigm in application functioning and communication. This new architecture was especially suitable for DBMSs, which took advantage of it by giving rise to distributed databases, improving intercommunication in organizations and making databases more consistent and useful (BI USABILITY: evolution and tendencies 2011; Ranjan, 2009).

In this period several publications from the field of BI and BI system usability were issued. The authors of these publications tried to explain how to design and build a data warehouse and BI applications.  At this time first software applications that were orientated to data warehouses were presented. To name a few:  IBM OLAP server, Cognos, SAS, Oracle, Business Object, etc. These BI 1.0 applications fulfilled the basic tasks inherent to data warehouses, and were also DW-orientated, but weren’t really flexible. This was neither their main limitation. They were also limited with respect to analysing large volumes of data in an acceptable time. The tools and the physical storage structures were just not yet optimized for this purpose. The applications were also limited with respect to the possible sources of data. Finally, there was still no general consensus regarding the design of the GUIs for administration and navigation.

*Figure 2.* BI development




Source: *BI USABILITY: evolution and tendencies*, 2011.

In recent years many of technologies that allow representation and transportation of data in an efficient and standardized manner appeared. These technologies allow the creation of attractive and powerful GUIs and interaction between data and GUIs (Web services, frameworks, JavaScript, flash, etc.). Modern business tools and technologies changed the development paradigm and provided unique features and capabilities. BI 2.0 incorporates service-oriented architecture and Web 2.0. That means that the applications that are being used today are bringing a more browser-based approach to information gathering. These applications are focusing on design and presentation of queries, reports, OLAP analysis, etc. All this is being done through the interactive graphics, flash and JavaScript objects, personalized and parameterized dashboards, etc. As it can be seen, this places emphasis on the graphic interface and user interactivity (BI USABILITY: evolution and tendencies, 2011; Business Intelligence 2.0. (BI 2.0), 2012).

## 2.3 BI architecture fundamentals

A BI architecture is a framework that is needed for organizing the data, information management and technology components, which will be presented later on. These components are used to build BI systems. Mission of these systems is to facilitate reporting and data analytics. It is important that organization has a well-structured BI architecture, because this affects the implementation, and development decision, and also plays an important role in BI projects.

From the literature review it can be seen that there is more than one general BI architecture. This is not strange since the BI systems operate in different businesses and in different IT structures. The organizations, where BI is present, are also different in data and information needs. It doesn't matter if the organization is dealing with small or large amounts of data, it is always expected that BI systems will enable efficient processing of data and information and will always perform well. For that matter BI structures include common components that are presented.

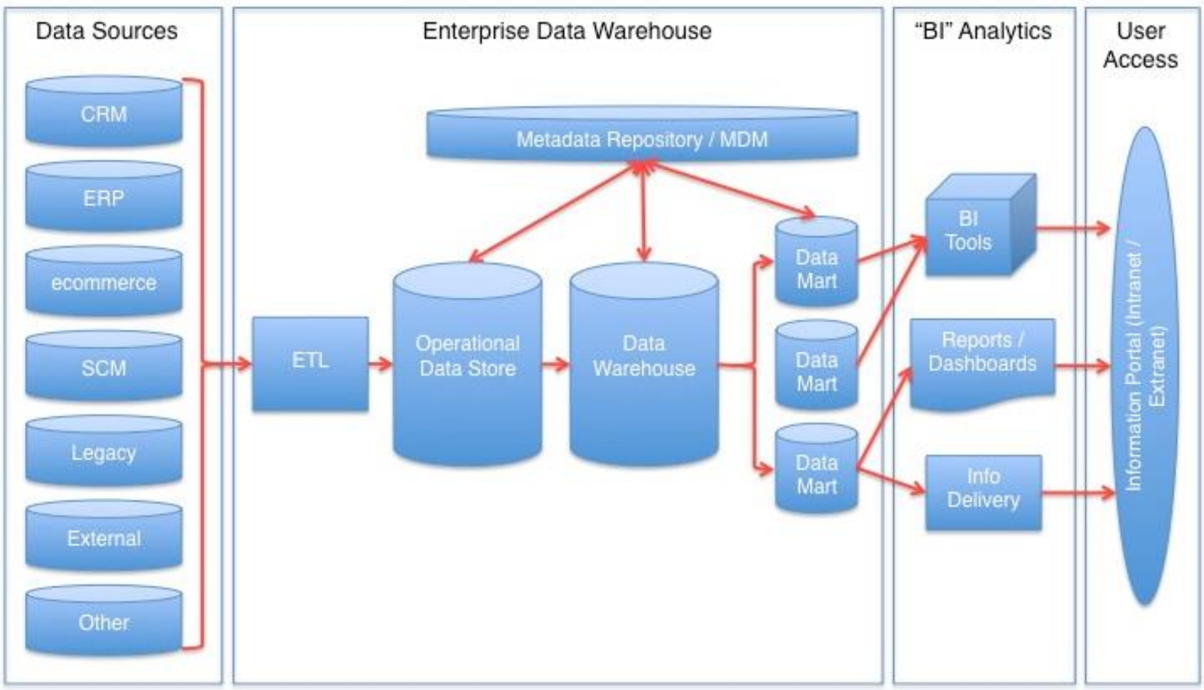
The data components of a BI architecture include the data sources that are needed in order to meet specific business needs and to improve organizational effectiveness. Data can be provided from both, internal and external data sources, and can be structured and unstructured. When selecting the data sources and later on, when extracting the data from them, it is important to have some criteria that includes data accuracy, data quality and the level of detail in the data.

In the next part of the architecture, the information management architectural components are used for transforming the raw transaction data, obtained from the data sources, into a consistent set of information that can be used by BI users and knowledge workers. The BI system should be able to handle the large amount of data efficiently. In the part of BI structure, where organizing of the "Enterprise Data Warehouse" is being performed, it is also desired to integrate the data and perform the data cleansing. Data cleansing is affecting the BI system efficiency. By setting the criteria for data dimensions and business rules, we can also define structures for data warehousing or for a data federation/virtualization approach. In theory the data federation/virtualization approach creates an abstraction layer for all data, thereby achieving flexibility for change and consistent data access and greatly reduced costs, because there is less need to create physically integrated data warehouse or data marts (Rouse, 2010; Data Federation – Rapidly Integrate Multiple Data Sources, 2012).

The BI technology components are used to present the information to BI users, and enable them to perform BI analytics. The analysing of the data includes the use of BI suite or other BI tools and the use of supporting IT infrastructure which includes hardware, database software and networking devices.

More and more work is also being executed outside of the organizational intranet. In a global organizations, there can be needs for some professionals that are dispersed worldwide. Some work needs to be done on field and many B2B transactions are, or can also be done directly by the business customers. For that matter an Enterprise Information Portal (hereinafter: EIP) is in many basic structures an addition. This system is basically a framework for integrating information, people and processes across organizational boundaries. The system provides a secure access point, often in the form of a web-based user interface (hereinafter: UI), and is designed to perform information exchange through web application, which interfaces with backend systems. From stated above it can be argued, that it is important that BI system can be accessed through a variety of channels (Need for Business Intelligence, 2012).

*Figure 3.* BI architecture fundamentals




Source: *Need for Business Intelligence*, 2012.

Unfortunately there are still many organizations that are unaware of the advantages that a well-structured BI architecture brings. Consequently, these organizations cannot take advantages that the BI system provides, thus usability of it is being limited.

One of the main reasons for this state or inability is a poor shape of IT architecture that supports the implementation and operation of such a system. If the IT structure is not a solid and well-structured one, organizations are simply unable to control the implementation process of the BI system and also the operating of the entire BI environment that follows. But these are not the only problems that the organizations face when considering the BI infrastructure. Many architectures still feature one-way communication flow between different components. For instance, the data flow only goes from metadata repository to operational data store and not vice versa. The limitation of this kind of uni-directional traffic is that, no adjustment or correction can be performed on metadata even in the case that an error is found. In order to improve this state and if organizations want to avoid the Garbage-In-Garbage-Out effect, and improve BI and its usability, the entire BI process has to be redone (Thomas, & Jeanne, 2007).

Another important issue with existing BI architectures is the lack of support on metadata management. If we want to standardize metadata across different systems, BI architecture should include the layer of metadata. That allows organizations to track and monitor data flows within their BI environment (Prashant, 2012).

When listing BI architecture issues the exclusion of the operational data stores (hereinafter: ODS) cannot be overlooked. When there are no ODS, it means that the structure is lacking the operational data store in the BI environment, so the BI user cannot provide current or in time information, that can be directly accessed or uploaded by other users.

Furthermore, in the ETL process it is necessary to have a data warehouse staging area. The data warehouse staging area is a temporary location, where data from source systems is copied. All required data must be available before data can be integrated into the data warehouse. Most of the retrieved data, which comes from different data sources, require some sort of purification and transformation. These processes, next to other business rules that conform to the architectural guidelines, are also important to optimize and speed up loading the data into data warehouse.

To sum up, every modern BI system architecture should consist from at least three layers. Or a global structured enterprise structure that consists from four layers. These connected and intertwined layers need to be well structured and should allow some adjustments in order to meet different business needs. As already stated these layers are:

- Data sources (CRM, ERP, ecommerce, SCM, in-house data, external and other sources);

- Enterprise data warehouse (ETL, operational data store, data warehouse, data marts and metadata repository);
- BI analytics (BI tools, reports and dashboards and other information delivery systems);
- End user access (information portal being able to operate within intranet and extranet).

If we take a quick look at the market, there we can find many different IT solutions on the basis of which the BI system architecture can be set up. There are some more “generalized” solutions that are meant for big organizations, but there are also many “in-house” or specially prepared solutions meant for smaller enterprises. Even more, there can be find solutions that are special prepared for the different divisions, departments or projects within one organization or even for a certain user within the organizational subject. Common characteristic of these solutions are, that they all provide premium and specialized representation of the patterns of the given or available information. However, all of these tools, no matter how faultless they are, they cannot compensate errors or anomalies, which might occur at any point of the process of implementation and operation. These errors, anomalies, etc. distort the final message. For that reason, it is important that business architects and analysts are aware of the BI architecture that must be seen as a big picture. This is the basis, if we want to ensure that the BI users always have the access to a clear definitions of both, the base data - information source - and the processed results/solutions that were introduced and produced by software tools (English, 2005).

## 2.4 The main components of BI

Modern BI tools and technologies are usually not just a single application within one organization. They mostly consist of different components that are closely related or even intertwined with each other. These components enable knowledge workers to analyse the data, retrieve information and finally display the results in a form that is understandable and easy to manage. From the architecture point of view, a modern BI system should incorporate data warehousing, database querying and reporting, Online Analytical reporting (hereinafter: OLAP), data mining and visualization components, Advanced Analytics and Extraction Transformation and Loading (hereinafter: ETL) tools. In order to detect, measure and improve the usability of BI platforms, we need to look at how usable it is to handle with each one of these components. To do that, we need to take a closer look at these BI system components (Berson, Smith, & Thearling, 2002).

Data warehousing emerged as a consequence of the observation by W. Inmon and E. F. Codd in 1990's. Those two scientists found out, that because of their different transaction characteristics, operational-level on-line processing (hereinafter: OLTP) and decision support applications cannot coexist efficiently in the same database environment. Meanwhile, data warehousing has taken a much broader role (Jarke, Lenzerini, Vassiliou, & Vassiliadis, 2003, pp. 1-4).

Hobbs, Hillson, Lewande & Smith (2005, pp. 771–775) define data warehouse as a database that contains data from multiple operational systems. This data has been consolidated, integrated, aggregated and structured in a way, that it can be used to support the analysis and decision-making process of a business. Data warehouse can be formally understood as a various layers of data. That means that data warehouses cannot be off-the-shelf products, but must be designed and optimized with the great attention to the end user situation.

Database querying basically stands for searching for information within the database. There are different query languages and querying techniques for different database types. Usually queries are constructed using SQL, which resembles a programming language, designed for managing data in relational database management systems. There are many different approaches to displaying previously searched information. By definition, database reports are formatted result of database queries and are containing useful data for decision-making and analysis (What is a database query?, 2013).

