ISCTE◈IUL

University Institute of Lisbon

Department of Information Science and Technology

Attributes of information systems design leading to user satisfaction – A banking case study

Bruno Padinha

A dissertation presented in partial fulfillment of the Requirements for the

Degree of *Master in Computer Science and Business Management*

Supervisor:

Henrique O'Neill, PhD, Associate Professor,

ISCTE-IUL

October, 2014

Abstract

With the growing, pervasive use of information systems (IS) by most organizations, particularly companies in technology-intensive businesses such as banking, questions arise as to the effective success of those systems, how to measure it and, most of all, what influences it. User satisfaction, even if not an end goal of IS organizations, is frequently used as a measure of that success and it has been empirically shown to correlate with other more direct measures. Several research lines, then, look at what influences user satisfaction, particularly what characteristics of information systems and their development processes tend to result in higher user satisfaction.

The research reported here looks at the specific case study of a Portuguese bank, for which a comprehensive survey is undertaken yearly to record the satisfaction of its thousands of IS users' regarding its numerous information systems. Additional primary data was collected to characterize the information systems and their development processes, which, once structured and standardized alongside the user satisfaction survey results provided the basis for a quantitative analysis of the relationships between IS success, measured by user satisfaction, and its antecedents, using correlation and multiple linear regression techniques. The significant relationships are analyzed and the conceptual model's results discussed in light of prior theory on the subject. Several implications for the practice and research communities are finally identified.

Key words: information systems; information systems success; information systems design; user satisfaction; banking information systems; multiple linear regression

Resumo

Com a crescente utilização de sistemas de informação (SI) por muitas organizações, particularmente empresas que actuam em sectores intensivos no uso de tecnologia, surgem muitas questões relacionadas com o sucesso destes sistemas, como medi-lo e, principalmente, o que o influencia. A satisfação dos utilizadores, embora não seja um fim último dos departamentos de SI, é frequentemente utilizada como medida desse sucesso, havendo evidência empírica para a sua correlação com outras medidas mais directas. Muitas linhas de investigação, consequentemente, lidam com as causas da satisfação dos utilizadores, particularmente com que características dos próprios sistemas de informação e dos seus processos de desenvolvimento levam a maiores níveis de satisfação.

A investigação aqui descrita concentrou-se no estudo do caso de um banco português, que executa anualmente um inquérito abrangente para medir a satisfação dos seus milhares de utilizadores de SI em relação aos seus diversos sistemas de informação. Outros dados primários foram recolhidos para caracterizar os sistemas de informação e os seus processos de desenvolvimento, dados esses que, uma vez estruturados e normalizados em linha com os resultados dos inquéritos de satisfação, permitiram uma análise quantitativa das relações entre o sucesso de SI, medido pela satisfação dos utilizadores, e os seus antecedentes, utilizando técnicas de correlação e regressão linear múltipla. As relações significativas são analisadas e discute-se também os resultados do modelo conceptual enquadrado no estado da arte nestes temas. Finalmente, identifica-se várias implicações para a prática e para a investigação.

Palavras-chave: sistemas de informação; sucesso de sistemas de informação; desenho de sistemas de informação; satisfação do utilizador; sistemas de informação na banca; regressão linear múltipla

Acknowledgments

I am indebted for the support to this research provided by the management team of the case study Bank's IS department, which are not named here for confidentiality reasons. They know who they are, particularly the previous and the current CEO, as well as the always available Methods and Quality manager.

Thank you also for the invaluable support that came from my dissertation supervisor, Professor Henrique O'Neill, as well as the very insightful and demanding technical revisions of Professor Raúl Laureano.

To Professors Nuno Guimarães and Filomena Martins, I am very thankful for the insights they provided into the scientific method and what it takes to go through such an endeavor.

Some friends have also provided feedback for which I am thankful, namely Filipa de Sá Carneiro, who was patient enough to read some of my preliminary draft text and very polite when telling me everything that was wrong with it, and all the colleagues in the class of MIG '13 who have provided an adequate balance of support and relaxing distractions that I needed.

Finally, the development and writing of this dissertation would not have been at all possible without the unwavering support of my loving wife, Xana, who in critical moments has valiantly kept at bay our attention-demanding three little devils at home. Thank you.

Table of Contents

Table of figures

Table of tables

Glossary

Term	Definition
End-user satisfaction	Same as *User satisfaction*.
Information system	An electronic system or collection of systems designed to collect, process and/or analyze information, here used in the context of a business organization.
Information systems (or IS) organization	The department or division charged with planning, designing, developing and running the information systems of an organization.
Information technology	Computer-based hardware and software used to collect, process and analyze information, here in the context of a business or organization. Sometimes used as a synonym for *Information systems*, although the later usually has a stricter sense that is limited to the software components.
IS	Cf. *Information system*.
IT	Cf. *Information technology*.
User satisfaction	The degree of satisfaction reported by the user towards an information system, an application or one of its underlying systems

1 Introduction

1.1 Preamble

It is quite common nowadays for companies and governmental organizations to use information systems (IS)[1] to automate activities and generally support their business activities. These systems enable organizations to become more effective and efficient in delivering their products and services to their customers and have become, in many cases, intrinsic to the businesses themselves, as is the case of many high-tech enabled industries like banking and telecommunications, among others, which could not exist in their modern form without extensive use of information systems. Banks and other financial services institutions are a case in point, spending between 5% and 9% of their operating income in information technology (IT) (Gopalan et al. 2012). A direct contribution of IT assets and capabilities to the increase of productivity and general performance of businesses across many sectors of the economy has been reported (Bharadwaj 2000; Farrell et al. 2002). For example, a study of public banks in the US concluded that "a firm's IT capability is crucial for its competitive advantage" (Lin 2007).

As a result, bank employees have become frequent users of information systems, which give them access to information related to the bank's customers, products and services and allow them to register and process transactions of all kinds. The systems are usually heterogeneous, based on different technologies, with various user interfaces and

---

[1] The expression Information System, in this dissertation, means a specific application of Information Technology to some strict set of functional needs of a company or organization such as the Bank, for a certain business process or function. Throughout the text, groups of these information systems are sometimes referred to as an Application, which is the term that the (studied) Bank's IT management employs when communicating to the users to measure their satisfaction. Other authors deal with the ambiguity of the expression with a broader definition of Information System, such as "*[...] either some aspect of an application of information technology (IT), one individual application, a group of applications (including those of an entire organization), or an application of one type of IT*" (Seddon 1997).

functionalities, and differing levels of integration of the information that is captured and processed (Heidmann 2010).

Because users do not usually have a choice regarding which system, if any at all, they shall use for each business process (i.e., system use is compulsory), it happens that they exhibit varying levels of satisfaction regarding each system, according to how they perceive it or not as an efficient, effective tool for accomplishing their tasks and responsibilities. In general, this user satisfaction is derived both from how each information system supports them in the fulfillment of their day-to-day activities, as well as, in a broader sense, from how easy the system is to learn and use, how quickly and responsively it performs the needed calculations and other information processing tasks and how effective the information systems department is at developing, operating and maintaining the organizations' information systems, among other factors (Al-Maskari and Sanderson 2010).

For the information systems department of such a large and complex organization as the typical bank, the user satisfaction is very important to measure and monitor, not only because users are their immediate, internal customers, but also because it has been shown that it is usually an acceptable and objectively-measurable proxy for the success of the IS organization. For example, a study of "*88 IS success measures and 192 User Satisfaction measures [in] 27 organizations […] identified three broad User Satisfaction measures that may be treated as overarching measures of IS success.*" (Sedera and Tan 2005).

If user satisfaction measures the success of the information systems of an organization, a natural question arises, then, of what can management do to increase it in a significant and sustainable way?

It is immediately apparent that for the most part, user satisfaction cannot be changed directly, since it is based on a subjective perception, but rather it has to be influenced

via the more objective characteristics of the information systems and the IS organization that provides them, such as the following:

- Technical characteristics of the systems (e.g. technologies employed, hardware and software architectures, functional footprint, among others);

- Processes employed for the development of the information systems (such as the methods followed for analyzing, designing, coding, testing and exploring information systems);

- Models of organization and governance of the entities that are in charge of managing and evolving the information systems of an organization (e.g. organizational structure of the information systems department, assignment of responsibilities between it and the business community, technical competencies of the involved staff, etc.).

Many of the decisions in these areas are, understandably, also not trivial. For example, theory and practice related to the benefits of thin- vs. fat-client architectures have come full circle, from the dumb terminal used to access a time-sharing server of the 1970's through the DOS/CPM Personal Computer of the 80's and 90's all the way back to the web browser client, cloud computing and virtual desktop trends of the latest decades, then to the more recent mobile client "fat" applications architecture once again, just to cite a few examples of technologies.

Management has to analyze and decide upon information systems' topics such as those and hope to make the right decisions regarding their influence on the ultimate success of the information systems, which will be patent in user satisfaction as well as in actual benefits accrued from their usage.

The research reported here comprised the study of a specific case, that of a Portuguese bank, which has numerous information systems and whose management is keen on conducting a yearly appraisal of the satisfaction of its users. Throughout this

dissertation, the actual bank is not identified, in order to preserve its confidentiality, but rather just referred to as "the Bank."

1.2   Problem and objectives

Throughout the years, questions have arisen as the organization observes the ups and downs of user satisfaction with each of the Bank's main systems and attempts to identify their root causes, in the hope of reinforcing the positive ones and eliminating or at least minimizing the negative ones. While the Bank's Information Systems' management attempts to identify and isolate the reasons that lead to the evolution of user satisfaction, there had never been a systematic and objective search for its antecedents.

That was an important factor driving the execution of this study, since the increasing challenges of providing more IT and IS services, with a budget that is regularly expected to decrease, require a comprehensive understanding of what leads to users satisfaction and therefore, ultimately, to IS success.

This research looked at the case study of this bank in light of the existing knowledge in the field of Information Systems Research, in particular the findings regarding user satisfaction, information systems adoption and success and its antecedents.

The analysis of the relationship between variables upon which management makes objective decisions (such as, but not limited to, the aforementioned technological architecture decisions) and user satisfaction, here taken as a proxy of IS success, is prone to be very relevant for the management of the Bank and possibly provide food for thought for other organizations of a similar nature.

In addition, the methodology, described in chapter 3, can be applied to similar studies in the future, either of the same organization or of comparable ones, which would provide more insights into the conclusions reported later in this dissertation, and therefore

further inform the Bank's management in making decisions regarding the information systems and their development processes, with a somewhat clearer understanding of what outcomes of those decisions in terms of user satisfaction and, ultimately, IS success, could be expected.

The main objective of this study was, in summary, to increase the understanding of the relationship between satisfaction and the characteristics of information systems and their development processes in the specific case of this Bank. With that in mind, the problem was formulated as follows:

> *Problem statement: Which characteristics of Information Systems and their development processes influence user satisfaction?*

The above-mentioned organizational aspects of the IS function could not be included in the problem to be addressed by this study, since the unit of analysis of the satisfaction data – each of the bank's main applications / information systems – were not easily connected individually to the characteristics of the organization. It is possible that such objective could better be achieved by analyzing the satisfaction of end-users with the processes and services of the IS organization, instead of with its actual software products. That research path is therefore suggested in the conclusions of this dissertation.