Because users often mix up reporting and querying, the difference of these two terms should be highlighted. Result of a query is a "raw data" and result of report is representation of the data based on a query. The easiest way to think of it is that query returns of set of data that typically looks like a spreadsheet, and a report returns the data in a more presentative form.
Online Analytical Processing is delivering the simplest forms of analysis. Business analytics can slice and dice interrelated subsets of data or so called "cubes" using BI tools. They can use standard OLAP features such as page-by, pivot, sort, filter and drill up or down to analyse the data. All the analyses provide multidimensional, summarized or in some other way calculated views of business data. This data can be easily put to a series of report views. OLAP analyses are offering users access to the data warehouses or data marts, that are being designed for sophisticated enterprise intelligence systems. These systems process advanced analysis, like analysing trends and critical factors that is required by IT workers and analysts.

Data mining or sometimes referred to as "knowledge discovery", is a process of identifying new patterns and insights in data. It is positioned at the intersection of multiple research areas, like pattern recognition, machine learning, statistics, databases and visualization. As the monstrous quantity of data collected and stored in database is growing bigger and bigger, there is an increased need to provide data summarization through visualization. Since vision frequently dominates the integrated visual-haptic percept, this helps to quickly identify important patterns and trends. Finally it also helps to take actions upon the findings. Insight derived from data mining can provide an economic value that can in many occasions be crucial for a business which is seeking for competitive advantages (Kohavi, 2001; Fayyad, Piatersky-Shapiro, & Smyth, 1996, pp. 1-34).

We know two types of data mining. One is predictive and the other descriptive. Predictive data mining was already described in the previous paragraph and uses variables or fields from a dataset to predict unknown or future values. Descriptive data mining focuses on finding patterns which describe the data and can be interpreted by data analysis. Kobielus (2010) defines Advanced analytics as »Any solution, that supports the identification of meaningful patterns and correlations among variables in a complex, structured, semi structured and unstructured, historical, and potential future data sets for the purposes of predicting future events and assessing the attractiveness of various courses of action. Advanced analytics typically incorporates such functionality as data mining, descriptive modelling, econometrics, forecasting, operations research, optimization, predictive modelling, simulation, statistics, and text analytics«. The goal of such analysis is to gain understanding of the data by uncovering new relationships, patterns and important information regarding the dataset (Philpott, 2010, pp. 4-6).

The term ETL that stands for Extract, Transform and Load, is a three-stage process in database usage and data warehousing. The ETL process starts with extraction of the data from different source data stores. The data comes from different sources which usually means, that also the data comes in different forms and types. For that reason after this phase, the extracted data is propagated to a special-purpose area of the warehouse that is being called Data Staging Area (hereinafter: DSA). Here the transformation, homogenization and cleansing of the data takes place. Finally, it is loaded into a target data warehouse including all its counterparts (data marts and views) in order to be analysed. To sum up, what is the main goal of ETL processes, we can say, that it enables integration and analysis of the data that is being stored in different databases and in heterogeneous formats (Vassiliadis, & Simitsis, 2013).

## 2.5 BI trends

One of the most obvious trends in information and communications technology (hereinafter: ICT) is the involvement of employees in corporate data manipulation. ICT is used as an extended synonym for information technology, but is a more specific term, that captures the role of unified communications, the integration of telecommunications, computers, storage, and audio-visual systems, which enable users to access, store, transmit and manipulate information. Better and faster business decision-making is particularly important in the current economic slowdown. In order to enable better decision making process, we need the information that is stored in one place. That means, that all the information gathered is being stored in one main database or so called data warehouse. For this reason we need to provide uniformity and quality data. There are many technologies like Decision Support Systems (DSS-s), Query and Reporting tools, Fourth generation programming languages (4GLs) etc., that allow users by improving the access to data and information to improve their manipulation. Before these technologies, the data management was hard to or even impossible to perform. Furthermore virtualization of data, and integrated enterprise-wide information access improves security of data and worker’s mobility. These are just few reasons to be addressed, that help to put BI ahead of some more widely discussed ICT issues (World Youth Report, 2003).

Enterprises continue to recognize the economic value of information, and see the opportunity to capture and apply even bigger amounts of data. These organizations will need analytics technologies capable of making sense from this detailed data. This means that organizations will need BI technologies that will be capable of producing autonomous insights and interfaces quickly (Gartner Predicts Business Intelligence and Analytics Will Remain Top Focus for CIOs Though 2017, 2013).

According to Fosters survey, that was taken in mid-2011 and involved more than 200 Australian companies, the level of implementation of BI is catching up with other core business systems. Manufacturing and wholesale/retail sectors with more advanced implementation of BI dominate over education, health and welfare sectors, which are slowly following (Insight Quarterly, 2011).

The survey responses show, that BI platforms implementation is not particularly high. The level of investment largely reflects the current level of implementation. The more mature the implementation is, the higher is the expected level of investment. But in general BI implementation is not particularly high, and most of the organizations are trialling BI solutions on a limited scale (Insight Quarterly, 2011).

BI in a cloud or a Cloud BI is growing in importance, but according to CIOs and ICT managers, it is the least likely enterprise application to have been moved to the Cloud especially when thinking of a bigger scale. The main reason for that is the sensitive nature of the data. The wholesale/retail sector is the most susceptible to take the cloud BI for its own. There are two important reasons for wholesale and retail sector being ahead of other industries in this respect. Firstly, there is dispersed need for business information across this fast-moving sector. Secondly, this sector also has many ups and downs. For that reason organizations must be able to quickly adapt to increasing or reducing needs and at the same time optimize costs (Chadha, & Iyer, 2010, pp. 39-42; What is Cloud Business Intelligence?, 2013).

In the past few years, especially major software vendors worked on rationalisation in the market of BI and other end user access technologies. Because the main focus was on other technologies, BI promise remained largely unfulfilled. That, and the need for greater business efficiency in the economic slowdown show the BI as an area which requires further investments. Implementation is not a one-off process. Directly proportional to the implemented stage of BI in organization, the need for further investment can be seen, and the companies are also aware of.

In the Gartner conference, they revealed predictions that going forward, companies will make their future investments in the business-user-lead analysis solutions. Those organizations will focus most of its effort on data modelling and governance. As a result, data discovery will become more important than IT authored static reporting. Further on, Gartner predicts that BI, analytics and user interaction will become dominant paradigm for new implementations by 2015 (Gartner Predicts Business Intelligence and Analytics Will Remain Top Focus for CIOs Though 2017, 2013).

In the January 2011, the Gartner group published "Magic Quadrant for Business Intelligence Platforms" study. This study presents a global view of Gartner's opinion of the main software vendors, that should be considered by BI customers. In this study "ease-of-use" surpassed "functionality" for the first time. Ease-of-use became the most important selection criteria when purchasing a BI platform because demanding and influential business users drive BI purchasing decisions in favour of easier to use data discovery tools over traditional BI platforms. In Match 2011 there was made another Gartner survey titled: "Bi Platforms User Survey, 2011: Customers Rate their BI Platform Functionality". This survey also evaluated major vendors' products based on how respondents rated their satisfaction with the capabilities and those products' ease of use. The results of this survey were also similar to the first survey, and showed that products with the highest ease of use scored tend to also have the highest composite product functionality rates (Sallam, Richardson, Hagerty, & Hostmann, 2011; Sallam, 2011, p.7).

# 3 BI USABILITY

Usability is a quality attribute, that assesses how easy systems are to use. This term also refers to the methods, that are required and being used when improving ease-of-use during the design and implementation processes of a system. This means that when implementing the new solution, we are at any given moment trying to achieve the full satisfaction of the needs, which occur by users in the organization. And if we consider the big picture, these improvements and efforts to improve the usability, of the system, should lead to the satisfying the needs and wishes business owners and stakeholders have. To achieve the goal of making the system being as easy to use as possible, we should define usability attributes, which can be also understand as milestones, in the process of evaluation of system usability. We can say that system is usable, when performing the work with using the system is efficient and satisfying (Rubin, & Chisnell, 2008, p. 4).

Usability can be presented as a degree to which a product enables a user to achieve their goals. This is an assessment of the user's willingness to use the product. Without the user's motivation, other measures make no sense. If a system is easy to use, easy to learn and also satisfying to use, but does not achieve the specific goals, that the user wants to achieve, it will probably not be used, or will be poorly used. This attribute is unfortunately in most cases overlooked and not taken into the consideration. In the initial stages of software implementation, and even later on, when the software is being used, the developers need to know, what features are desirable and necessary, before other elements of usability are even considered. If development team doesn't know these features, they are simply guessing user's point of view or even worse, they use themselves as the user model (Rubin, & Chisnell, 2008, pp. 4-8).

With efficiency we measure, how quickly can users, that are using the system, accomplish their goals in the accurate and complete way. For example, we can measure the time spent, that users need to load certain reports needed to be presented. To make a good assessment, like with the attribute presented below, we should link efficiency with the percentage of total users (Quesenbery, 2013).

The next attribute, effectiveness refers to the extent to which the product behaves in the way that users expect it to, and the ease with which users can use it to do what they wanted to do. This can be measured quantitatively, with error rate. To extend the example from the previous paragraph, when evaluating effectiveness, we can express the benchmark as "90 percent of users will be able to load certain reports correctly on the first attempt." (Quesenbery, 2013).

Learnability is a part of effectiveness. It is the user's ability to operate the system to some defined level of competence after defined period of training. - Optimally there would be no training at all. - It also refers to the ability of infrequent users to relearn the system after periods of inactivity (Jeng, 2005, pp. 106-108).

When making the evaluation of the IS usability, we are also considering user's satisfaction, or how the user feels about the system and what are their opinions. Users that use the operational IS, are using it for ongoing operational tasks and processes. For these users, as also Popovič et. al (2012) argue, it is mandatory to use the operational IS, for which we can say that it is becoming incorporated and even indispensable in operational tasks and processes. When the users are more satisfied with the operational IS, it is more likely, that they will perform well, when comparing them to the others, who don't think that a product meets their needs. On the other hand we have BI systems. These systems are used for different objectives and goals which are not being so directly connected with the operational processes, as when talking about operational IS. For instance sale department uses operational IS to manage a sale campaign. This campaign has certain resources, limitations, objectives and goals that need to be achieved. In nowadays MLEs it is almost impossible to run a sale campaign along with other sale campaigns, without the help of operational IS. This becomes infeasible because of the data needs, time limitations, people involved and also other factors. The BI system is not being used for this operational processes, but can for instance be used before the sale campaign, to set goals, and after the campaign, to evaluate the results, and to compare these results with other campaigns. This kind of evaluations are being done by knowledge workers, who use the BI system that is helping them to efficiently present the results. For this employees is not mandatory to use the BI system. From them it is only required that they produce the presentations, deliver the reports or in some other way provide the necessary information. As it can be seen, these knowledge users will use the BI system when they will find it usable, but if they think that the system is not usable they will simply not use it. This means that BI system BI system satisfaction can be used as a proxy measure for usability and vice versa. The attribute BI system user satisfaction can be for this reason excluded from the proposed model, that measures the BI system usability.

The last attribute, accessibility talks about having the access to the data and information sources, that are needed to accomplish a goal. This attribute goes hand in hand with system usability. Making systems more usable and accessible is part of the larger discipline of UCD. This design encompasses a number of methods and techniques to help system designers change the way they view and design products. These methods work from the end user's needs and abilities to the implementation and operation of the system – customer/end user orientated (Keinonen, 2008, pp. 211-219).

The attributes, that are being addressed, except for the attribute BI system user satisfaction, are being used in the proposed model, in order to evaluate if and to which degree they effect the BI system usability. If we want to introduce the BI system that is usable, it is not enough that we consider just the ability to generate numbers about usage. With the results about the usage we can evaluate if the product works or there are any problems with it, but we can't say if it is usable or not. There is a distinct qualitative element to how usable something is, and this can't be captured only with numbers. This element assesses how one interprets the data in order to know how to fix a problem, because the behavioural data tells why there is a problem. It can be easy for let's say a production manager to find a report about material consumption in the production, but interpreting those numbers on the report, and on their basis recommending the improvements is a true value that the user should contribute.