1.3   Dissertation structure

After this introductory chapter, focused in presenting an overview of the research background, stating the problem and research objectives and explaining the motivation for the work, this dissertation proceeds in chapter 2 – *Literature review* – to review the relevant existing literature in the fields of Information System Research and to present its main findings, upon which stands the remainder of the work.

An explanation of the research design follows in chapter 3 – *Methodological approach* – as well as an introduction to the object of study (the Portuguese bank) and a description of the steps that were taken to collect, standardize and analyze the data.

The results are subsequently presented in chapter 4 – starting with the overview of the analyzed variables, including the univariate behavior of the dependent and independent variables, as well as the results of the application of bivariate analysis techniques.

In chapter 5 – *Discussion* – those results are related to the prior analysis of the state of the art and existing research models, and possible explanations are laid out for the relationships identified between user satisfaction and its antecedents.

The dissertation closes with chapter 6 – *Conclusion* – in which the implications of this study to the research community and the practitioners are identified, as well as its limitations are pointed out and suggestions for further research are made.

2 Literature review

2.1 Overview

The literature review started with the identification of seminal works in the relevant fields for the scope of this research and then proceeded to review their references as well as subsequent applications and further research which could contribute to the research objectives.

Each section in this chapter presents the key conclusions of the review for each of the main fields, starting with Information Systems Success, given its role as one of the ultimate goals of IS Research, then moving on to Technology Acceptance, a parallel research stream which also deals with the final goals of information systems, followed by a review of the state of the art on User Satisfaction, which has a central role in the studied case as well as in the chosen scope for this research and finally, by an overview of the literature dealing with Software Development processes, which was also an important foundation for this research, which deals with the study of the many different approaches to the creation and operation of information systems in an organizational context.

The results of this review were ultimately used to design the research scope and methodology as well as to ensure that the data to be collected allowed as much as possible for comparison of the results with other published studies.

2.2 Information Systems success

As information systems become more prevalent in organizations today and developing and running them becomes a sizeable portion of the budget (Gopalan, Jain, Kalani and Tan 2012), the question of the benefits that organizations get in return for that investment rises in importance. The definition and measures of what constitutes success in the context of Information Systems have long been a focus of IS Research,

recognized as a complex subject, essentially because (i) there are multiple perspectives in which IS success can be evaluated, (ii) there are different environments in which the analysis is made and (iii) there are very distinct practical implications of IS success.

A recent structured literature review (Urbach et al. 2009) focused on the state of the art on IS success has identified and classified some of the more prominent alternative measurement models that have emerged, notable examples of which are the Delone & McLean (D&M) model, first published in 1992, then subsequently refined and improved a decade later (DeLone and McLean 1992; DeLone and McLean 2003), which is further explored below; a re-specification of that model by Seddon (Seddon 1997), which attempts to eliminate the process interpretation of the original model and to isolate the behavioral variance model related to IS use; the IS Effectiveness model (Grover et al. 1996); and the Enterprise System Benefit Framework (Shang and Seddon 2002), which focuses on enterprise-wide, package-based systems and proposes a taxonomy rooted in five main categories of benefits (operational, managerial, strategic, IT infrastructure and organizational) for those kinds of systems.

Among those, the D&M model emerges as the most cited and widely used theory and the "dominant basis of IS success measurement" (Urbach, Smolnik and Riempp 2009). The updated version of the model is summarized in the diagram in Figure 1.

The authors of the D&M model started with a revision of the many definitions of IS success at the time and classified their measures into seven interdependent variables, recognizing the multidimensional and interdependent nature of IS success: Information Quality, System Quality, (Intention to) Use, User Satisfaction, Net Benefits and Service Quality (this last one was not part of the original model, but was added by the authors in the 2003 revision, arguing that it is a useful complement to Information Quality and System Quality specially when the overall success of an IS department is being analyzed, as opposed to when the focus is in a single information system).

Figure 1 Updated D&M IS Success Model (DeLone and McLean 2003)
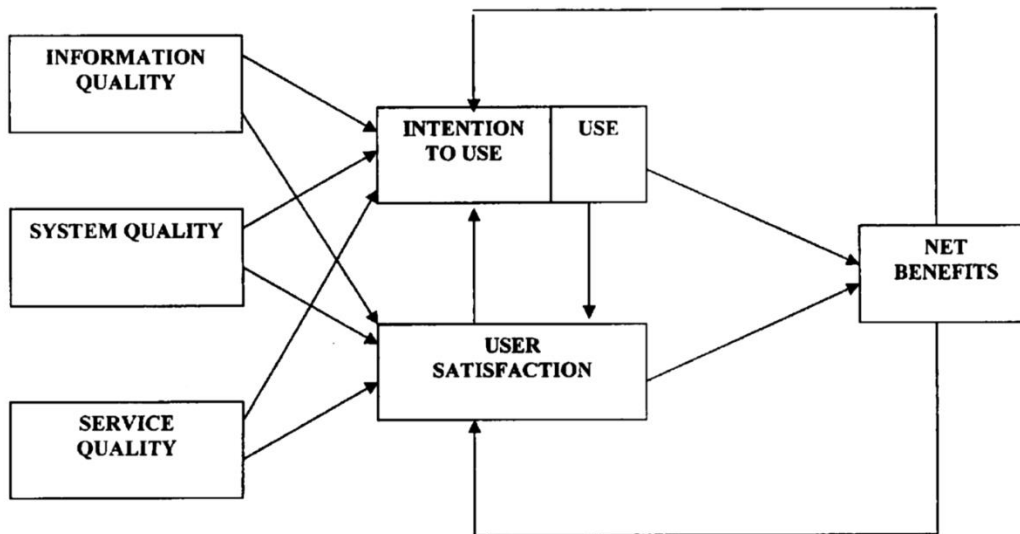
A high-level interpretation of the model, in a process perspective, emphasized by its authors, is that the intrinsic characteristics of a system can evaluated in terms of the three left-most variables in the diagram – System Quality, Information Quality and Service Quality – which affect the actual Use of the system (or, in compulsory use contexts, their Intention to Use) and the User Satisfaction derived from that use. These two intermediate variables interdependently reinforce each other and, in turn, lead to Net Benefits, i.e., a measure of the individual and organizational impacts of the information system.

The authors of the D&M model did not explicitly specify measures for each of those aspects, since the measurements and variables they found in the literature, both for field and lab application, were quite numerous and, in many cases, contingent on the scope of the empirical investigation to be undertaken (cf. Table 1). Nevertheless, it is advised that in the careful process of selecting variables, all efforts should be made to considerably reduce the number of measures applied to IS Success research, in the interest of comparability and validation of results.

Table 1 Original D&M summary of MIS Success Measures by Category (DeLone and McLean 1992)

System Quality	Information Quality	Information Use	User Satisfaction	Individual Impact	Organization Impact
Data accuracy	Importance	Amount of use/ duration of use:	Satisfaction with specifics	Information understanding	Application portfolio:
Data currency	Relevance	Number of inquiries	Overall satisfaction	Learning	Range and scope of application
Database contents	Usefulness	Amount of connect time	Single-item measure	Accurate interpretation	Number of critical applications
Ease of use	Informativeness	Number of functions used	Multi-item measure	Information awareness	Operating cost reductions
Ease of learning	Usableness	Number of records accessed	Information satisfaction:	Information recall	Staff reduction
Convenience of access	Understandability		Difference between information needed and received	Problem identification	Overall productivity gains
Human factors	Readability	Frequency of access		Decision effectiveness:	Increased revenues
Realization of user requirements	Clarity	Frequency of report requests	Enjoyment	Decision quality	Increased sales
Usefulness of system features and functions	Format Appearance Content Accuracy	Number of reports generated	Software satisfaction Decision-making satisfaction	Improved decision analysis	Increased market share
	Precision	Charges for system use		Correctness of decision	Increased profits
System accuracy	Conciseness	Regularity of use		Time to make decision	Return on investment
System flexibility	Sufficiency Completeness	Use by whom? Direct vs. chauffeured use		Confidence in decision	Return on assets
System reliability	Reliability Currency	Binary use: Use vs. nonuse		Decision-making participation	Ratio of net income to operating expenses
System sophistication	Timeliness Uniqueness	Actual vs. reported use		Improved individual productivity	Cost/benefit ratio
Integration of systems	Comparability Quantitativeness	Nature of use: Use for intended purpose		Change in decision Causes management action	Stock price Increased work volume
System efficiency	Freedom from bias	Appropriate use Type of information used		Task performance	Product quality
Resource utilization		Purpose of use Levels of use:		Quality of plans Individual power or influence	Contribution to achieving goals
Response time		General vs. specific		Personal valuation of I/S	Increased work volume
Turnaround time		Recurring use Institutionalization/ routinization of use		Willingness to pay for information	Service effectiveness
		Report acceptance Percentage used vs. opportunity for use			
		Voluntariness of use Motivation to use			

Upon publishing of the original model, as well as following its update in 2003, a considerable amount of research work ensued, looking to validate and advance the theory, a good summary of which is provided in a recent qualitative literature review of more than 600 articles published between 1992 and 2007 (Petter et al. 2013). Recognizing that there is a lack of research that systematizes and integrates the variables that influence IS success, Petter and the original authors propose the 43 variables shown in Table 2, which are posited to influence one or more of the

dimensions of IS Success present in the D&M model. These variables were then organized into the IS success determinants categories – task, user, social, project and organizational characteristics – as per three of the dimensions of Leavitt's Diamond of Organizational Change (Leavitt and March 1962), from which, finally, 15 IS success factors emerged as the ones that were most consistently demonstrated to influence IS success across types of information systems and contexts, which are summarized in Figure 2.

2.3   Technology acceptance

In addition to the IS Success front, another research stream from which insight has been derived that is directly relevant to the present study is the investigation of technology acceptance, whose seminal work proposes a Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al. 2003), which posits that attitudes such as user satisfaction influence behaviors like actual system use (for non-compulsory systems), which furthers the case for satisfaction being a driver of real benefits from information systems.

UTAUT was derived from eight prior prominent models of IT user acceptance, starting with the application of those models in a longitudinal study which collected data from four organizations at three points in time across a six-month period. The individual models explained between 17 and 53 percent of the variance in user intention to use a system. Then a unified model was specified, proposing a small set of core determinants and up to four moderators. This model outperformed all the original eight when applied to the same data, explaining up to 69 percent of the variance. Finally, using data from two additional organizations, the authors confirmed the validity of the model (adjusted R^2 of 70%). The model is summarized in Figure 3 and definitions of its main constructs are presented in Table 3.