When designing a new BI solution, judging a several possible alternatives causes a design problem. When this happens, a product designer should know or inquire which alternatives are especially likely to happen for each particular case. This in most cases requires looking beyond individual data points in order to design effective treatment (Rubin, & Chisnell, 2008, pp. 4-7).

## 3.1 User-centered design

This way of designing is not a new approach. In the history it was presented under different names, such as human factors engineering, ergonomics and usability engineering. As already stated, the UCD represents a set of techniques, processes, methods and procedures that are needed to design and develop usable systems. And within all this, the designing and development, it places the end user in the center of the process (Abras, Maloney-Krichmar, & Preece, 2004).

It cannot be argued, that the system designers must first of all think about the technology that is needed for their product being developed. Only when they are hundred percent sure, that it can be built, what they have in their minds, they can start thinking about the features, that the system will be delivering, and if the system will be able to do what the users will want from it to do. And only when these requirements are accomplished and assured, they can start thinking about what the user's experience will be like. In the UCD and development of the system, the developer is user orientated. But before this, it needs to be taken into account, that there are some limitations and dis/abilities of the available technology and also different features, that the customer wants to obtain or deliver.

When implementing and/or developing the new system using the UCD approach, the goal is to support how the users actually works, rather than forcing them to change what they do, in order to use the new solution. The International Organization for Standards (hereinafter: ISO) is with standard 12407 providing guidance on achieving quality in use by using UCD activities throughout the life cycle of interactive computer-based systems. The standard describes user centered design as a multi-disciplinary activity. This activity incorporates human factors and ergonomics knowledge and techniques, that are intended to enhance effectiveness and productivity. Improving human working conditions, and counteracting the possible adverse effects of use on human health, safety and performance is also taken into the consideration (Human centred design processes for interactive systems, 2013).

There are four UCD activities defined, that should be taken into the consideration as soon as at the earliest stages of a project implementation and also later on in development stages. To the extent to which these activities come closer to user needs and wishes, can indicate well if the system is usable or not.

- Understanding and specifying the use context;
- Specifying the user and organizational requirements;
- Producing design solutions;
- Evaluation of designs against requirements (Human centred design processes for interactive systems, 2013).

These activities can be performed in different sequences and in different effort and detail levels, varying on the design environment and the stage of the design/development process (Human centred design processes for interactive systems, 2013).

## 3.2 Why considering the UCD and usability

In order to make the BI system implementation, introduction and its day to day use successful, it is at high importance that we consider system usability. If the users will find the system difficult to use, they will try to avoid using it. If the system can't clearly state, what it offers and what users can do with it, they will not use its performances in full. If users get lost in the system, and if information is hard to read or doesn't answer users' questions, that discourages them from using the system. Here are for demonstration purposes stated just a few, most obvious, problems that occur and demotivate users to use the system. We must be aware that users don't like to spend too much or in most cases even any time reading the manuals or otherwise spend time figuring out an interface. There are plenty of excuses available out there and users know each one of it.

For the BI intelligence systems, usability is also a matter of employee productivity. Time that users waste being lost in the system or pondering difficult instructions is also money waste. An organization needs to pay the employees to be at work studying and resolving issues without getting any work done.

Current best practices propose spending about 10 percent of a design project's budget on a system usability. For the BI intelligence systems the contributions and consequently improvements are typically smaller, but still substantial. For these internal projects it is an idea of doubling usability as cutting training budgets in half and doubling the number of transactions that employees are performing per hour (Nielsen, 2012).

It is clear, that from the user's perspective, usability is important. In more and more events it makes the difference between performing task accurately and completely or not, and enjoying the process or being frustrated by it. As already stated, from a management point of view, system with poor usability reduces the productivity of the workforce. In the worst case scenarios it can be reduced to the level, where the performance is worse than without using the system. Finally also system developers are aware of the importance of usability, because it can mean the difference between the success and failure of a software solution. If people have a choice, they tend to use systems that are more user-friendly (Introduction to User-Centered Design, 2013).

## 3.3 Acceptance of information technology

The main goal of organizationally based IS, is to improve business processes performance. These performance improvements directly correlate with overall organizational performance. In the end, this is mirroring in the obtained organizational profit. Unfortunately performance impacts, that could have a positive effect, are lost whenever systems are rejected by users. User acceptance is in most cases the key factor, that determines the success or failure of the implementation and later on, successful usage of the IS including the BI systems.

For this reason, it is interesting to address, why users accept or reject information technology, and how user acceptance is influenced by system characteristics. The IS designers, developers, selectors and managers are not only interested in explaining why a system is unacceptable to some users. They also want to understand, how to improve user acceptance throughout the design of the system. For that reason several models were developed. These theoretical models study adoption (Theory of Reasoned Action), usage behaviour (Theory of Planned Behaviour) and user acceptance (Technology Acceptance Model). In the work presented I am adopting the modified version of Technology Acceptance Model (hereinafter: TAM) in order to evaluate the user's motivation to use the BI system.

# 4 USABILITY EVALUATION

Foltz, Schneider, Kausch, Wolf, Schlick and Luczak (2008) say that usability evaluation is any analysis or empirical study of the usability of a prototype or a system. Tullis & Albert (2008) argue that this evaluation involves usability metrics which can be observed, quantified and is focusing on measuring the interaction of the person with the system or investigated product. Foltz et al. (2008) propagate that the goal of usability evaluation is to provide feedback in software development, and to support the iterative development process.

Foltz et al. (2008) suggest that in general, two types of usability evaluation can be distinguished: formative and summative. Formative evaluation is being present during the design phase. This is being done order to identify aspects of the design that need to be improved, and to provide indices in how to make design changes. Summative evaluation is measuring a design result, and takes place towards the end of a design phase.

For that matter the evaluation methods can be separated into two different classes: analytic and empirical. Analytic evaluation methods are being used in the early stages of the development processes. They are being used even before there are users or prototypes available for empirical tests. Usually these analytic methods (cognitive walkthroughs, usability-expert reviews, group design reviews, etc.) are less expensive than making studies that involve users, but the hazard of this evaluations is that the software designers may feel that they are being evaluated (Foltz et al., 2008).

In order to present some proposals of how to detect, measure and improve the usability of BI systems, there exists a more interesting empirical evaluation. This kind of evaluation involves actual, or designated users. This evaluation can be relatively informal. For example, it can involve observing people while they explore a prototype. But on the other hand, those kinds of evaluations can be very formal and systematic. For example a controlled laboratory study of performance times and errors, or a comprehensive survey of many users (Foltz et al., 2008).

Usability principles can be operationalised as questions that help the designer to concretely evaluate all the aspects of an interactive system and the user experience. By retrieving the answers, the designers can already in early stages detect the potential design problems and conflicts that might exist (Rogers, Sharp & Preece, 2012; Preece, Rogers & Sharp, 2002).

Preece et al. (2002) proposes three main usability evaluation approaches. Firstly, there is usability testing that involves measurements of typical users' performance on typical task. Secondly, there are field studies which are being performed in a natural setting with the aim of understanding what people naturally do, and how products mediate their activities. In the end, there is also an analytical evaluation. This evaluation consists of two evaluation methods. Inspections which includes heuristic evaluations and walkthroughs, and theoretically based models which are being used to predict user performance.

Each one of these approaches has respective methods associated with them. For the purposes of this study, I am adopting the usability model. This model in a more precise way and partitioned looks at the task, that needs to be performed, the user and its characteristics and the system, that is being used in order to perform the task. Evaluation is making use of the following methods:

- observing users;
- asking users;
- asking experts;
- inspections and
- understanding user's performance.

Depending on the evaluation approach, some methods are being combined in order to get a broader understanding of a design.

## 4.1 Proposed usability model

Usability engineering is next to reliability, security and privacy one of building blocks of the trustworthy computing. In the presented work I am adopting the usability model that looks at the BI usability from the task, the user and the system point of view. This model offers examples of measuring the usability icons, and usability testing, as well as usability assessment methods beyond testing. Evaluating the nature of usability of BI platforms quantitatively is one of the goals of this work. This is being done by addressing a series of questions, which are designed to assess the user's perceptions of BI usability.

For the matter of the BI system usability evaluation, I am presenting the usability model that was adopted by Sahinoglu, Morton, Samelo and Ganguly's study from 2012. I chose this model because it is dealing with the concept of Usability Engineering (hereinafter: UE). This concept is generally concerned with human-computer interaction and specifically with making human-computer interfaces that have high usability or user friendliness. I find this model appropriate, since I am evaluating usability of the BI system. In the model, that is dealing with the UE, there is presented interaction between two end-points. Firstly there is computer side, where I find some similarities with the BI system, that can be also used in my usability model. Second end-point presented is the human side and in my case this is the user that uses the BI system. Here I found even more similarities with my research, that can be taken into consideration. Nevertheless this model was not fully appropriate for my research. This model presented two end points, one was the consumer of information that can be presented via the interface and the other was the interface. In my research I am evaluating the usability of complete BI system, and not only the usability of its interface. For this reason I slightly modified the model. Firstly, I needed to replace the system variables and adjust the indicators that are being important for the BI system. Then I modified the indicators that are being used for the task and user variables. Doing that, I modified the model, that is being used to evaluate usability of the system interface, so it can be used for BI system usability evaluation.

In the proposed model I included main aspects that are being important when making the BI system usability assessment. These aspects were chosen because of the specific that the BI system has. With the system learnability I want to evaluate, how learnability affects the usability of the BI system. This aspect is important in the concept of BI system usability, because the system is being used for daily and also tasks and processes that are being executed from time to time. Even if the system is being used daily, there can be some features that are used occasionally. Because BI system learnability possibly effects BI system usability this aspect is being included in the proposed model. Secondly there is system efficiency. It is important that the BI system is efficient especially when handling large amounts of data. Efficiency of the BI system is even more important in today's times, when it is necessary to provide accurate and timely data and information in order to assure business competitiveness. If the BI system is not being efficient, users are probably not finding it usable, and for this reason this aspect can’t be excluded from my research. The third variable concerning the BI system is its flexibility. The BI users are using the system for variable set of tasks. Even if the tasks seem similar to each other, there are different inputs and different procedures needed in order to successfully accomplish them. Because different users are using it, the BI system should be able to be adopted to their needs and also their personal specifications. Because of the nature of tasks, for which the BI system is being used, the rigidity of the system will probably have a negative effect on its usability. Further on I am presenting the user engagement. User engagement, or how much the BI system user knows about the system, and how much he uses it, for sure shows his attitude toward the BI system. Consequently this probably affects its perception towards the BI system usability. Finally I included the aspect that looks at the tasks that are being performed with the BI system. There is a variety of tasks that can be performed with the help of such system. These tasks probably have a certain effect on the BI system usability and for that matter this aspect also can’t be missed out.

In the presented model I am presenting general aspects and also their sub-aspects, that were taken into consideration when preparing the questionnaire. Some of these sub-aspects presented in the following model have, on the basis of previous researches and literature review, a greater impact on the BI usability than others. Taking this into account, I focused on the sub-aspects that are from previous researches known that play more important role when talking about the BI system usability.

As already stated, on the basis of sub-aspects the questionnaire was being formulated. Within task aspect, the BI users were being asked questions regarding task frequency, task variability, complexity and situational constraints. Regarding the BI user aspect, users were asked questions about their knowledge of BI system. They were also asked if there is an opportunity of choice and how they are motivated to work with the BI system.

Within the system aspect that is being divided into three sub-groups; system learnability, system efficiency and system flexibility. BI users were asked to answer questions regarding the BI system learnability and how efficient they find the BI system. Further on question referred on BI system flexibility. The respondents were asked, if they think that the BI system is flexible enough, and if the system has any task mismatches or some other errors, that might occur. Finally, the users were also asked about the overall satisfaction with the BI system. The subsequent evaluation of responses show, how much each of these factors impacts the BI system usability (Sahinoglu, Ganguly, Morton & Samelo, 2012).

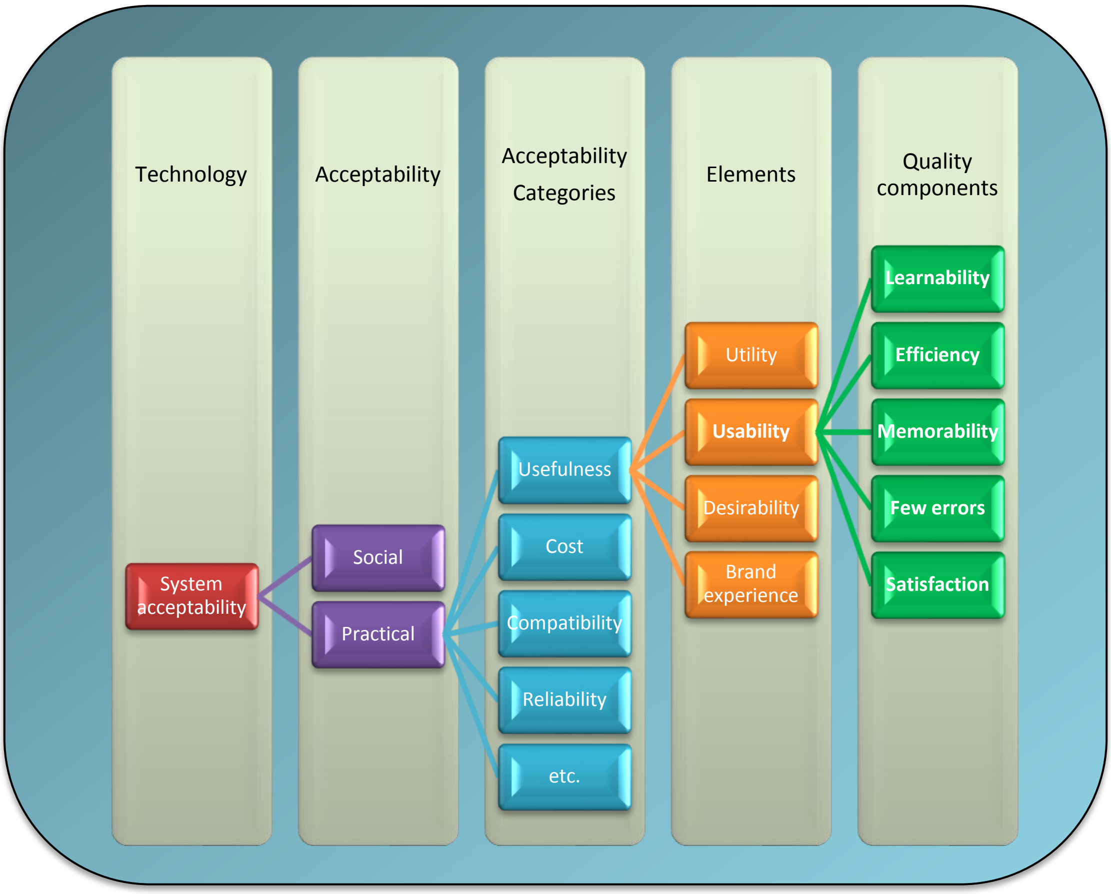
## 4.2 System analysis

In the book “Usability Engineering”, Jakob Nielsen is presenting the system acceptability model. According to this and also other authors, to some extent, the attribute system acceptability is, through the practical acceptability and usefulness, connected to the usability. If I make some adjustments to this system acceptability model, it can be implemented into the BI system usability model. With the help of the presented model, I can also produce a reliable answer to the question of whether the system is good enough to satisfy all the needs and requirements, that the BI system users and managers have (Nielsen, 1993, pp. 16-31).

Software system, including the BI system which is the central part of this work, can be accepted if it is socially acceptable and/or practical acceptable. Practical acceptability consists of categories like cost, support, compatibility, reliability, usefulness, etc. With the attribute usefulness we try to explain whether the system can be used to meet the needs, requirements or desires of all; the software vendors, users and stakeholders. BI system can be considered useful when it has the utility, usability and also some desirability. Utility is used to describe the extent to which the product provides the right kind of functionality to help users perform their relevant tasks. Through the user’s achievements of goals, objectives can be met by the rest of the stakeholders especially the owners.

System usability is being described as all aspects of a system with which a human being might interact, including installation and maintenance procedures. With the help of this attribute it can be measured how fast, and how easy the final user can find the information or carry out a desired task. The utility of BI system primarily affects performance, as usability affects efficiency. Despite the fact that these two terms are often used interchangeably, in essence they are different. The performance underlines the importance of “doing the right things”, efficiency underlines “do things right”.

*Figure 4.* A model of the attributes of system acceptability




Source: J. Nielsen, *Usability Engineering*, 1993, p. 25.

The implementation of a new technology or a system has to "fit" the organizational structure which is meant to support. Implementation success or failure is firstly tribute to organizational issues. That means that organization itself is at this point considered as a key factor in the effective use of information technology and BI. If an organization doesn't have a clear vision for change, it has ineffective reporting structures and responsibilities, that are not clearly defined or understood by everyone, usually contribute towards low acceptance among users, and consequently lead to failure of implementation and its usage (Azizah KS Mohamadali, 2013, pp. 31-34).

From that it can be seen, that user acceptance of BI system is one of the essential criteria for a system success. It is at great importance, that we measure the value and effectiveness of the BI system that is being implemented. These measurements are as important for implementation process as also for measuring the usability of the system itself (Moh'd Al-adeileh, 2009, pp. 226 - 231).

In the model of the attributes of system acceptability, there are presented five quality components that are defining the usability of IS. All of these components are for sure important for the IS, but might not be as important when evaluating the usability of the BI system. As already stated, in order to avoid content errors, it is important, that we take care about the data and information that is being inputted in the IS. The operational IS is being used for operational tasks, that are being on a daily basis. For this operational usage we need accurate data and information, so that we can ensure the successfulness of business operations and execution of the desired tasks. If the data and information that is being included in this operational process is not correct, or is even corrupted, this will result in bad outputs. This bad results of operational IS will probably also influence the perceived usability of these systems. The BI system is being used for different purposes than the operational IS. We use this system for more analytical evaluations, where we are handling large quantities of data and information. It is important that these inputs are as error free as possible, but as it can be seen, this is not as important as when talking about the operational IS. Even if some incorrect data comes in the BI system, the system will still provide relevant results. If there is greater amount of incorrect data and information input, there will be firstly effected the operational IS. This would be also detected by BI system and presented as anomaly or an error. The BI experts, who are using the BI system, will notice these anomalies and will have to interpret the results that the BI system produces. For that matter it is argued, that it is important that there is ensured a certain degree of data and information quality. But this does not affect the BI system usability. For this reason I can eliminate the component "Few errors", from the proposed model, that evaluates the BI system usability. Second component, that is also not being added to the proposed model that evaluates the BI system usability is system satisfaction. We can evaluate the operational IS satisfaction, because these systems are being used for daily operational usage. Operational IS are therefore in a way caught up in the daily operations and are even becoming part of them. For that matter for users who are working with the operational IS it is mandatory to use them. This means that they are using it even if they are not satisfied with it. On the other hand we have BI systems and their users. BI systems are being used to make more aggregated assessments or even indicate predictions. Users that use the BI system use it because they are satisfied with it and because they find it usable. If they wouldn't be satisfied with it and didn't find it usable they simply wouldn't use it. From this we can see that for the BI system users satisfaction with the BI system can be interchanged with the system usability. For this reason also the BI system satisfaction element can be excluded from the proposed model.

I included the other three system attributes that are presented in the model of the attributes of system acceptability. These three attributes are learnability, efficiency and flexibility. As already previously exposed, these three attributes are interesting for the presented research because of the BI system specifics.

BI system learnability is important because of the different tasks that are being randomly executed with the BI system. Because of this variety this attribute probably effects the BI system usability. Least but not last there is BI system flexibility attribute. From the BI system it is expected that it is flexible in more than one view. Firstly it needs to be flexible so it can handle different tasks, then it needs to be flexible when presenting the outputs (Amor, 2014).

Due to that I hypothesize:

**H1**: When the BI system is easier to learn, this improves its usability perception.

The second important component when talking about the BI system usability is the BI system efficiency. Efficiency of the BI system is also important because of the nature of the work that is being performed with the Bi system. This system handles large amounts of data that needs to be efficiently processed. Inefficiency probably affects the BI system usability (Amor, 2014).

Under the assumption that efficient BI system improves overall usability of it, I hypothesize:

**H2**: If the BI system is more efficient, the positive effects of that can be seen through the BI system usability.

There are different Bi system users that are interacting with the data and information. Different BI users need the BI system in different circumstances, and the system is being used for different tasks. For example let us look the reporting process that is being carried out with the BI system. For instance, some users might need complex reports with algorithms that are being only solved at the presentation layer, and there are other users who need fully customized look of the reports. These BI users do also evolve, and after a while may require more sophisticated or specific capabilities. For this reason the BI system should be able to adapt and be flexible enough for all the users and the needs that these users have (Amor, 2014).

Because of the stated above I hypothesize:

**H3**: When the BI system is more flexible this will positively affect its usability.

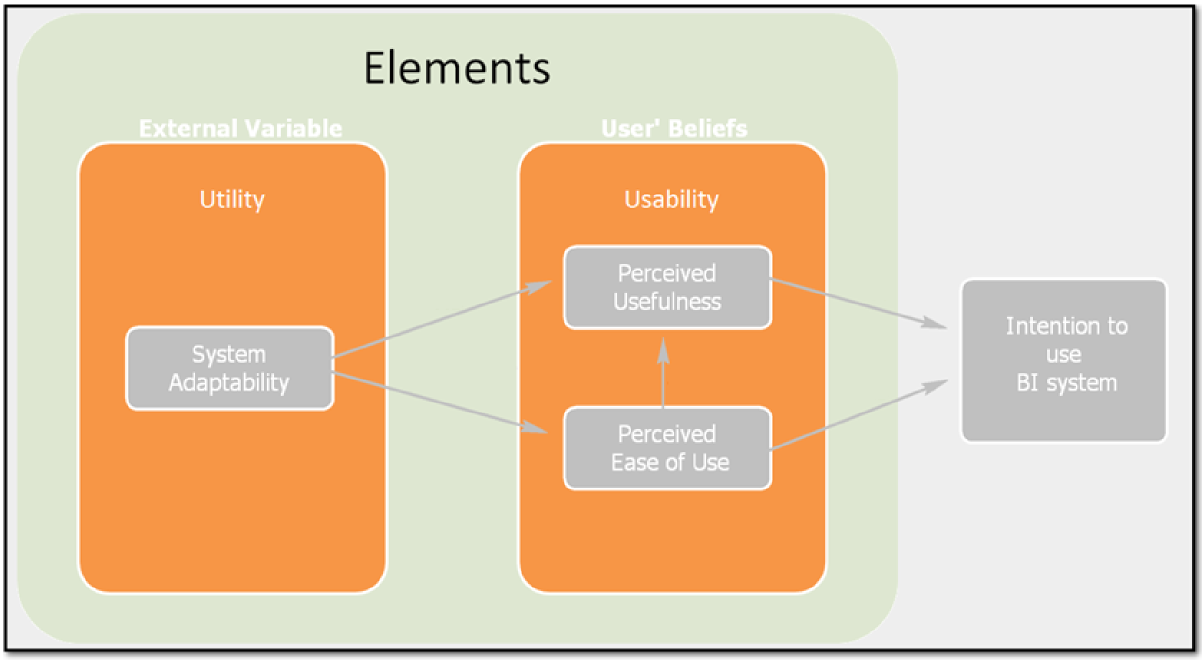
## 4.3 User analysis

The BI system is being embedded within the organizational and social system, where different people and environments are interacting with each other. In order to evaluate the user acceptance, there is a primarily need to evaluate, or at least define, some specifications of the environment, where technology is being embedded. In order to assess the BI system usability, this can be done through the evaluation of technology itself, and the user who uses this technology.