Table 2 Factors posited as determinants of IS Success (Petter, DeLone and McLean 2013)

Characteristic	Description	Related variables	Variable description
Task	Determinants related to the work activities that support an organization, often supported by IS.	Task compatibility	The fit or consistency between the task and the IS that supports that task.
		Task difficulty	The degree to which the task supported by the IS is challenging for the user.
		Task interdependence	The amount that the task supported by the IS is reliant on other tasks or IS for completion.
		Task significance	The importance of the task within the business process or organization.
		Task variability	The degree of consistency (or lack of consistency) between tasks that an individual completes as part of their interaction with a work process and/or IS.
		Task specificity	The level of clarity of the task supported by the IS.
User	Determinants related to the individuals that use IS, such as those related to attitudes, personal demographics.	Attitudes toward technology	The degree to which the user possesses a favorable view about technology.
		Attitudes toward change	The degree to which the user possesses a favorable view about change, such as technology change or change in general.
		Enjoyment	The level of pleasure or enthusiasm a person has regarding the use of technology.
		Trust	The degree to which the individual has a positive view about the technology in terms of the technology being used in the individual's best interest.
		Computer anxiety	The degree of fear or concern a user has regarding the use of technology.
		Self-efficacy	The user's self-confidence about their ability to use the IS or technology in general.
		User expectations	The degree to which the user's perceptions about the IS are consistent with the actual IS.
		Technology experience	The amount of past experience a user has had with technology, even if it is a different type of technology than the IS under study.
		Organizational role	The position of the user within the organization (i.e., worker, manager, secretary, senior executive).
		Education	The degree of education completed by the user of the IS (i.e., some high school, high school, college, graduate degree).
		Age	The age of the user of the IS.
		Gender	The gender of the user (i.e., male or female).
		Organizational tenure	The length of time the user has been an employee of the firm.
Social	Determinants related to the impact that others within a person's peer group or social network influence an individual.	Subjective norms	The level of perceived social pressure related to the use of the IS.
		Image	The user's perception of how others view him or her due to his or her use of the IS.
		Visibility	The degree to which others in the organization are aware that the user is using the IS.
		Peer support	The level of support provided to users from their peers for a specific IS.
Project	Determinants related to the processes established during a project to identify, develop, and implement an IS.	User involvement	The degree to which users participate and are involved in the IS development and implementation process.
		Relationship with developers	The nature of the interaction, or closeness, between the developers and users of the IS.
		Third party interaction	The role of third parties, such as vendors or consultants, in the development of an IS.
		Developer skill	The capabilities and knowledge of the developers creating the IS.
		Development approach	The software development method used within the project, such as prototyping or the systems development life cycle.
		IT planning	The degree of planning performed by the IS department for IT projects and systems within the organization.
		Project management skills	The skill level of the project manager who is overseeing the development and implementation of the IS.
		Domain expert knowledge	The knowledge level of those that provide the expertise regarding the requirements for the IS.
		Type of IS	The nature or purpose of the IS, such as strategic IS versus transactional IS or customer relationship management systems as opposed to knowledge management systems.
		Time since implementation	The length of time since the IS has been operational within the organization.
		Voluntariness	The degree to which users are not required to use the IS as part of their job.
Organizational	Determinants related to the overarching organizational procedures and environment, such as management influences, organizational characteristics, and the organization's environment.	Management support	The degree to which management supports an IS as a champion, sponsor, or promoter of the system.
		Extrinsic motivation	Incentives or rewards (financial, recognition, or reputation) offered by management within the organization to encourage users to use an IS.
		Management processes	Policies and procedures used by management within the organization to achieve IT alignment or to oversee the use and implementation of IS within the organization.
		Organizational competence	The knowledge possessed by the firm about the use, application, and operationalization of IT.
		IT infrastructure	The degree of sophistication of the IT infrastructure within the firm.
		IT investment	The amount of money spent by the organization on IS and technology.
		External environment	Factors beyond the organization itself, such as the industry, the competitive nature of the industry, or the influence of customers or suppliers.
		IS governance	The degree to which the IS department is centralized or decentralized.
		Organizational size	The size of the entire organization in terms of the number of people or amount of revenue.

Figure 2 Determinants of IS success (Petter, DeLone and McLean 2013)
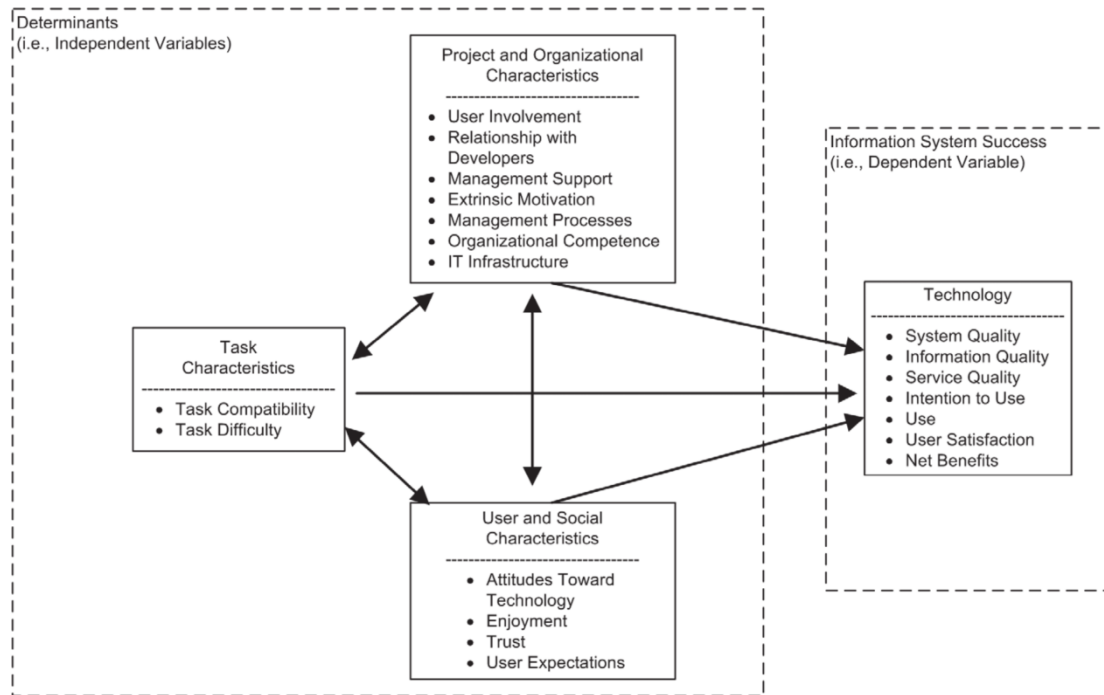
The UTAUT proponents also purport in prior research that satisfaction and other such attitudes evolve over time, in line with other antecedent or moderating variables, such as system use and user experience, which suggests that longitudinal studies, by analyzing the relationships between these variables over time, should be able to provide a richer understanding and deeper insight than simpler cross-sectional ones.:

> *"We found that as individuals gained direct experience with a system over time, they relied less on social information in forming perceived usefulness and intention but continued to judge a system's usefulness on the basis of potential status benefits resulting from use."* (Venkatesh and Davis 2000)

Even though these acceptance models, such as UTAUT, emerged from a stream of research that is essentially parallel to the IS Success and User Satisfaction ones, some authors have successfully combined them, allowing for an overall perspective on the entire information systems life-cycle, from design and development to the realization of business benefits and the resulting economic value. One such model (Wixom and Todd

2005) is shown in Figure 4, once again highlighting the central role of satisfaction, both that related to the information managed within the system ("*Information satisfaction*") as well as that with the system itself ("*System satisfaction*").

Figure 3 Unified Theory of Acceptance and Use of Technology (UTAUT) model
(Venkatesh, Morris, Davis and Davis 2003)
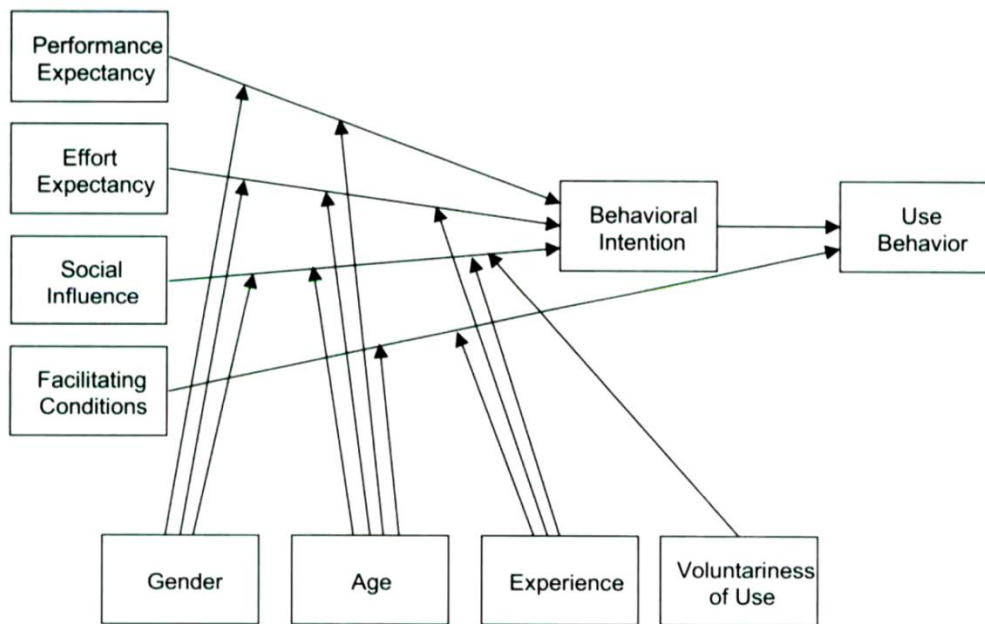
Table 3 Definitions of constructs in UTAUT (Venkatesh, Morris, Davis and Davis 2003)

Construct	Definition
Performance Expectancy	*"[...] the degree to which an individual believes that using the system will help him or her to attain gains in job performance."*
Effort Expectancy	*"[...] the degree of ease associated with the use of the system."*
Social Influence	*"[...] the degree to which an individual perceives that important others believe he or she should use the new system."*
Facilitating Conditions	*"[...] the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system."*

14

In fact, it is understood that the usefulness of satisfaction as a measure of IS Success, due to its significant relationship to antecedents related to system characteristics and associated processes, is hindered if it cannot be shown that satisfaction itself is a relevant antecedent of actual system use.

Figure 4 Integrated IS success research model (Wixom and Todd 2005)
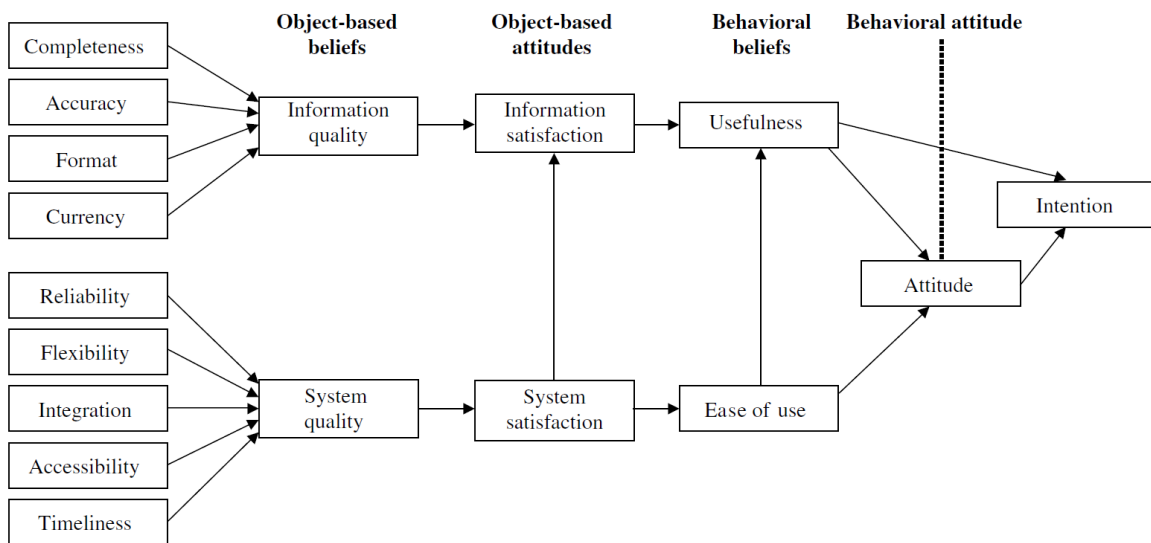
This model and associated empirical research provides evidence for that link, hence addressing important criticisms of the use of satisfaction as a measure of IS Success (Melone 1990), namely that:

1. It did not establish a link between the attitudes towards the system (satisfaction) and actual behaviors (such as system use); and

2. It did not account for variations of satisfaction throughout the user learning curve for the information system.

This key role of satisfaction is emphasized by those authors, which explain that the user perceptions of quality are based on their beliefs and attitudes related to the information systems. For example, information satisfaction positively influences the perception of usefulness. Likewise, system satisfaction *"represents a degree of favorableness with*

respect to the system and the mechanics of interaction. The more satisfied one is with the system itself, the more likely one is to find the system to be easy to use." (Wixom and Todd 2005). Therefore, the model adds related hypothesis which is that the easier to use a system is deemed, the more useful it becomes in the eyes of the users, since it is a pre-requirement to obtaining useful information from a system that one is able to use it at all, and as easily as possible. *"Thus, an individual's level of satisfaction with the system is likely to influence his or her sense of satisfaction with the information it produces"*, the authors add (Wixom and Todd 2005).