The attitude toward using the BI system has due a direct influence of perceived usefulness, indirect influence between user's beliefs and the actual use. For this reason it is justified to consider the question of attitude. In addition researchers also expose that TAM findings are not always consistent because of comprehensiveness of use (Bourgonjon, Valcke, Soetaert, & Schellens, 2010, p. 1146).

At this point I am presenting a TAM-based model which can be used when evaluating the user's intention, or motivation to use the BI system. Basically, this is a function of user's perceived usefulness, perceived ease of use and system ability to adapt. Intention to use the BI system is the extent to which the user wants to reuse the BI solution in the future.

*Figure 5.* Modified version of TAM model




Source: V. Tobing, M. Hamzah, S. Sura & H. Amin, *Assessing the Acceptability of Adaptive E-Learning System*, 2008, p. 4.

Usability increases employees' productivity and their understanding of business activities. There is likelihood that employees will accept the BI system because of the benefits that such system brings. System adaptability is hypothesized, to be directly related to intention to use BI system through perceived usefulness and perceived ease of use. McCormack and Jones support this prediction by arguing, that employee will use a particular system as long as he is motivated to use it. Additionally, perceived ease of use directly influences perceived usefulness of BI system (Tobing, Hamzah, Sura, & Amin, 2008, pp. 4-7).

From this model there can be developed some relationships. Firstly we can find a positive relationship between adaptability and perceived usefulness and ease of use. That means, that more the system is able to adapt, more the users will find it useful and easy to use. Secondly, perceived ease of use has a positive relationship with perceived usefulness. If the system is more easy to use, then the users will perceive it as more useful. Finally, we can find a positive relationship between the intention to use BI system and perceived usefulness and ease of use.

It is not enough that we are assessing the user motivation, and the possibility to use different parts of the BI system, when assessing usability from the user point of view. Another important aspect, that needs to be taken into the consideration, when assessing the BI system usability, is also the knowledge that user possesses. If the employee, that is using the system doesn't possess the education, skills and enough training, he will probably find the system difficult to use, and also not useful. For that matter, it is important, that we incorporate another component that will help us to evaluate the user knowledge.

Presented model is not including the component "user attitude", which could be to some degree important for the study. But in one of the studies made by Chen, Yang, Tang, Huang & Yu (2007), it was found out, that there is no significant relationship existing between attitude and behavioural intention to use the system. For that matter, the component "user attitude" is being excluded from this study.

According to the statements above and findings of prior studies I hypothesize:

**H4**: It has a positive effect on BI system usability, when the BI system user is being more engaged in the BI system and its processes.

## 4.4 Task analysis

In this section I would like to present an area, that is receiving more and more attention from IS researchers. They are considering technology acceptance issues, and its effects on usability and overall performance. More and more researchers are also trying to evaluate variables, that are primarily concerning the task characteristics.

The term task analysis can be applied to a variety of techniques, for identifying and understanding the structure, the flow, and the attributes of a certain task. Task analysis identifies the actions and processes, that the user needs to make in order to complete a task or achieve a particular goal (Usability Body of Knowledge, 2013).

More in depth task analysis should be conducted in order to understand the system and the information flows within it. It is necessary to have a good knowledge of the information flows, when considering and executing the maintenance procedures, and also when we are building a new IS. With the task analysis we make it possible to design and allocate tasks appropriately with the BI system. The functions, that are needed to be included within the system and the user interface are usually accurately specified.

The outputs of a task analysis included in this assessment are:

- Task frequency;
- Task flexibility;
- Task duration;
- Task variability;
- Task complexity and
- Situational constraints.

The inclusion of the variable, task frequency is important, because the consideration about frequency of the performed activities might help in deciding on the importance in designing a support for them. In some cases solutions other than a technical device might be considered. For example, if it is decided to use a device to support the user, but its functions are likely to be used very infrequently, then it needs to be extremely easy to use (Userfit Tools, 2013, p. 26).

When considering the task flexibility I would like to find out, how the different levels of task flexibility, in usability testing of BI system, influences the results that are being obtained from the analysis. From the usability point of view, I would like to find out, which levels of task flexibility contribute best to achieve certain goals and quality aspects. The research focuses on the behaviour of knowledge workers, and on detection of the optimal task flexibility in the BI systems (Van Waes, 2000, p, 16).

Task duration, or a time estimate for an expert estimates, how long it would take an expert to complete the task. This evaluation is ignoring time that is being needed for the system to do its processing, and is focusing on the time spent entering data and clicking buttons. Some tasks, such as composing an unstructured report, require time for thinking or creative effort, and for that matter it should be considered also the time needed for knowledge activities (Snyder, 2003, p. 131).

Task variability directly correspondents to Petrow's "number of exceptions", and is defined as the number of exceptional cases, that are being encountered in the work process regarding different methods or procedures (Van de Ven, & Delbeq 1974). Van de Ven, & Delbeq are empirically demonstrating that task variability results in three basic structural models; low task variability, intermediate task variability and high task variability. I find this layout appropriate, and for that matter, it is being used in this assessment (Kitaygordskaya, 2008, pp. 58-60).

An employee daily performs many tasks. These tasks usually consist of levels of progressively smaller subtasks. Tasks can be either given to, or identified by, the worker. For each task it can be determined a recognizable beginning and end. The former is containing recognizable stimuli and guidelines that are concerning goals and/or measures to be taken (Hackman, 1969). From the literature review, there can be retrieved many suggestions about task characteristics related to task complexity. To address just a few; repetitively, analysability, determinability, the number of alternative paths of task performance, number of goals and conflicting dependencies among them, uncertainties between performance and goals, number of inputs, cognitive and skill requirements, and also the time-varying conditions of task performance (Campbell, 1988; Daft et al., 1988; Hart, & Rice, 1991. These characteristics, and also other ones, belong into two main groups; characteristics that are related to the determinability of task, and characteristics that are related to the extent of task (Byström, & Järvelin, 1995, pp. 196).

The situational constraints that are perceived in the specific work environment can be assessed by an eleven item scale, that was in 1988 developed by Spector and Jex. The scale items were centred around various situational constraints, that may be perceived to impede completion of job tasks and included; poor equipment, organizational rules and procedures, other employees, supervisors, lack of equipment, inadequate training, interruptions by other people, lack of necessary information about what to do or how to do it, conflicting job demands, inadequate help from others and incorrect instructions. The situational constraints scale is a casual indicator scale in which the items are not manifestations of a single underlying construct. That means that the items are not parallel forms of a single underlying construct, and they do not replicate each other. Instead of that, they are considered to act as a whole when they are combined (Ferguson, 2011, pp. 221-223).

Since each individual finds software solution more or less usable, it is important to review the task component. With this evaluation, next to other assessments, I would also like to evaluate the "fit" between the task requirements and technology capabilities to support these tasks. In order to test usability from the technical side we need to be aware of the different tasks and other variables that are concerning an objective assessment of the BI system usability (Bass, 2010, pp. 19-26).

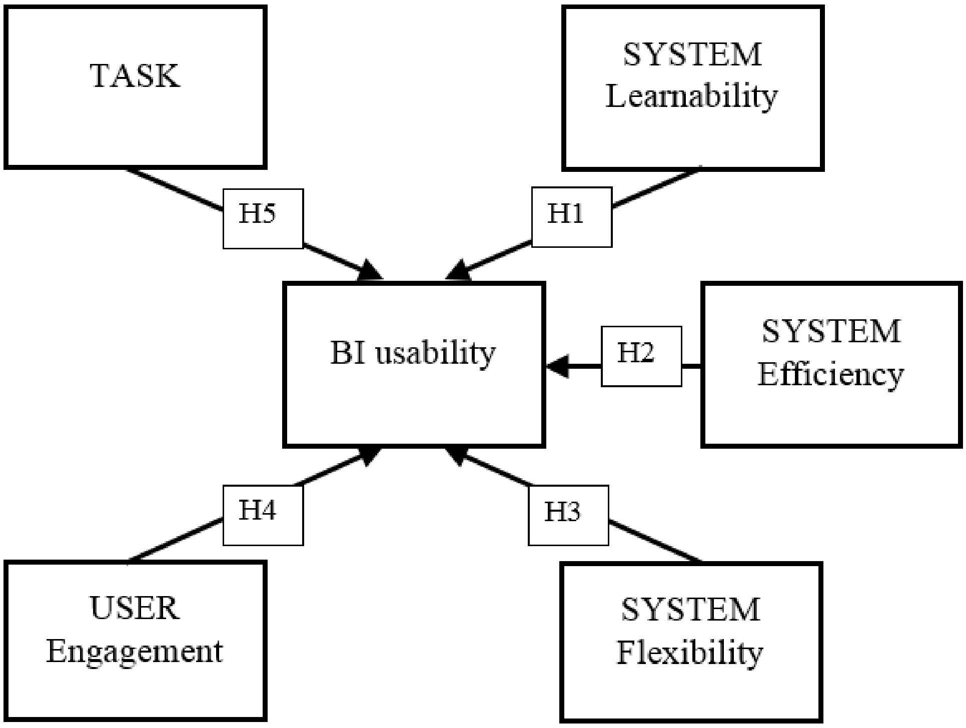
Thus, I hypothesize:

**H5**: When the task, where the BI system is being used, is more sophisticated, the more BI system users perceive the BI system as being useful.

## 4.5 Research model

When preparing the research model I took into consideration previous research from the field of BI and usability. Based on the Sahinoglu, Morton, Samelo and Ganguly's study from 2012, and taking hypotheses (H1, H2, H3, H4, H5) placed into account, I propose the conceptual model (Figure 6). This model demonstrates the factors that influence the BI system usability.

*Figure 6.* Proposed conceptual model of BI usability evaluation




Source: adapted from M. Sahinoglu, S. Ganguly, S. Morton & E. Samelo, *A New Metric for Usability in Trustworthy Computing of Cybersystems*, 2012.

# 5 RESEARCH METHODOLOGY AND METHODS

This chapter is structured in a way that firstly the set of research is being described. Secondly, I am presenting, how the data were collected and finally, I am presenting the methods for data analysis.

## 5.1 Measurement

In order to make a proper investigation of the theoretical constructs of the BI system usability evaluation, a survey was carried out in Slovenia. This survey was primary covering the BI experts from MLE-s. In order to prepare a valid questionnaire, I made a review of former studies that are covering the fields of BI and usability. Further on, I tried to prepare the right set of questions that would in a best way cover all five, in the proposed model included, aspects; task, system learnability, system efficiency, system flexibility and user engagement. This step was important, because only the right and well prepared questions present as credible results as possible. All in all, I also used the already presented and empirically tested variables of the construct of the discussed model, to make sure the findings will be comparable to the results of similar studies.

The presented questionnaire, which is being described below, consists of several close-ended questions where variables, i.e. task, system learnability, system efficiency, system flexibility and user engagement, were measured using a five point Likert scale. All the respondents had to indicate the extent to which they agreed with a given statement, ranging from "completely disagree" (1) to "completely agree" (5) (McLeod, 2008).

Before circulating the survey to the appropriate survey group, there were some adjustments made. Since the questionnaire topic is quite specific, the goal was to make the specific questions as understandable as possible. Further on, the efforts were directed into making the questionnaire shorter and easier to be fulfilled, but still retain its all important parts. Finally I had a meeting with two experts from the field of BI that come from two different companies. The first meeting took place at the company, that is BI system provider and the second one took place at the company who uses, and is therefore a customer of such system. These two meetings were important, because at this point, together with the BI experts, we thoroughly looked at each individual pre-cleaned question and made some new adjustments. Finally the questionnaire was ready enough to test it. In order to perform the testing phase, I distributed the 6 questionnaires by e-mail. Three of which were distributed to the organization which is BI system provider and three to the organization who is BI system user or customer. All of these six questionnaires were validly completed and sent back. The results of these questionnaires were satisfactory and there were no issues when completing the questionnaire reported. Since these six questionnaires were only for purpose of testing the responses were excluded from the main research.