2.4   User Satisfaction

Definitions of user satisfaction in the literature tend to start from the psychology literature's broad definition of satisfaction as *"[…] in a given situation […] the sum of one's feelings or attitudes toward a variety of factors affecting that situation."* (Bailey and Pearson 1983), then apply it to the realm of Information System users with a focus on the information in those systems:

> *"User information satisfaction [UIS] […] is defined as the extent to which users believe the information system available to them meets their information requirements. […]"* (Ives et al. 1983)

The same authors then go on to praise the use of user satisfaction as a measure of IS success:

> *Although ideally one would like to evaluate the effectiveness of an information system based on its degree of use in decision making and the resultant productivity benefits, this "decision analysis" approach is generally not feasible. Satisfaction of users with their information systems is [therefore] a potentially measurable, and generally acceptable, surrogate for utility in decision making. […] UIS is a perceptual or subjective measure of system success; it serves as a substitute for objective*

16

determinants of information system effectiveness which are frequently not available" (Ives, Olson and Baroudi 1983).

Subsequent research has confirmed the usefulness and validity of user satisfaction as either one dimension of or an overarching construct for information systems success. For example, the authors of the D&M IS success model, referred to before (DeLone and McLean 1992), advance three reasons for this, particularly for contexts in which use of the information system is compulsory, and therefore other measures, such as actual usage, become less relevant: first of all, its face value, i.e., the fact that a system whose users are satisfied is undeniably successful, at least up to a certain degree; second the availability of reliable tools for measuring it (such as Bailey and Pearson's one (1983), among others); finally, due to the conceptual weaknesses or empirical obstacles of other proposed measures of IS success.

In fact, user satisfaction features prominently in the D&M model, being among the most widely studied components of IS Success, for which popular measurement instruments have long since been proposed, refined and extensively applied (Bailey and Pearson 1983; Doll and Torkzadeh 1988; Doll and Torkzadeh 1991; Galletta and Lederer 1989; Ives, Olson and Baroudi 1983). There has been empirical confirmation of user satisfaction's validity as a measure of IS Success (Doll et al. 1994; Thong and Yap 1996) and it is even proposed as a potential single measure of IS success by some authors more recently (Sedera and Tan 2005).

Finally, another key insight regarding user satisfaction's relevance is that the multivariate nature of the IS success models supports the idea that there is a direct relationship between satisfaction and some of the success determinants such as user involvement (Baroudi et al. 1986; Doll and Torkzadeh 1989; Tait and Vessey 1988), namely through training (Guimaraes et al. 1996), and quality of information (Saarinen 1996; Shirani et al. 1994).

2.5   Software related processes

The vast literature on software development processes and other information systems related processes (CMMI Product Team 2010; Wohlwend and Rosenbaum 1993) shows that the research so far yielded only a few conclusions regarding their influence on user satisfaction and IS success in general.

One such conclusion is that the involvement of users throughout the development of the system (for example on the design of the system, testing it, training and other such activities) has a significant influence on the ulterior user satisfaction (Baroudi, Olson and Ives 1986; Doll and Torkzadeh 1989; Guimaraes, Yoon and Clevenson 1996).

Another relevant conclusion is that the maturity of the overall software development and maintenance organizational processes, of which a widely accepted measure is the CMMI-DEV model, from the Carnegie-Mellon Software Engineering Institute (CMMI Product Team 2010), has a relevant influence in overall IS success (Jiang et al. 2004).

3   Methodological approach

3.1   Research design

Given the stated problem and research objectives already presented (cf. section 1.2), the approach chosen was that of a case study, which has benefited from the long-term relationship of the author as a consultant with the Portuguese bank that was the object of the study.

Focusing on a specific case study allowed for a deep analysis of the details of the Bank's information systems, eliciting rich information on their characteristics, the Bank's development processes and the ultimate user satisfaction with the applications, as well as ensuring that information was interpreted in the correct context, a key tenet of the case study method (Yin 2002).

From the possible alternative designs that could be applied (Creswell 2002), this research was conceived as descriptive, leaning essentially on the collection and analysis of quantitative data.

3.2   Object of the study

The Bank is a medium-sized financial institution operating in the Portuguese Market since the early 20th century, with net assets over 13 billion euros and more than 600 branches at the end of 2012.

The group includes the core banking operating units as well as specialized companies operating in related businesses such as insurance and asset management.

In addition, there are a number of corporate and shared service centers providing centralized functions such as marketing, legal support and information systems.

In particular, the Information Systems and Information Technology shared service center effectively fulfills the role of an IS department of the Bank and other group companies, providing the hardware, software and services that enable the use of information technology by the business units. That center was therefore the main source for this study, and is henceforth referred to as "the Bank's IS Department" or simply "the IS Department".

3.3   Approach to the literature review

The literature review (presented in chapter 2) started with the seminal papers on the key topics of information systems success, user satisfaction, technology acceptance and software development, then proceeded to include their references and subsequent references, as well as other research and documentation found via keyword search for specific topics. Several important theoretical and conceptual constructs emerged from this review, which informed the subsequent field work.

3.4   Design of the conceptual model

The idea for this research came from the practice of the Bank's IS Department to measure the users' satisfaction every year with a comprehensive survey. This prompted the question of what can management do to increase that satisfaction, which could be informed by an analysis of processual determinants that could likely be having a positive or negative influence in the user's satisfaction. Satisfaction, therefore, took the place of dependent variable and a quest to identify suitable independent variables to test ensued. Even though user satisfaction is a perception, therefore a subjective measure, the research strived to collect and analyze real, objective measures as well, such as training and testing approach, among others.

In order to design a conceptual model for this research which is consistent with the theory and which can be applied to the case study, a preliminary interview took place

with the Bank's IS Department leadership for identifying which data was available to operationalize variables that corresponded to the concepts and constructs in the literature, particularly the D&M model and its more recent taxonomy of IS success determinants (cf. Table 1 and Table 2). This lead to the identification and subsequent collection and standardization of data related to the variables presented in Table 4, which are grouped according to those models and associated research, as shown in Figure 5.

Based on the collected data, the simpler conceptual model for this study was then designed and is presented in Figure 6.

Table 4 Collected variables classified according to theoretical research and models

Collected variable	D&M Model category (*measure(s)*) (DeLone and McLean 2003)	Determinant category (*measure(s)*) (Petter, DeLone and McLean 2013)
User satisfaction	User Satisfaction (*overall satisfaction, Single-item satisfaction*)	Technology
Online information	Information Quality (*Currency*)	Technology
Browser access	System Quality (*Ease of use / Convenience of access*)	Technology
Development effort	System Quality (*System sophistication*)	Technology
Testing approach	N/A	Project characteristics (*Relationship with the developers*)
Formal training	N/A	Project characteristics (*User involvement*)
Age	N/A	Project characteristics (*Time since implementation*)

Figure 5 Collected variables shown in light of theoretical research and models
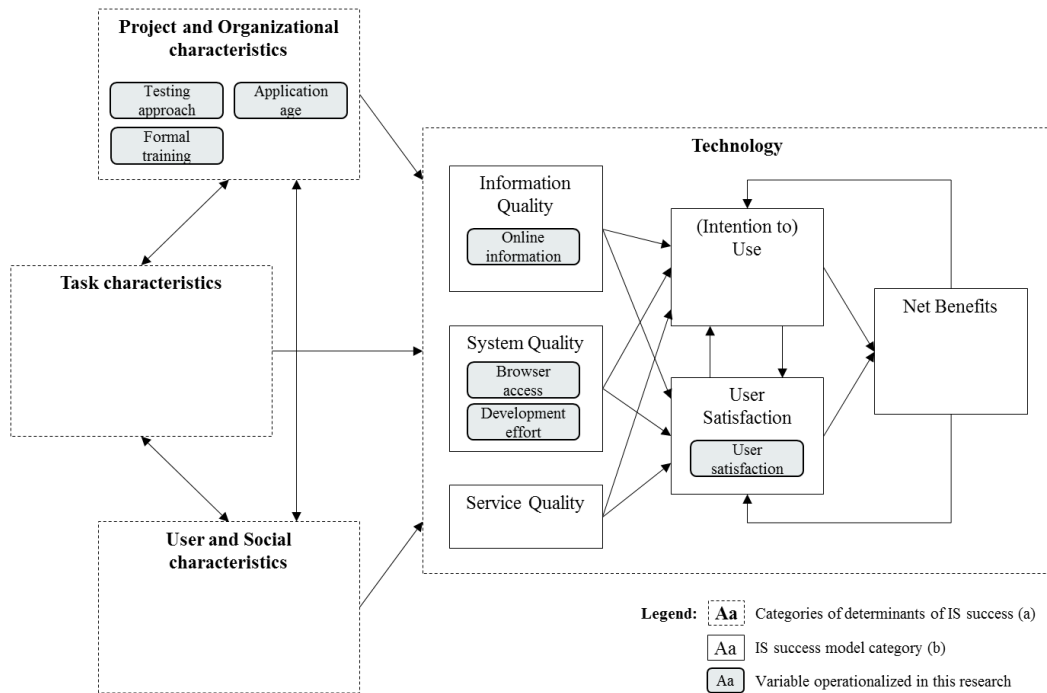
Sources:(a) (Petter, DeLone and McLean 2013), (b) (DeLone and McLean 2003)

Figure 6 Conceptual model
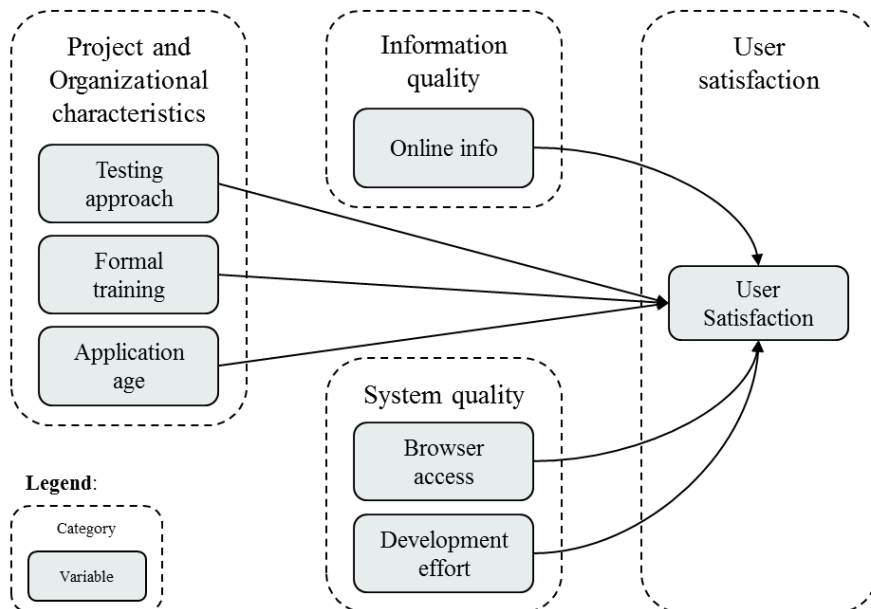
3.5   Collection of data

3.5.1   Main concepts and variables

Once the conceptual basis was established, research then proceeded with the collection of data related with the user satisfaction as well as the characteristics of the Bank's information systems and their development processes for which information was available for collection and which could serve to operationalize the concepts identified in Table 4. This data was subsequently used to operationalize the dependent and independent variables.