### 5.1.1 System vulnerability

When setting up variables that determine the BI system vulnerability (BI system learnability, BI system efficiency and BI system flexibility), I took for the basis research from Sahinoglu, Morton, Samelo and Ganguly (2012), where they are presenting a new metric for usability in trustworthy computing of cyber systems. From this research I selected the variables that are important when evaluating the BI system usability. The questions were chosen based on the knowledge gained from the literature review. In this literature review I find well described specifics of the BI system. Because of the specifics, that differ the BI system from the operational IS, the questions needed to be adjusted. Some questions presented by Sahinoglu, Morton, Samelo and Ganguly needed just a small changes in wording. Other ones needed to be changed completely in order to expose the BI system specifics and their importance when evaluating the BI system usability. In the following three tables I am presenting the variables of the BI system vulnerability, that was divided into three constructs; SYSTEM Learnability, SYSTEM Efficiency and SYSTEM Flexibility.

Measuring BI usability under this definition is basically evaluating how quickly the task performance, for users who have never been exposed to a system or at least have little exposure to the system, is increasing. A more learnable system reduces the time necessary to complete tasks as users spend more time with a system faster than others. This is especially important in instances, when a certain amount of training is expected or required with an application (Sauro, 2013).

Table 1. SYSTEM Learnability variables

| Question Code | SYSTEM Learnability |
| --- | --- |
| Q1l | Reliable and up-to-date knowledge database covers answers to most questions that arise when using the system. In this way users, without assistance by themselves are able to solve problems. |
| Q1n | Formal education of the use of BI system enables the rapid and efficient management and helps in learning about its features. |

Source: adapted from M. Sahinoglu, S. Morton, E. Samelo, & S. Ganguly, *A new metric for usability in trustworthy computing of cyber systems*, 2012.

Efficiency in context of BI systems plays even more important role than in the operational IS. We cannot argue that efficiency is not important for operational IS. It is important that these processes are carried out effectively, with a minimum amount of errors and unnecessary effort. The BI systems are dealing with even bigger amount of data and information than the operational IS. Next to that, the BI systems incorporate more complicated tasks and equations which are being executed in order to deliver the results. Because at BI system there is a greater impact on efficient processing of large amounts of data, this is also being reflected in questions and ways to measure BI system efficiency.

Table 2. SYSTEM Efficiency variables

| Question Code | SYSTEM Efficiency |
| --- | --- |
| Q1h | Because of its involvement in the business process the BI system fully supports the work and the tasks that needs to be performed. |
| Q1k | BI system enables efficient processing of data which are being collected in a database, that is being used in the context of the system. |
| Q1m | BI system handles a large amount of data and is effective, irrespective of the amount of data and the complexity of the processes. |

Source: adapted from M. Sahinoglu, S. Morton, E. Samelo, & S. Ganguly, *A new metric for usability in trustworthy computing of cyber systems*, 2012.

BI systems are being able to manage and to combine all types of data and information streams across the organization. One of the BI system capabilities is also its flexibility. BI users are continuously requiring more tailored solution, because they need to combine data and information from the BI environment with their own data and information, or need to mix data and information from various sources including external sources. These users are expecting the BI system to be flexible enough to answer their newly occurred demands, to easily include new sources or new reports as quickly as possible. These are just a few reasons, why it is important to evaluate the BI system flexibility in order to assess the BI system usability.

Table 3. SYSTEM Flexibility variables

| Question Code | SYSTEM Flexibility |
|---|---|
| Q1f | BI system has built-in functionalities that can be at any time upgraded or in some other way adjusted. |
| Q1g | BI system user has the access to the reports editor anywhere, via a web browser. |

Source: adapted from M. Sahinoglu, S. Morton, E. Samelo, & S. Ganguly, *A new metric for usability in trustworthy computing of cyber systems*, 2012.

### 5.1.2 User Engagement vulnerability

User engagement is a quality of user experience with technology that depends on the aesthetic appeal, novelty, and usability of the system. It is the ability of the user to attend to and become involved in the experience, and user's overall evaluation of the experience. Engagement depends on the depth of participation the user is able to achieve with respect to each experiential attribute (O'Brien, & Toms, 2008, pp. 23-26).

Because user engagement encompasses users' attitudes toward system (e.g., usability), its thoughts, feelings, and degree of activity during system use, it is important that this vulnerability is also included in the study when evaluating the BI system usability.

Similar as with the vulnerabilities presented above, also the foundation for the user engagement vulnerability was already mentioned in the research of Sahinoglu, Morton, Samelo and Ganguly. In order to cover the needs of my topic I adjusted the wording of the questions. The next table presents the variables that were being used.

Table 4. USER Engagement vulnerability variables

| Question Code | USER Engagement |
|---|---|
| Q2a | I have the necessary knowledge and skills in the use of BI system. |
| Q2b | I am aware of all of the available information in the BI system. |
| Q2d | I am familiar with the procedures, which are necessary to achieve the set goals. |

Source: adapted from M. Sahinoglu, S. Morton, E. Samelo, & S. Ganguly, *A new metric for usability in trustworthy computing of cyber systems*, 2012.

### 5.1.3 Task vulnerability

In the next table I am presenting the variables that were used to measure task vulnerability. In this user-based evaluation, users were being asked to evaluate the tasks that are being performed using the BI system. For the purposes of my research I made some adjustments in order that variables adapted from the Sahinoglu, Morton, Samelo and Ganguly research suite best to my research. The statements that were redesigned to be applicable in the context of task vulnerability are presented in the following table.

Table 5. Task vulnerability variables

| Question Code | TASK |
|---|---|
| Q3a | Tasks being performed with the BI system are commonly practiced.[1] |
| Q3c | With the help of the BI system the tasks which require a high level of competence are mostly being performed |
| Q3e | Using the BI system we are typically solving a complicated tasks. |

Source: adapted from M. Sahinoglu, S. Morton, E. Samelo, & S. Ganguly, *A new metric for usability in trustworthy computing of cyber systems*, 2012.

### 5.1.4 Metric for usability

For the purposes of the research I included some questions that directly affect the BI system usability. The groundwork for these variables was also the Sahinoglu, Morton, Samelo and Ganguly's research from 2012. Modified questions were prepared to be used for the purposes of the presented research. These questions are gathered in the following table.

Table 6. BI Usability variables

| Question Code | BI Usability |
|---|---|
| Q4a | BI system is very useful. |
| Q4b | When using the BI system I am effective. |
| Q4c | BI system helps me solving tasks. |
| Q4d | BI system contributes to faster and easier compliance with set tasks and goals. |

Source: adapted from M. Sahinoglu, S. Morton, E. Samelo, & S. Ganguly, *A new metric for usability in trustworthy computing of cyber systems*, 2012.

[1] This question was before running the data analysis reverse coded. This was important so that a high value indicates the same type of response on every item.

## 5.2 Collecting the data

Data collection was mostly performed via e-mails. The e-mails with the link of the online questionnaire were sent to the Slovenian large enterprises. Regarding to the SURS[2], large enterprises have 250 or more persons employed. Further on, the e-mails were also sent to some medium sized enterprises, for which I researched, that they are possessing the BI solution. Regarding to the SURS, medium-sized enterprises have from 50 up to 249 persons employed. Since I confronted a really bad response rate, I also asked some BI experts, to help me distributing the questionnaire within their BI users' databases (Statistični urad Republike Slovenije, 2014).

Data were collected in July 2014, particularly from the 27th and to the 30th calendar week of the precise year. In order to determine a correct sample size for the given population, I visited the Creative research systems website and used their Sample size calculator. For the population of 986, with the 9-percent margin of error, and a confidence level of 95 percent, I needed to obtain at least 106 responses (Sample Size Calculator, 2012).

All in all, in four week period of collecting the answers, 136 responses were received, out of which 128 responses were valid. The overall response rate was 12.98 percent, which illustrates statistically representative image of the population that is being considered. In the table presented below, I am presenting the overall report. From the report, we can see in detail, the successfulness of the questionnaire distribution. Data collection report includes also distributed e-mails by BI experts, who helped me in distribution of the e-mails.

Table 7. Data collection report

| | **Contacts** | **% of population** |
|---|---|---|
| **Clicks on survey address** | 986 | 100.00 % |
| **Clicks on survey** | 534 | 54.16 % |
| **Began the survey** | 158 | 16.02 % |
| **Partially completed** | 22 | 2.23 % |
| **Completed surveys** | 136 | 13.79 % |
| **Invalid surveys** | 9 | 0.91 % |
| **Valid surveys** | 128 | 12.98 % |

The sample profile, as presented in the table 8, shows the age characteristics of the sample. In this sample, the employees that are using the BI system are divided into three age groups.

The first group of users are users that are younger than 30 years old. The second group consists of users that are aged between 31 and 50 years old and the last group consists of users that are older than 51 years old.

[2] SURS stands for *Statistični urad Republike Slovenije* (Statistical Office of the Republic of Slovenia)

Table 8. Age groups of the sample

| Sample characteristics<br>Age groups | Number | Percent (%) |
|---|---|---|
| **Younger than 30 years** | 53 | 41.40 % |
| **From 31 to 50 years** | 60 | 46.87 % |
| **Older than 51 years** | 15 | 11.72 % |

In the following table the sample profile of 128 valid responses shows the distribution of sample by sex variable. There were 60.94 percent male respondents and 39.06 percent female responses.

Table 9. Distribution of sample by sex

| | Number | Percent (%) |
|---|---|---|
| **Male** | 78 | 60.94 % |
| **Female** | 50 | 39.06 % |
| **Total** | 128 | 100.00 % |

## 5.3 Data analysis

Further on I needed to analyse the data of 128 collected questionnaires that were valid. The empirical assessment of the relationships, defined in the proposed research model, was executed using the descriptive statistics. This was being applied by the Structural Equation Model (hereinafter: SEM). The Partial Least Square Regression (PLS-Regression) is particularly useful when we need to predict a set of dependent variables from a larger set of independent variables (i.r., predictors). For that matter I find the PLS-Regression appropriate for data analysis in the research presented (Abdi, 2010).

For the purposes of the research I firstly conducted an assessment of the measurement model. This provided validity of constructs and reliability of the measurements. After that, the structural modelling followed. At this phase I tested the study hypothesis and the quality of the proposed research model.

# 6 RESULTS

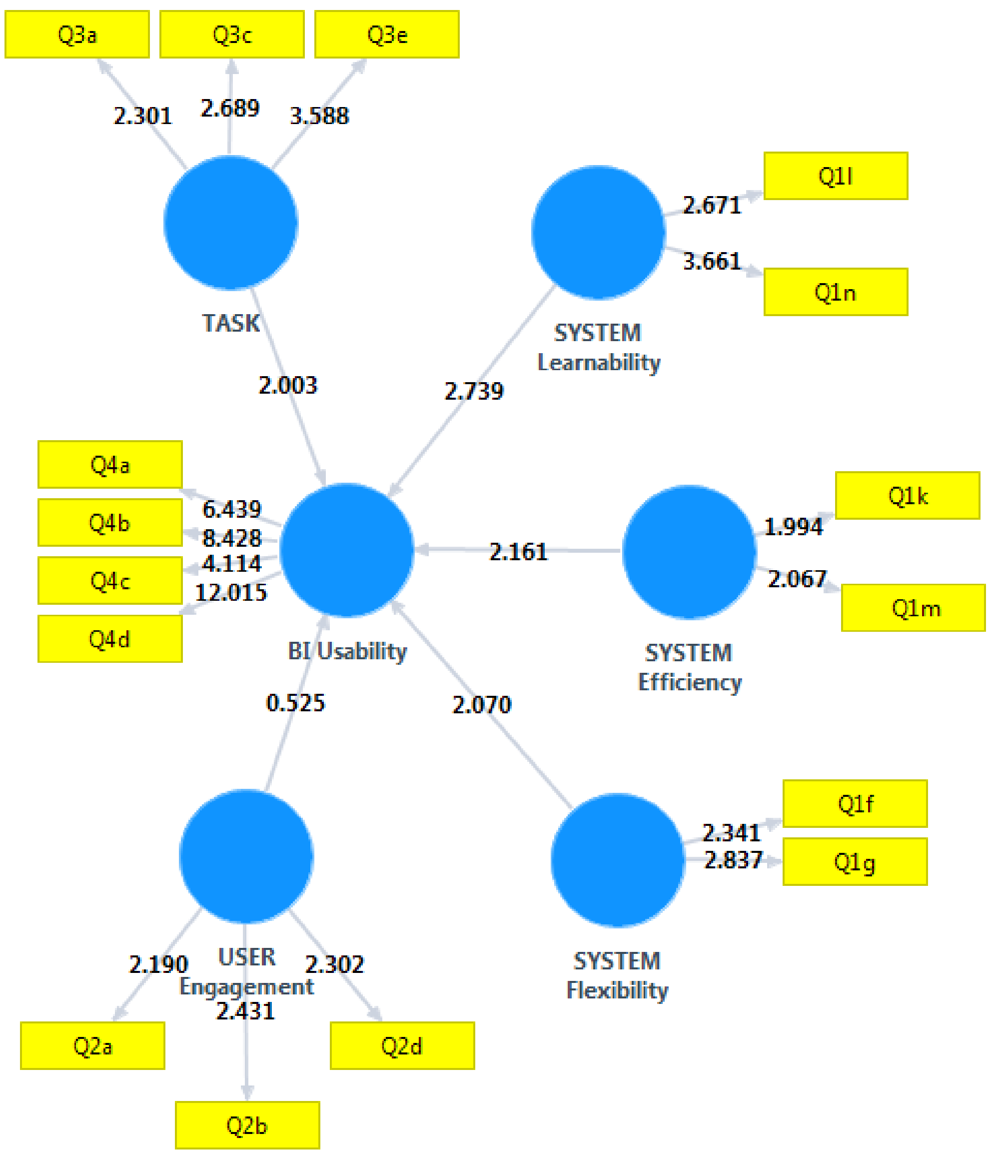
I performed the evaluation of the proposed research model, that evaluates BI system usability in two stages. In the first stage I performed the assessment of the measurement model. Here I conducted an analysis of the proposed research model by checking the reliability and validity of the model constructs. When the reliability and validity of the model construct was confirmed I tested the structural model with hypotheses.