The collected data covers a time span of five years, from 2008 to 2012, which existed thanks to the Bank's commitment to regularly monitor its IS business processes and yearly measure the corresponding user satisfaction. This provided the opportunity to analyze the dynamics of the relationships between IS success and its antecedents, which is relatively uncommon due to the cross-sectional nature of the approach followed by many of the research works in the literature in these fields (Melone 1990; Wixom and Todd 2005).

While the dependent variable data came directly from the yearly user satisfaction surveys, the operationalization of the independent variables required the collection of and manipulation of data from many sources in order for it to be in a format that was compatible with the user satisfaction data. The approach that was followed for that data collection is explained in detail in the following sections of this chapter.

3.5.2   User Satisfaction

The Bank's IS Department conducts three yearly satisfaction surveys: an IS user satisfaction survey, a management IS satisfaction survey and an internal IS employee satisfaction survey. All of these are issued electronically to the Bank's employees, with the responses being collected anonymously and analyzed by an external entity. The first

of those surveys was used as the source of information for operationalizing the dependent variable in this research. It usually has considerably high response rates, as shown in Table 5.

Table 5 User satisfaction survey response rates

Year	2008	2009	2010	2011	2012
Total number of users (u)	3,836	4,289	3,779	4,063	4,119
Number of valid survey responses (n)	1,618	2,246	1,850	1,752	2,095
Rate (n/u)	42%	52%	49%	43%	51%

The set of responses to those surveys over a five year period (2008 through 2012) was used as data for the dependent variable, The user satisfaction surveys considerably resemble some of the most widely used instruments for measuring satisfaction found in the literature review (Bailey and Pearson 1983; Doll and Torkzadeh 1988) and which have been empirically validated (Melone 1990). They have three main sections, covering (i) the user's satisfaction with the Bank's Information Systems, (ii) the IS Department's provision of services and (iii) the importance of those systems and services to the user. The data collection for the Satisfaction variable focused on the first of these sections.

Although some changes are made every year to the surveys, mainly to add questions related to newly introduced systems or services and to remove those which are no longer in use, the majority of the items related to the main banking applications have been regularly included in the surveys for at least a majority of the years included in the research.

Each question in each questionnaire was associated, whenever possible, to a main application in the information systems inventory already collected, and coded as shown in Table 6.

Table 6 Number of questions regarding satisfaction with each application

Application (code) year	2008	2009	2010	2011	2012	Total
ATM (atm_softw)	1	1	1	1	1	**5**
Central NET (centralnet)			1	1	1	**3**
Collections (collection)					1	**1**
Commercial management (commercial)			1	1	1	**3**
Contact Center (contcenter)	1	1	1	1	1	**5**
Customer Information (cust_info)			1	1	1	**3**
E-mail (email)			1	1	1	**3**
Financial Markets (finmarkets)		1	1	1	1	**4**
Imparity (imparity)			1	1	1	**3**
International (internat)		1	1	1	1	**4**
Intranet (intranet)			1	1	1	**5**
Internet, e-mail (inet_mail)	1	1				**2**
Local system - Legacy (local_leg)	1	1	1			**3**
Local system - New (local_new)			1	1	1	**3**
Management Information System (mis)	1	1	1	1	1	**5**
Online Banking (onlinebank)	1	1	1	1	1	**5**
Payments - Cards (pay_cards)	1	1	1	1	1	**5**
Payments - POS (pay_pos)			1	1	1	**3**
Profile (profile)	1	1	1	1	1	**5**
Scanned Signatures (scan_sign)	1	1	1	1	1	**5**
total	9	11	18	17	18	75

The user satisfaction survey questions ask the respondents' to rate their satisfaction with each main application developed and operated by the Bank's IS department. The responses are recorded in the form of a 4-point Likert item, which is a commonly used approach for measuring satisfaction (Bailey and Pearson 1983; Carifio and Perla 2007; Melone 1990), following the template in Figure 7 (translated from the 2012 survey,

originally in Portuguese). The scale has an even number of points (four) which prevents indecisive responses, for which the users are asked to select the "Don't know" option instead.

Figure 7 Example user satisfaction survey question (translated)

"Overall, I am satisfied with the [Application Name] application provided by the IS department."

○ Fully disagree　　○ Partially disagree　　○ Partially agree　　○ Fully agree　　○ Don't know

Although the same Likert-type scale was used in all the questionnaires (see Figure 7), the coding of the responses was not exactly the same in each year. Therefore, carefully recoding of the survey responses was undertaken in a spreadsheet program, using the codes shown in Table 7, and then all the responses were consolidated in a single satisfaction variable source file, being careful to map each question to the appropriate Application column.

Table 7 Standardized satisfaction survey response codes

Response	Code
Fully disagree	1
Partially disagree	2
Partially agree	3
Fully agree	4
Don't know	*. (blank)*

While Likert-type scales comprised of multiple items are commonly used for measuring user satisfaction, the use of single-item Likert-scales has also been reported in published research, as well as the treatment of such variables as continuous, which is, in practice,

widely used in many of the instruments to measure user satisfaction (Hayes 1998), and several authors back their use, if carefully applied, as continuous or, at least, ordinal variables (Botelho et al. 2011; Göb et al. 2007).

The operationalization of the variable for user satisfaction regarding each application in each year was achieved by averaging the valid responses from all users to the relevant question in the year's questionnaire. The median was also calculated as an additional measure of satisfaction, but later discarded since it proved to be too limited in range for many analyses and did not yield significantly different results for the remaining ones.

This yielded a preliminary case file consisting of the attributes per line presented in Table 8.

Table 8 Attributes in preliminary case file (up to the dependent variable)

Variable	Description
c_APPV	Main application: code
c_APPN	Main application: name
c_APPD	Main application: description
c_YEAR	Year to which the case applies
d_SAT	Average user satisfaction regarding the application in that year

3.5.3 Applications and systems

An obstacle that had to be overcome in the data collection process was the level of detail at which the information systems in the Bank are analyzed and recorded: each of the Bank's main Applications is comprised of one or more underlying Systems, each of them fulfilling a specific role. The Bank's IS Department management provided an exhaustive inventory of these underlying systems, including key characteristics such as their names and short descriptions of their functions, the vendors that provided them,

the types of technologies used, the initial production years, how they were developed, namely whether the users were formally involved in activities such as acceptance testing and training, and to which main application each one belongs to.

While in the user satisfaction surveys' questions, global Application names are referred to, many other sources of information record the data at the underlying System level of detail. Since satisfaction was the driver for this research, it was decided that in the cases in which data was collected at the System level of detail, it would be aggregated in some way for all the Systems which are associated with a specific Application. The relationship between Applications and Systems is shown in Table 9. The Applications listed in that table are not an exhaustive inventory of all of the Bank's information systems, since collected information was discarded if it applied to Applications for which satisfaction was not measured in the surveys.

3.5.4 Projects, requests and maintenance

The IS Department regularly executes large-scale projects (designated "projects" below), which develop new features or even replace existing entire systems and applications altogether, as well as smaller-scale initiatives dealing with features requested by the end-users ("user feature requests"), and other smaller application maintenance activities ("maintenance activities").

Information was gathered on the projects and requests that were executed throughout the period in analysis, namely which ones contributed to the development of each system and application, how many person-days were employed, when the activities took place and some of the methodological approaches undertaken.

Although some effort was spent trying to elicit additional information regarding these projects, sadly no other structured data could be obtained about the software development life-cycle, since the main change that was introduced at the Bank in this period, which was the level 2 CMMI certification of the development processes, was

achieved precisely in 2007, prior to the projects under analysis taking place, which means that all of the projects for which data has been collected were implemented already following the new processes.

Table 9 Applications and underlying systems

Application	Codename	Underlying systems
ATM	ATM_SOFTW	Expand Server
Central NET	CENTRALNET	Central NET
Collections	COLLECTION	CollectionsBox, Jvris
Commercial management	COMMERCIAL	*Análise Desempenho Comercial*, *Gestão Comercial*, SAS
Contact Center	CONTCENTER	Altitude
Customer Information	CUST_INFO	*Cliente Grupo*
Financial Markets	FINMARKETS	*Futuros*, Voyager, Calypso, Central Online, Focus ALM, GESTPROC, Globus (*Histórico*), OPICS (*Histórico*), Sifox, Sifox (*Histórico*)
Imparity	IMPARITY	*Imparidade*, *MOAI*
International	INTERNAT	Eximbills CS, Eximbills EE, Smart
Intranet	INTRANET	Logger, CAFT, CS, CSAPP, CSAPP (IMCA), *RSAdmin*, *Simuladores Intranet*
Local system - New	LOCAL_NEW	CATS, *Balcões*
Management Information System	MIS	ODS, *SIG*
Online Banking	ONLINEBANK	Backoffice *Canais* WEB, Mobile, Online *Empresas*, Online *Gestão*, Online *Particulares*, *Publicação de Contas*, *Relatórios*, *Loja ABC*, SAGE BE, Site *Institucional*, sms.SE
Profile	PROFILE	Profile FMS, Profile IBS
Scanned Signatures	SCAN_SIGN	*DICA*

In total, 96 main projects, 142 user requests and 2,020 maintenance initiatives that took place from 2008 to 2012 were analyzed and either associated with the systems and applications that they deal with or discarded if they did not directly affect the applications being studied.

Table 10 shows the number of relevant projects, requests and maintenance initiatives that took place in each year.

Table 10 Projects, feature requests and maintenance initiatives

Year	2008	2009	2010	2011	2012
Projects	16	16	12	5	12
User feature requests	8	7	33	59	44
Maintenance initiatives	329	300	353	333	966

Each project was individually mapped to each of the Bank's applications' underlying systems and then finally aggregated for each of the main applications presented in Table 9. The detailed mapping between the projects and the applications is presented in appendix A, on page 63.

After all the information was collected and processed, tables summarizing and relating the various items were prepared and submitted for validation by the management of the IS Department of the Bank, in order to have an additional measure of confidence on the collected and processed data.

The final tables were then setup in a database layout in order for their contents to be cross-referenced and combined into the final case file, as per the data model in Figure 8.