## 6.1 Measurement model

The model has five (5) exogenous variables – task, system learnability, system efficiency, system flexibility, user engagement, and one (1) endogenous variable – BI usability.

Firstly I was presenting 17 indicators. With these indicators I was trying to explain the five exogenous variables. For the variable, system efficiency I used three indicators. One of these three indicators didn't achieve the threshold 1.96 of factor loading and was for this matter excluded from the proposed model. The indicator that didn't achieve the threshold 1.96 of factor loading was being connected with the question Q1h. This question was asking about the BI user involvement in the business processes, and didn't quite fit to the other two questions, that were asking about the BI system efficiency. After the exclusion of this indicator the factor loading of remained 16 indicators was above the threshold 1.96.

*Figure 7.* Measurement model



## 6.2 Assessment of the reliability and validity of the measurement model

In order to determine construct validity, I examined two elements of factorial validity, particularly convergent and discriminant validity. These two validities show, how well the measurement items relate to the construct. Convergent validity is proved when every measurement item strongly correlates with its assumed theoretical construct, while discriminant validity is proved when every measurement item correlates weakly with all other constructs expected for the one to which it is theoretically associated (Gefen, & Straub, 2005, p. 92).

The internal consistency reliability was estimated by calculating Cronbach's Alpha and Composite validity. Convergence validity was estimated by calculating Average Variance Extracted (hereinafter: AVE). The results are presented below.

Value of AVE should be greater than 0.500, to ensure a sufficient degree of convergent validity. (Gefen, & Straub, 2005, p. 94). In the table 10 we can see, that all items have AVE greater than 0.500, which is important for demonstrating convergent validity.

Table 10. Average Variance Extracted

| | **AVE** |
|---|---|
| **BI Usability** | 0.574 |
| **SYSTEM Efficiency** | 0.626 |
| **SYSTEM Flexibility** | 0.722 |
| **SYSTEM Learnability** | 0.762 |
| **TASK** | 0.673 |
| **USER Engagement** | 0.738 |

Discriminant validity of the constructs was assessed using Fornell and Larcker test. The method impose, that the square root of the AVE of each construct exceeds the correlation shared between the construct and other constructs in the model, in order to achieve discriminant validity (Van Raaij, & Schepers, 2008, p. 845). In the following table I am presenting the results that indicate, that all constructs satisfactorily pass the test, as the square root of AVE is larger than the cross-correlations with other constructs, which proves validity of all constructs.

Table 11. Correlations

| | BI Usability | SYSTEM Efficiency | SYSTEM Flexibility | SYSTEM Learnability | TASK | User Engagement |
|---|---|---|---|---|---|---|
| **BI Usability** | **0.757** | | | | | |
| **SYSTEM Efficiency** | 0.069 | **0.791** | | | | |
| **SYSTEM Flexibility** | 0.181 | 0.033 | **0.850** | | | |
| **SYSTEM Learnability** | 0.219 | 0.531 | 0.099 | **0.873** | | |
| **TASK** | 0.196 | 0.246 | 0.058 | 0.194 | **0.820** | |
| **User Engagement** | 0.073 | 0.275 | 0.062 | 0.304 | 0.491 | **0.859** |

To analyze reliability, Compose Reliability (hereinafter: CR) was assessed. The minimum value that still justifies reliability is 0.700 (Van Raaij, & Schepers, 2008, p. 845). The corresponding fit measures are presented in the table 12. From the table it can be seen, that values vary from 0.767 (SYSTEM Efficiency) to 0.894 (USER Engagement). The results are higher than 0.700 and are in general above 0.800, suggesting that the scales are reliable.

In addition discriminant validity of the model was comparing the square root of the AVE with construct correlations. The results do not indicate the problem with discriminant validity.

Table 12. Composite Reliability

| | Composite Reliability |
|---|---|
| **BI Usability** | 0.841 |
| **SYSTEM Efficiency** | 0.767 |
| **SYSTEM Flexibility** | 0.837 |
| **SYSTEM Learnability** | 0.863 |
| **TASK** | 0.860 |
| **USER Engagement** | 0.894 |

The internal consistency reliability was estimated by calculating Cronbach's Alpha. Results of measurements are presented in table 13. The measurements of the internal consistency reliability – Cronbach’s Alpha are all above threshold level of 0.700. Cronbach’s Alpha are in the presented survey all above threshold level of 0.700, which means that model is reliable. The validity of the model was also supported by AVE values, which are all above the 0.700 level.

Table 13. Cronbach's Alpha

| | Cronbach's Alpha |
|---|---|
| **BI Usability** | 0.749 |
| **SYSTEM Efficiency** | 0.722 |
| **SYSTEM Flexibility** | 0.708 |
| **SYSTEM Learnability** | 0.725 |
| **TASK** | 0.779 |
| **USER Engagement** | 0.826 |

To verify validity and reliability of the measures, I further on observed factor loadings. The factor loadings are presented in the table 14. From this table it can be seen, that all items load sufficiently high on the corresponding constructs, which demonstrates convergent validity. Factor loadings vary from 0.650 to 0.960, and they all exceed the minimum edge value of 0.500 suggested by Peterson (Van Raaij, & Schepers, 2008, p. 845).

Table 14. Factor loadings

| | BI Usability | SYSTEM Efficiency | SYSTEM Flexibility | SYSTEM Learnability | TASK | USER Engagement |
|---|---|---|---|---|---|---|
| **Q1f** | | | 0.747 | | | |
| **Q1g** | | | 0.941 | | | |
| **Q1k** | | 0.680 | | | | |
| **Q1l** | | | | 0.775 | | |
| **Q1m** | | 0.888 | | | | |
| **Q1n** | | | | 0.960 | | |
| **Q2a** | | | | | | 0.818 |
| **Q2b** | | | | | | 0.931 |
| **Q2d** | | | | | | 0.824 |
| **Q3a** | | | | | 0.724 | |
| **Q3c** | | | | | 0.823 | |
| **Q3e** | | | | | 0.904 | |
| **Q4a** | 0.650 | | | | | |
| **Q4b** | 0.731 | | | | | |
| **Q4c** | 0.714 | | | | | |
| **Q4d** | 0.910 | | | | | |

## 6.3 Assessment of the structural model

When the validity of the measures were determined, I tested the structural paths in the research model. This is being done because we want to examine the significance of the path coefficients and to analyze placed hypothesis. The results of the analysis are being presented in the tables presented below. From the data it can be seen the explanatory power and significance of the hypothesized paths. On the basis of amount of variance explained in the endogenous construct, the explanatory power of the structural model is being assessed.

The statistical significance of each path was estimated using PLS bootstrapping method utilizing 500 samples to obtain standard error estimates and t-values. The statistical significance of the path coefficients allows us to see which hypothesis were supported and which were not.

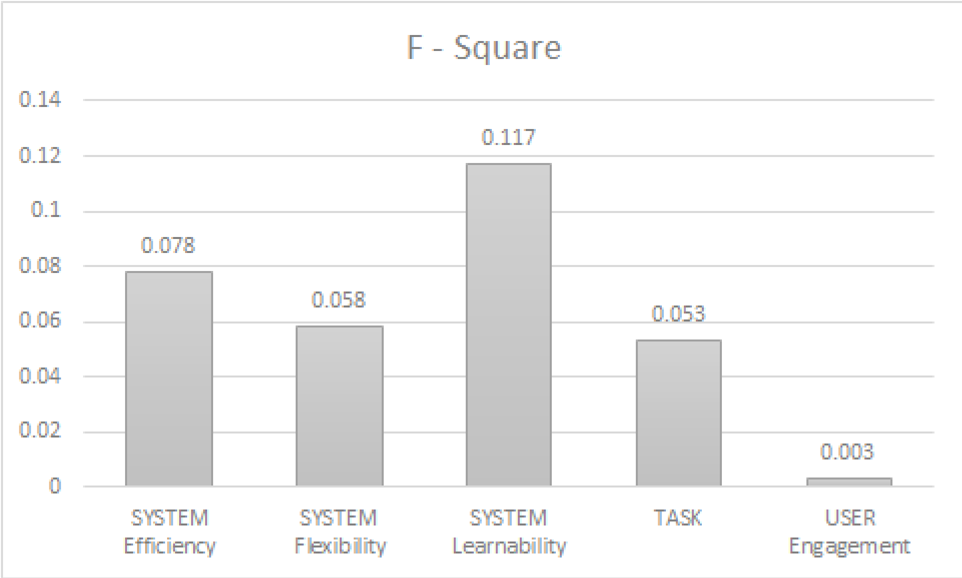
The path coefficients and effect size for each coefficient are provided below. The results show that all path coefficients are positive. Path coefficients tell us about the relation. It means that the increase of SYSTEM Efficiency by 1 point increases BI Usability by 0.302 points, respectively, maintaining all other variables constant. The increase of SYSTEM Flexibility by 1 point increases BI Usability by 0.218 points, respectively, maintaining all other variables constant. The increase of SYSTEM Learnability by 1 point increases BI Usability by 0.373 points, respectively, maintaining all other variables constant. The increase of TASK variable by 1 point increases BI Usability by 0.241 points, respectively, maintaining all other variables constant. The increase of USER Engagement by 1 point increases BI Usability by 0.061 points, respectively, maintaining all other variables constant.

Table 15. Path coefficients and f – Square values

| | **BI Usability** | |
|---|---|---|
| | **Path coefficients** | **f – Square values** |
| **SYSTEM Efficiency** | 0.302 | 0.078 |
| **SYSTEM Flexibility** | 0.218 | 0.058 |
| **SYSTEM Learnability** | 0.373 | 0.117 |
| **TASK** | 0.241 | 0.053 |
| **USER Engagement** | 0.061 | 0.003 |

Affect rations between SYSTEM Efficiency and BI Usability, SYSTEM Flexibility and BI Usability, SYSTEM Learnability and BI Usability, TASK and BI Usability indicate weak effect. The effect size is considered weak if the ratio is in the range from 0.02 to 0.15, while the effect ratio in relation between USER Engagement and BI Usability does not even reach 0.02 level.