Figure 8 Variable operationalization data model: Class diagram
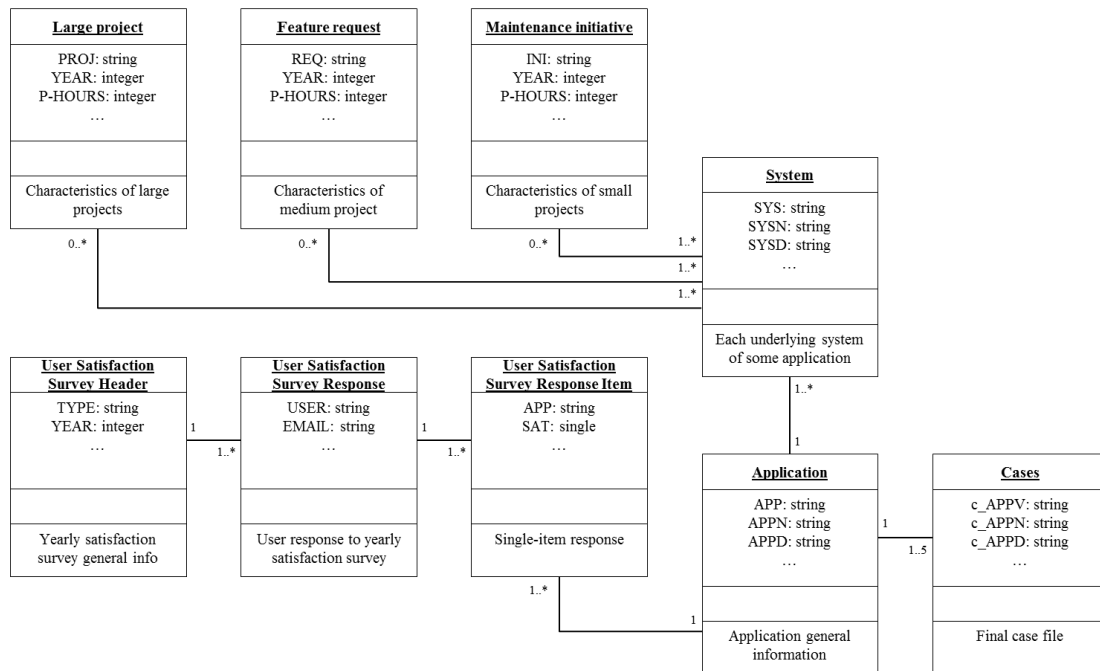
3.6   Operationalization of independent variables

By combining the information on the applications and systems, on one hand, and projects, requests and initiatives, on the other, the independent variables where operationalized, presented in the following tables grouped according to their ability to measure key concepts from the literature:

- Application development, including effort and user involvement (Table 11);

- Application characteristics (Table 12).

In some cases, dummy variables were coded to represent the presence or absence in an Application of certain characteristics in its underlying systems. For example, the *i_BrowserA* and *i_BrowserB* variables are both dummy codings related to the execution (or not) of formal acceptance tests for each underlying system associated with a certain application, the first one following a more conservative approach (1 only if formal

acceptance tests took place for <u>all</u> underlying systems) and the second one a more lax approach (1 if <u>any</u> underlying system went through acceptance testing). As described later, a correlation significance test was conducted to select the stronger of these two approaches.

Another data modelling step consisted in the conversion of person-hours to person-years, which assumed one year has 12 months of 21 days, each corresponding to 8 hours of work, which was introduced for convenience in some calculations and analysis.

The final case file was then built, by combining the independent variables with the appropriate lines in the application satisfaction case file (described in section 3.5.2 above), resulting in the complete list of attributes presented in Table 13.

Table 11 Independent variables related to application development

Concept	Concept description	Variable description	Variable code[2]
Total development	Application development effort (large scale projects, medium- and small-sized maintenance requests)	Total person-hours spent	*i_TotH*
		Total person-years spent	*i_TotY*
Accept-ance Tests	User involvement in application development through formal acceptance tests	Percentage of underlying systems of the application for which formal acceptance tests were undertaken	*i_Tests*
Training	User involvement in application development through formal classroom training	Dummy variable (1 if training took place for most underlying systems, 0 otherwise)	*i_Train*

---

[2] These codes are used throughout the remainder of this text to refer to these variables.

Table 12 Independent variables dealing with application characteristics

Concept	Concept description	Variable description	Variable code[3]
Browser-based access	Access to the application by the users takes place through a web browser interface (i.e., not through a terminal nor dedicated client software)	Dummy variable (1 if access is browser-based for all underlying systems, 0 otherwise)	*i_BrowserA*
		Dummy variable (1 if access is browser-based for any underlying system, 0 otherwise)	*i_BrowserB*
Online information update	The information residing in the application is updated online (i.e., not only in daily batches)	Percentage of underlying systems of the application for which information is online	*i_Online*
Application maturity	How long has the application been in production use	Since how many years has the earliest underlying system been introduced	*i_Age*

3.7 Analysis of variable behavior and inter-relationships

After all the information was collected, validated, standardized and consolidated into a single case file, analysis started with descriptive measures of the dependent and independent variables: central tendency measures (mean and median, where applicable) and dispersion measures (range and standard deviation). The evolution of satisfaction and of the independent variables over time was thus analyzed, as a whole, as well as per main application. This allowed for the checking of potential outliers and whether there was any missing or incomplete information that needed to be dealt with or discarded.

The next step focused on evaluating the correlation between the candidate independent variables and the dependent variable, User Satisfaction, upon which some variables were considered for discarding and others were selected to be applied for operationalizing the conceptual model (previously presented as Figure 6). This was particularly required due to the already mentioned fact that there were several possible

---

[3] Idem

approaches to coding some of the literature concepts from the collected data, particularly in those cases of variables for which information was aggregated for each application based on more detailed information collected at the underlying system level. The final variables used to operationalize the conceptual model are shown in Figure 9.

Table 13 Attributes in case file

Variable	Description
c_APPV	Main application: code
c_APPN	Main application: name
c_APPD	Main application: description
c_YEAR	Year to which the case applies
d_SAT	Average user satisfaction regarding the application in that year
i_TotH	Grand-total of person-hours spent on projects of all types
i_TotY	Person-years spent on projects of all types (*i_TotH* / 2,016)
i_Tests	Percentage of underlying systems of the application for which formal acceptance tests were undertaken
i_Train	Dummy variable, coded as 1 if training took place for most underlying systems and as 0 otherwise
i_BrowserA	Dummy variable, coded as 1 if access is browser-based for all underlying systems, and as 0 otherwise
i_BrowserB	Dummy variable, coded as 1 if access is browser-based for any underlying system, and as 0 otherwise
i_Online	Percentage of underlying systems of the application for which information is online
i_Age	Since how many years has the earliest underlying system been introduced

Finally, in order to test the influence of the antecedent variables in satisfaction, the multiple linear regression technique was selected as the main approach, due to its applicability to the data, as well as it being among the main analysis techniques employed in IS Success research, in line with the conclusions of a literature review

(Urbach, Smolnik and Riempp 2009) which analyzed articles published in the previous decade, the results of which are shown in Figure 10.

Figure 9 Conceptual model with variables assigned
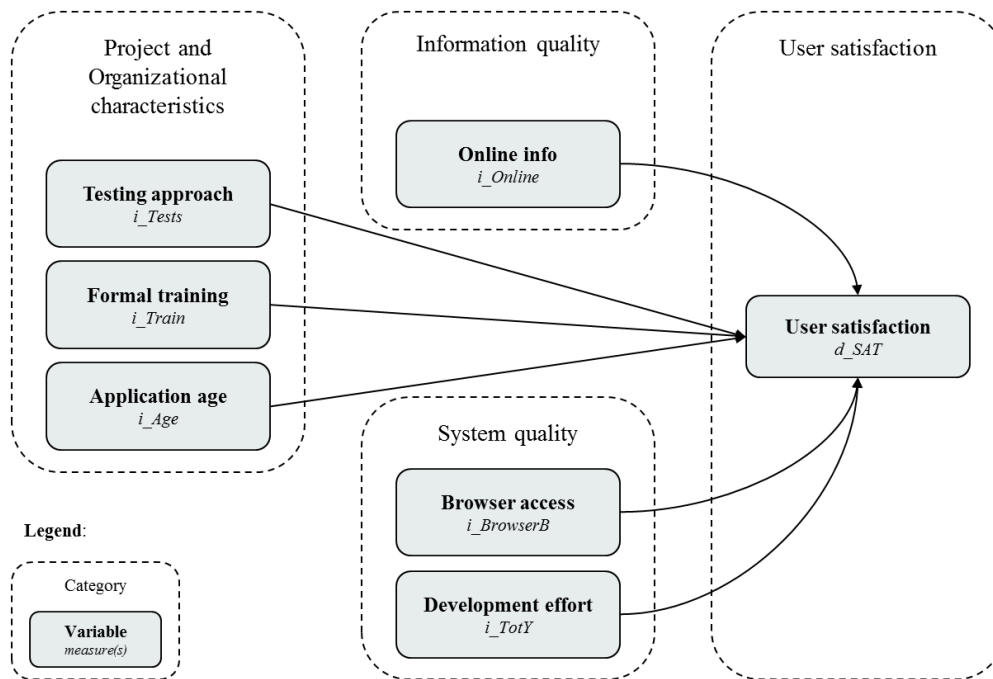
The linear regression models were evaluated taking into account the following requirements on the data (Laureano 2011; Pestana and Gageiro 2008):

- The relationship between the dependent variable (Y) and the independent variable or variables (X) has to be linear in the β parameters.

- The errors can assume values above or below zero (their average, therefore, is assumed to be zero).

- The errors are homoscedastic (i.e., their variance is constant for any value).

- The errors are independently distributed in relation to one another.

- The explanatory variables are independent (i.e., collinearity is not present).

*Figure 10 Classification of empirical publications in IS Success research
(Urbach, Smolnik and Riempp 2009)*

No. of publications (multiple allocations possible within one category)

48	28	40	28	32	46

Theoretical foundation:
- n/a (1)
- Other (15)
- Seddon (1997) (2)
- Davis (1989) (4)
- D&M (2003) (8)
- D&M (1992) (18)

Object of analysis:
- n/a (3)
- IT function (1)
- All IT applications (3)
- Type of IT or IT application (15)
- Single IT application (6)

Unit of analysis:
- n/a (2)
- Individual level (26)
- Organizational level (12)

Evaluation perspective:
- n/a (2)
- Multiple stakeholders (4)
- IS executives (2)
- IS personnel (1)
- Users (19)

Data gathering:
- Other (5)
- Case Study (1)
- Interview (3)
- Survey (23)

Data analysis:
- Other (6)
- Cluster anal. (2)
- Variance analysis (7)
- Factor analysis (11)
- Regression analysis (3)
- Structural equation modeling (17)

Several regression models were evaluated, each focusing on testing the relationship between User Satisfaction and one or more of the groups of variables in the conceptual model. Due to the number of cases containing all the relevant variables, in some instances only a few variables from each group could be tested, since regression analysis requires at least 10 cases per dependent variable, with some authors even advocating a minimum of 15 (Stevens 1996).

The actually calculated models are listed in Table 14. Model #1 was created to test the influence in User Satisfaction of variables from the Project and Organizational (P&O) characteristics group, model #2 analyzed the influence in User Satisfaction of Information Quality (IQ) and System Quality (SQ) and model #3 looked after the influence in User Satisfaction of all three variable groups (P&O, IQ and SQ). If any non-significant variable was identified any of the main models, an additional variant of

that model was also created by removing that variable (these additional models are denoted by a 'b' appended to their number, i.e. #2b and #3b).