*Figure 8.* f – Square values




I performed bootstrapping test to evaluate the statistical significance of path coefficients. The results are being presented in table 16. The results show that all path coefficients are statistically significant except the path coefficient between User Engagement and BI Usability, which has also very low effect size.

Table 16. T-value

| | **BI Usability** |
|---|---|
| **SYSTEM Efficiency** | 2.161 |
| **SYSTEM Flexibility** | 2.070 |
| **SYSTEM Learnability** | 2.739 |
| **TASK** | 2.003 |
| **USER Engagement** | 0.525 |

The hypothesis of SYSTEM Learnability as a predictor of BI Usability (H1) is confirmed since the path coefficient was significant ($\hat{\beta}$ = 2.739). The relation between SYSTEM Efficiency and BI Usability is being concerned in H2. This hypothesis states that system efficiency has a positive impact on the BI Usability. The path coefficient was significant ($\hat{\beta}$ = 2.161), and this result supports the H2. The last hypothesis concerning the BI system, indicates that more flexible BI system is, the better is its usability. This hypothesis (H3) is also being confirmed, as the path coefficient was significant ($\hat{\beta}$ = 2.070).

The path coefficient of task ($\hat{\beta}$ = 2.003) was smaller than those which have been linked to the system. In the H5 I stated that when the task, where BI system is being used, is more sophisticated, the more BI system users perceive the BI system as being useful. Despite that the path coefficient was smaller, than those which have been linked to the system, it still is significant and supports the H5.

H4 states that it has a positive effect on BI system usability, when the BI system user is being more engaged in the BI system and its processes. Results show that the path coefficient was not significant ($\hat{\beta}$ = 0.525), which means that H4 cannot be supported. When comparing this result with studies that were made for the IS, we can see deviation. However, this result is not surprising and is revealing the BI system specification, that also differs it from the ordinary IS. BI system is being used for more sophisticated operations. These operations are usually being carried out by professionals which do not deal much with their engagement, which is believed to be already high, but have their objectives set in carrying out their activities as effective as possible.

# 7 DISCUSSION

Employees from each level of the organizational structure are encouraged to make business decisions by themselves without the involvement of their superiors on a daily basis. This can be also seen from the sample profile of data collection. In the sample I divided the employees into three age groups.

The first group of users are users that are younger than 30 years old. The second group consists of users that are aged between 31 and 45 years old and the last group consists of users that are older than 51 years old.

It is not surprising, that the most users of the BI system come from the middle group, where the users are between 31 and 50 years old. This group represents 46.87 percent of population. It can be argued, that this group is the most represented, because according to the SURS, this age group is the biggest if we look at the average active population by labour force.

The second group is represented with only 11.72 percent of population. In this group there are employees older than 51 years old. This result is also not surprising. If we look at the SURS, this group is smaller than the group presented before. Next to this, BI system users that fall into age group between 31 and 50 years old, are believed to be more operative users that take smaller decisions, prepare reports, and use the BI system in a more “active” way. Because of the questionnaire specifications respondents from this age group probably found easier to answer the questions. On the other side, the users that are older than 51 years old, are believed to be more “passive” when using the BI tools. Those users, because of the questionnaire specifications might also find the questionnaire more difficult to answer.

Lastly there is another well represented group with 41.40 percent of BI system users. These users are younger than 30 years old. This result means that younger users, who are believed that are not so experienced, are already using the BI system in every day, operative, work and are taking decisions. From that it can be argued, that the empowerment process is truly important for the nowadays organizations.

The goal of presented research is to deliver another evaluation of the BI system. This evaluation is considering the BI system usability, and what affect do defined variables have on the BI system usability. Results retrieved from the presented work indicate, that BI system usability evaluation is important for BI providers and customers. All in all, the users who come in touch with BI are the real customers of such system, and their opinion is important in the organizations where the empowerment process is taking place.

BI system is a system that is being used by knowledge workers in the organizations. The BI system is being specialised to handle big amounts of data and information, that flows within organization. Since this data and information is coming from different sources it is necessary to ensure, that the data is a quality one. When this is being ensured, we can start evaluating if the BI system is efficient or not. Another important specification of the BI system usability is its flexibility. Different knowledge workers use the BI system in different frequencies. Even more they are using different tools and techniques within the system. And all tasks are being performed slightly different from user to user. At this point the importance of BI system learnability arises. It is important that BI system is easy to learn, because more and more employees that work in different fields are being involved in its usage. Next to that, it is important that the system can be quickly learned and if not used for a while, users do not need a lot of time to relearn the system. Another important specification of the BI system are the tasks, for execution of which, the BI system is being used. These task are believed to be more specific and are usually more complicated that the tasks being performed by IS.

The results presented can be used as soon as during the designing phase, and cannot be missed out also later on when implementing a BI system in the organization. Considering and implementing the quality components presented and the UCD in these two important stages of BI system construction, improves the overall quality, transparency and velocity of BI user work.

Presented results are also confirming the importance of improving quality components that are being presented throughout of this work. As expected these quality components have a positive effect on the BI system usability and their improvement can make a significant change in overall contribution of the BI system in the organization.

## 7.1 Implications for theory

Findings of this study are important, because they make a contribution in the field of the BI and BI system usability evaluation. The presented study is a supplement of the prior studies that were made in the fields of usability and BI.

Prior studies from the field of BI are in general examining and validating the contribution of the BI system from the economical and performance point of view. However these evaluations do not include the view of the BI system usability. This means, that these evaluations are not showing the overall contribution of such specialized system in the organization. Taking these studies into consideration and merging them with other studies from the usability field resulted in a new model being formed.

The presented usability model was adopted from a model that is being used to evaluate usability of system interfaces. The BI system is being used to manage large amounts of data and information. This data and information is with the help of the system being processed in a way, that it shows the "big picture" of the organizational business. This is just a general explanation, but in reality the BI system that is being used by BI experts is executing numerous tasks. As it can be seen I pointed on three factors that are important when talking about the BI. These factors are tasks, system and users. Also in the model that is being used to evaluate usability of the system interfaces there are these factors presented as important ones. This was the reason, that I find this model appropriate to be included in the presented work.

Results of the presented study have been verified as reliable and valid ones. Because of this, the proposed model can be proclaimed as a model that can be used to evaluate the BI system usability. If we modify or adjust this model, it can be also used in future studies, in the field of the BI usability evaluation.

## 7.2 Practical implications

The BI products are for several years now, with their increased functionality trying to help BI users, that come from each level of the organizational structure, to make the best business decision. Because data and information is being more and more accessible, and because of almost limitless processing power, and storage capabilities, expectations about the BI technology and its usage are promising.

In the IS and BIS context a lack of understanding of the challenges, and constraints in implementing technology in the organization processes, has many times resulted as failure. If the solution was successfully implemented, this does not mean that the users utilize it to the extent that it was meant to. The findings of this study can be taken into consideration and help the BI system providers to offer customers a useful BI solution. The study can also be considered from the customer side. If the customer of the BI system is aware what is important to be considered, when searching for the BI solution, then their purchase decision will be based on firmer foundations.

Results of the study are revealing the importance of BI system learnability. This variable is being recognized as a variable that effects the BI usability the most. Especially when comparing it to the other variables used in the model. When we are talking about the BI system learnability, both, the system provider and customer can have significant impact on it. Despite the fact, that this is also a personal trait, BI system providers can try to make the system easier to learn by providing professional training and workshops. At workshops customers and potential customers could learn more and also ask questions about the system that they are or will be using. Both, system providers and customers should also provide a reliable and up-to date knowledge database. This database should cover answers to most questions that arise when using the system. This is important especially in the organizations where the empowerment approach is taking place.

BI system providers should always try to improve system efficiency. As research suggests BI systems should be able to efficiently process the data which is being collected in a database that is being used in the context of the system. Further on, it is also important, that BI system is able to handle a large amount of data and is effective, irrespective of the amount of data and the complexity of the process. Therefore system providers should always look into how to improve system efficiency and by doing that also improve its usability.

Moreover, research suggests that system flexibility has an influence on BI system usability. This result was expected, since one of the BI system specifications is functionality. Nevertheless BI system providers shouldn't take the BI system flexibility that is being present in the system as final version. They should always look for and continuously cooperate with BI users in order to find new better solutions. This will ensure constant development of the BI system, its flexibility and consequently its usability.

Results of the presented study further on reveal that when the task, where the BI system is being used, is more sophisticated, the more BI system users perceive the BI system as being useful. As results show, the tasks that are being performed with the BI system require a high level of competence. Next to this fact, the results also indicate that the same or similar tasks are commonly being performed, but are typically complicated. The results also reveal that the BI system is a tool that is being used for more complicated tasks. Users are recognizing this and are also aware that the BI system brings great contribution to their work. Therefore this users should be a driving force of the BI system development. They should also play an important role when presenting the system and improving its acceptability in all parts of the organizational structure.

The last vulnerability in the presented model, the user engagement vulnerability, was despite effort not supported as a significant factor of BI system usability. This variable was recapitulated from the model, that is being used to evaluate usability of operational IS. As already stated, the operational IS is being used for operational processes. Because of its inclusion in these processes also the users of operational IS need to use it in order to finish their tasks. On the other hand the BI system is being more data-orientated and is being used for different tasks. Users of BI system are also being more engaged. When these users are becoming more and more engaged, this affects negatively on the perception of BI system usability. From this we can conclude, that the fact, that one is being more or less engaged, doesn't really have an effect on the evaluation of BI system usability.

## 7.3 Limitations and future research

The study presented contributes to practice and theory. But unfortunately it is not without limitations. Next to that it also provides opportunities for further research. The first limitation derives from the sample size of the survey. The presented sample size is limited to medium sized and large sized enterprises that are using the BI systems in Slovenia. This implies that the research only reflects the reality in these two segments. Another limitation is the respondent sample. The sample presented includes all employees who come into contact with the BI technology.

Because of the presented reasons, in the future, the research model could be also tested among the other organizations, that are using this technology and across countries as well. Next to this it would be also interesting to make a segmentation of BI users and put them into two groups. The first group would include more "active" users that are using the system as a tool to prepare information. And the second group would include "passive" BI users, who use the system to view the information that was previously prepared. Later on some comparison between findings could be made and the model could be developed or specialized just for certain parts or for broader environment.

The model presented is providing a basis for the future researches in the field of BI system usability. Because of the possibilities and limitations of the research model, I suggest extending it to involve additional constructs to explain higher variance of usability. For instance we could include a construct of BI system evolvability. This is the BI system capacity to adapt to the diversity that the trends bring. The BI trends are evolving pretty rapidly. I the recent years, there were included many new solutions and concepts, that can be used also in the concept of BI systems. One of these concepts, for instance, is including mobile technology in the BI. This is being largely done because of the growth of mobile device use in the workplace and also because of its technical improvements.

# CONCLUSION

BI systems are being present, and are constantly evolving, from as early as from 1960s. The perspectives of recent BI system developments (BI 2.0) are high. More and more organizations are already obligated to use the BI systems, and others are using it if they want to stay competitive. Next to that, the success rate of implementation and the percentage of successfully implemented and then fully used BI systems is rather low. These are just few reasons, why it is important that we understand the determinants of the BI system.

Understanding the determinants of BI system usability is very important when considering the BI system acceptance and its usability.

In the work presented I determined factors that are influencing the BI system usability. I used "a metric for usability in trustworthy computing of cyber systems" and modified it so it can be applied to the BI system usability evaluation. The model reveals the importance of system and task vulnerabilities when evaluating the BI system usability.

I assessed the modified model in the MLE-s in Slovenia. The results revealed that BI system learnability is the most important factor when evaluating BI system usability. BI system efficiency and BI system flexibility are also positively affecting the BI system usability. Furthermore, I realized, that BI system usability of a system also depends on the task that is being performed. Finally the results revealed, that user engagement in the BI system does not have an impact on usability. Nevertheless, the inclusion of this vulnerability in the model was also important. It revealed, that the nature of work, that the BI system users have demands that they are already engaged in the business processes. And if they become even more engaged, they also become more demanding. And this is the reason why they do not find the vulnerability user engagement as an important indicator of the BI system usability.

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