Table 14 Linear regression models

Model #	Dependent variable	Independent variable(s)
#1	Satisfaction (*d_SAT*)	Testing approach (*i_Tests*) Formal training (*i_Train*) Application age (*i_Age*)
#2	Satisfaction (*d_SAT*)	Online information (*i_Online*) Browser access (*i_BrowserB*) Development effort (*i_TotY*)
#2b	Satisfaction (*d_SAT*)	Online information (*i_Online*) Browser access (*i_BrowserB*)
#3	Satisfaction (*d_SAT*)	Application age (*i_Age*) Online information (*i_Online*) Browser access (*i_BrowserB*) Development effort (*i_TotY*)
#3b	Satisfaction (*d_SAT*)	Application age (*i_Age*) Online information (*i_Online*) Development effort (*i_TotY*)

After running each model, its significance was checked, as well as the strength of its explanatory ability, then each variable's significance was checked as well and only then were the variables coefficients analyzed, in order to understand the strength and direction of the influence of each independent variable in the dependent variable (User Satisfaction).

4 Results

4.1 Behavior of the dependent variable – Satisfaction

Looking at the overall user satisfaction measures, for all assessed applications and all years being analyzed, the dispersion is small (st.dev./mean = 5%), but there are considerable differences between the assessed applications under analysis, ranging from the low 2's to the high 3's (in the 1 to 4 scale presented in Table 7, on page 26), as shown by the histogram and table in Figure 11.

Figure 11 Frequencies of user satisfaction

User satisfaction (*d_SAT*)		Histogram
Mean	3.349	
Median	3.353	
Std. deviation	0.161	
Range	0.718	
Minimum	2.921	
25th percentile	3.265	
50th percentile	3.353	
75th percentile	3.464	
Maximum	3.639	
Count (n)	73	
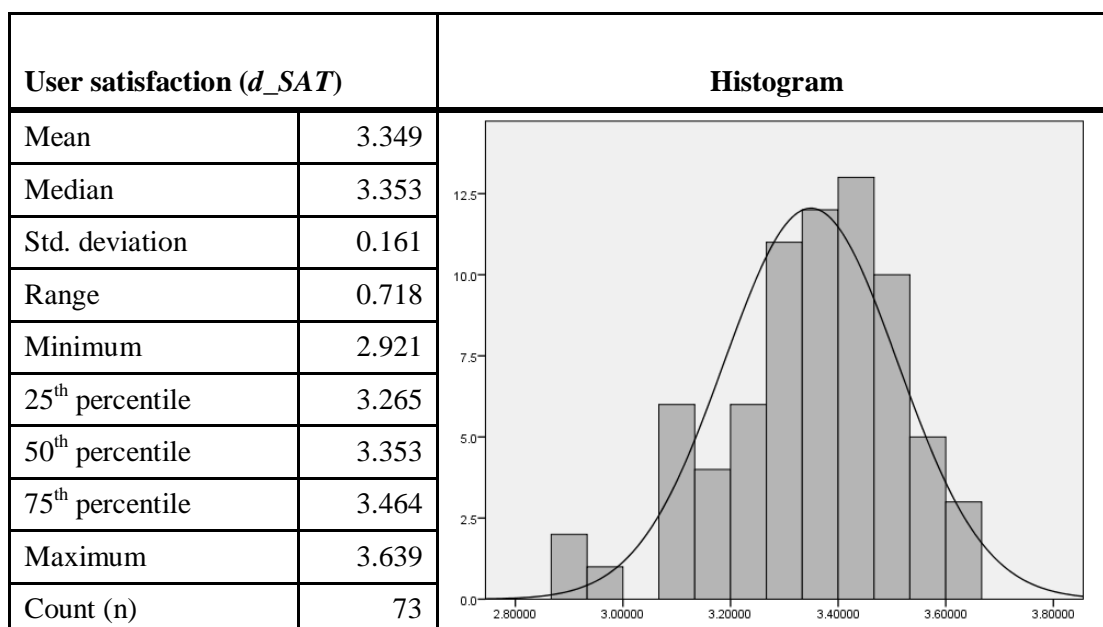
Looking at the evolution of the average user satisfaction for each application throughout the years (Figure 12), it can be seen that not all applications vary in the same direction from one year to the other, suggesting that there are more variables at play here than just a mere change in the overall perception of the users regarding the Bank's information systems in general.

This is, in part, what motivated the development of this study, since there did not appear any obvious, trivial explanations to what could be the driving factors behind the variation of user satisfaction at the Bank.

Figure 12 Evolution of average user satisfaction
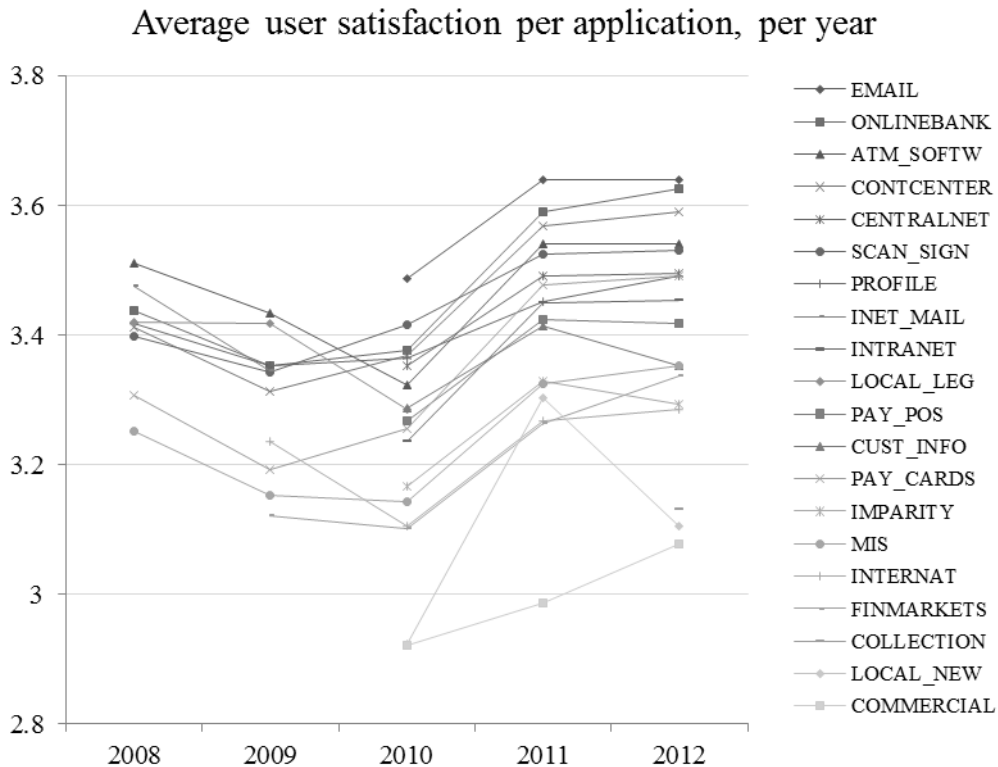
Another way to examine the dispersion of this variable at an even more detailed level is shown by the chart in Figure 13, which plots the mean and standard deviations for user satisfaction regarding each of the Bank's applications throughout the years. It is evident in that chart that satisfaction varies considerably from one application to another, as well as it does from one year to the following, but also that standard deviations imply that the user satisfaction as measured by the mean of the questionnaire responses to each question has varying degrees of consensuality.

Figure 13 Central tendency and dispersion of user satisfaction measurements
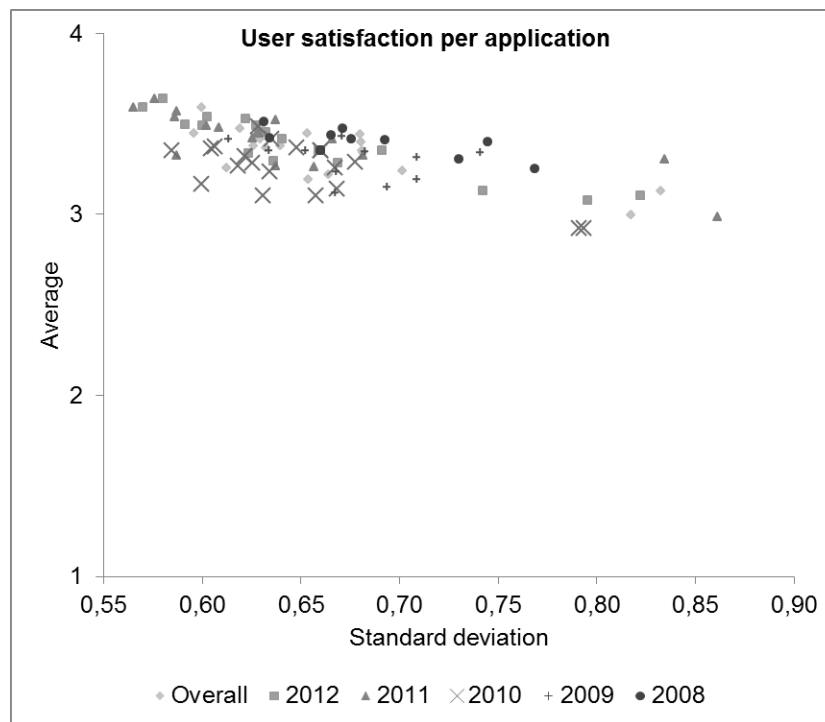
4.2 Behavior of the independent variables

The Bank spends considerable effort maintaining and further developing its information systems. This effort is coordinated according to business needs, leading to considerable variance of focus from one application to another throughout the years, as can be seen in Table 15, which shows that the amount of person-hours (as well as person-years, which is the same measure, only in a different scale) spent on each development initiative ranges from zero or close to zero all the way to very high values.

Another analyzed perspective was the involvement of end users in the development of the Bank's applications, which usually takes place through their participation in the execution of acceptance tests as well as through formal classroom-based training lessons. This was coded in the two variables shown in Table 16, which leads to the conclusion that those approaches are not the same for all underlying systems of the Bank's applications.

Table 15 Behavior of variables related to effort spent on the Bank's applications

Variable description	Variable code[4]	N	Min.	Max.	Mean	Std. dev.
Person-hours spent on large projects	n/a	61	414	33,800	6,594	7,411
Person-hours spent on medium-sized projects	n/a	151	0	14,043	926	2,154
Person-hours spent on small-sized projects	n/a	2,281	0	26,838	1,928	5,110
Total person-hours	*i_TotH*	2,493	16	53,605	5,732	9,884
Total person-years ($\frac{i\_TotH}{12\ months \times 21\ days \times 8\ hours}$)	*i_TotY*	2,493	.008	26.590	2.843	4.903

Table 16 Behavior of variables related to user involvement in IS development

Concept description	Variable code[5]	Min.	Max.	Mean	Std. dev.
% of underlying systems for which users were formally involved in acceptance tests	*i_Tests*	28.57	100.00	87.30	23.05
Users were formally involved in training sessions for all underlying systems (1=yes or 0=no)	*i_Train*	.00	1.00	.73	.45

Looking at some of the most visible characteristics of the applications to the users, on average, exactly half (.50) of the underlying systems allow for browser-based access, but there are extreme cases ranging from purely terminal-/client-based access to fully browser access, as show in Table 17.

---

[4] A more detailed explanation of these variables, using these codes as a reference, can be found in section 3.6, on page 17.

[5] Idem

Table 17 Behavior of variables related to user information satisfaction

Variable description	Variable code[6]	Min.	Max.	Mean	Std. dev.
Access is browser-based for all underlying systems (1=yes, 0=no)	i_BrowserA	.00	1.00	.53	.50
Access is browser-based for at least one underlying system (1=yes, 0=no)	i_BrowserB	.00	1.00	.60	.49
% of underlying systems with online information	i_Online	.00	100.00	32.00	41.00
Age in years of earliest underlying system	i_Age	0.00	18.00	4.46	3.77

There is also still a strong prevalence of batch-based systems, given that, on average, only about one third (.33) of the underlying systems of each application has online-updated information and close to one half (.47) have no such underlying systems at all.

The strong pace of change is clearly patent in the fact that the average application has underlying systems which are, on average, approximately four and half years old (4.46), although the dispersion of this variable portrays the broad range of mature and recent applications that are included in the Bank's information systems environment.

4.3 Preliminary correlation analysis

A correlation analysis was between the dependent variable and each of the independent variables, which is summarized in Table 18, provides a preliminary evaluation of the relationships between the variables and the selection of those that shall be included in the subsequent analysis.

---

[6] Ibidem

Table 18 Analysis of correlation with Satisfaction – results and decisions

Concept	Variable code	N	Pearson Correlation	Sig.	Notes
Development effort	*i_TotY*	54	-0.126~	0.364	
Acceptance testing	*i_Tests*	57	0.213~	0.112	
Formal training	*i_Train*	57	-0.241+	0.071	
Browser-based access	*i_BrowserA*	57	-0.230+	0.086	Discarded
	i_BrowserB	57	-0.340**	0.010	
Online information update	*i_Online*	57	0.411**	0.001	
Application maturity	*i_AgeA*	57	0.376**	0.004	

Correlation significance level: *** < 0.001, ** < 0.01, * < 0.05, + < 0.1, ~ = not significant

From this analysis, it emerges that several variables are significantly correlated with user satisfaction: the type of access to the application i.e., via browser instead of via specific client or terminal software (variable *i_BrowserB*, for example), whether the information in the information system is updated online or not (variable *i_Online*), how old the underlying systems are (variable *i_Age*) and, with a weaker significance, whether formal classroom-training took place (variable *i_Train*).

In the case of other candidate independent variables which proven not to be significantly correlated with the dependent variable (e.g. Acceptance Testing), they were still kept still kept for subsequent analysis, in order to account for the possible existence of suppressor effects among some of those, i.e., variables that when included in the regression have the effect of strengthening the influence of other variables in the dependent variable, even if they have no isolated influence themselves (Pandey and Elliott 2010).

The only discarded variable at this stage was one of the two alternate codings of the related to the type of user interface access provided to the users of the Applications (*i_BrowserA* and *i_BrowserB*), since it became apparent from this analysis that the later, laxer approach, seemed to yield a stronger relationship with satisfaction of the user, was

the former, more conservative approach, therefore, discarded for subsequent analysis work.

4.4 Relationship between User Satisfaction and its Antecedents

The following step deals with quantifying the eventual influence that each independent variable may have upon User Satisfaction, via the application of linear multiple regressions.

The first model, "*Model #1*", focuses on the variables in the conceptual model (cf. Figure 9) which are associated with Project and Organizational characteristics. Its results are summarized in Table 19.

Table 19 Results of Model 1 – Influence of Project and Organizational variables in Satisfaction

Model	Dep. variable	Independent variables	Standardized coefficients	Non-std. coefficients	T	Adj. R^2	F-test	Std. error
#1	User satisfaction (*d_SAT*)	Constant	–	3.190 (se .084)	37.843***	20.2%	$F_{(3:57)}=$ 5.729**	.148
		Testing Approach (*i_Tests*)	.207	.156 (se .092)	1.699+			
		Formal training (*i_Train*)	−.282	−.102 (se .044)	−2.336*			
		Application age (*i_Age*)	.353	.015 (se .005)	2.931**			

Correlation significance level: *** < 0.001, ** < 0.01, * < 0.05, + < 0.1, ~ = not significant

se = standard error

The model appears to have a good fit, since its F statistic is significant, which leads to the conclusion that the model is better at explaining the variance in User Satisfaction than pure guesses. In fact, the Adjusted R^2 shows that 20.2% of the variance in user satisfaction is accounted for by that of the dependent variables included in the model.

All the independent variables are significant, which leads us to conclude that their variance effectively predicts some of the variance in User Satisfaction. In particular, the coefficients show that there is a positive increment, of +.156, of Satisfaction for each unit increment in the Testing Approach variable, Formal Training and Application Age remaining constant. Similarly, there is a positive increment, of +.015, of User Satisfaction for each additional year of Application Age, all other variables remaining constant. Finally, the independent variable Formal Training has a negative influence on User Satisfaction, which decreases by −.102 for each unit decrease of that independent variable, *et ceteris paribus*.

Of the variables in the model, Application Age has the strongest influence in User Satisfaction, with a change of one standard deviation in this variable resulting in a change of +.353 standard deviations in User Satisfaction. The second strongest influencer of User Satisfaction in this model is Formal Training (−.282 standard deviations), followed by the weakest, Testing Approach (+.207 standard deviations).

A second model, "*Model #2*", was developed to focus on the variables in the conceptual model (cf. Figure 9) which are associated with Information Quality and System Quality. The results are summarized in Table 20.

This model appears to also have a good fit, with a significant F statistic, accounting for 18.2% of the variance in User Satisfaction. However, on variable, Development Effort, is not significant, which renders the model itself not significant. As explained in section 3.7, in these cases, an additional model was also estimated, removing the non-significant variable. The results are shown as "*Model #2b*" in Table 20.

This variant model also has a good fit, with a significant F statistic, accounting for 23.2% of the variance in User Satisfaction. In this new model, all the independent variables are significant, which leads us to conclude that their variance effectively predicts some of the variance in User Satisfaction. It can be seen in the coefficients that there is a positive increment, of +.150, of User Satisfaction for each unit increment in

the Online Information variable, Browser Access remaining the same. Conversely, the Browser Access variable has a negative influence on User Satisfaction, with each unit increment of the former leading to a change of $-.101$ in the later, *et ceteris paribus*.

Table 20 Results of Model 2 – Influence of Information and System Quality variables in Satisfaction

Model	Dep. variable	Independent variables	Standardized coefficients	Non-std. coefficients	t	Adj. R2	F-test	Std. error
#2	User satisfaction (*d_SAT*)	Constant	–	3.348 (se .043)	77.808***	18.2%	$F_{(3:47)}=$ 4.405**	.150
		Online information (*i_Online*)	.366	.150 (se .055)	2.178**			
		Browser access (*i_BrowserB*)	–.294	–.098 (se .045)	–2.189*			
		Development effort (*i_TotY*)	–.128	–.004 (se .004)	–.946~			
#2b	User satisfaction (*d_SAT*)	Constant	–	3.336 (se .035)	96.597***	23.2%	$F_{(2:57)}=$ 9.474***	.146
		Online information (*i_Online*)	.381	.150 (se .046)	3.242**			
		Browser access (*i_BrowserB*)	–.303	–.101 (se .039)	–2.574*			

Correlation significance level: *** < 0.001, ** < 0.01, * < 0.05, + < 0.1, ~ = not significant

se = standard error

Of the variables in the model, Online Information has the strongest influence in User Satisfaction, with a change of one standard deviation in this variable resulting in a change of $+.381$ standard deviations in User Satisfaction, whereas Formal Training accounts for $-.303$ standard deviations.

A third and final model ("*Model #3*") was developed to include variables in the conceptual model (cf. Figure 9) which belong to all groups (Project and Organizational characteristics, Information Quality and System Quality). Due to the previously mentioned limitation in the number of variables that can be included in linear regression

models like these (to ensure at least a 1:10 ratio of variables to cases), only the Application Age variable from the first group was used, since it was the one that model #1 shown to be the strongest influencer of user satisfaction. The results are summarized in Table 21.

Table 21 Results of Model 3 – Influence of P&O, IQ and SQ variables in Satisfaction

Model	Dep. variable	Independent variables	Standardized coefficients	Non-std. coefficients	t	Adj. R^2	F-test	Std. error
#3	User satisfaction (*d_SAT*)	Constant	–	3.170 (se .046)	68.522***	51.5%	$F_{(4:47)}=$ 13.200***	.115
		Application age (*i_Age*)	.719	.029 (se .005)	5.524***			
		Online information (*i_Online*)	.456	.187 (se .043)	4.344***			
		Browser access (*i_BrowserB*)	−.068	−.023 (se .037)	−.613~			
		Development effort (*i_TotY*)	−.459	−.013 (se .004)	−3.819***			
#3b	User satisfaction (*d_SAT*)	Constant	–	3.150 (se .033)	94.819***	52.2%	$F_{(3:47)}=$ 17.731***	.115
		Application age (*i_Age*)	.748	.030 (se .005)	6.227***			
		Online information (*i_Online*)	.459	.188 (se .043)	4.409***			
		Development effort (*i_TotY*)	−.466	−.014 (se .003)	−3.924***			

Correlation significance level: *** < 0.001, ** < 0.01, * < 0.05, + < 0.1, ~ = not significant
se = standard error

The model appears to have a good fit, since its F statistic is significant, with an Adjusted R^2 showing that 51.5% of the variance in User Satisfaction can be accounted for by that of the dependent variables included in it. However, here too, one variable in the model, Browser Access, is not significant, which renders the model itself not

significant. Once more, an additional, variant model was estimated, removing the non-significant variable. Its results are shown as "*Model #3b*" in Table 21.

This variant model also has a good fit, with a significant F statistic, accounting for 52.2% of the variance in User Satisfaction. In this new model, all the independent variables are significant, which leads us to conclude that their variance effectively predicts more than half of the variance in User Satisfaction. In particular, the coefficients show that there is a positive increment, of +.188, of User Satisfaction for each unit increment in the Online Information variable, Development Effort and Application Age remaining constant. Similarly, there is a positive increment, of +.030, of User Satisfaction for each additional year of Application Age, all other variables remaining constant. Finally, the independent variable Development Effort has a negative influence on User Satisfaction, which decreases by −.014 for each unit decrease of that independent variable, *et ceteris paribus*.

Of the variables in the model, Application Age has the strongest influence in User Satisfaction, with a change of one standard deviation in this variable resulting in a change of +.748 standard deviations in User Satisfaction. The second strongest influencer of User Satisfaction in this model is Development Effort (−.466 standard deviations), followed closely by Online Information (.459 standard deviations).

4.5 Summary of the results

In summary, as shown in Figure 14, model #1, which deals with project and organizational characteristics, suggests that, all other things remaining equal:

- The higher the age of the underlying systems (variable *i_Age*), the higher the satisfaction that users derive from the system;

- Similarly, the higher the involvement of end-users in acceptance testing (variable *i_Tests*), the higher the user satisfaction that is ultimately derived from the system once it goes into production; and

- Conversely, as requirements for formal, class-based training increase (variable *i_Train*), user satisfaction decreases and vice-versa.

As summarized in Figure 15, model #2b, which looks at information and system quality, adds that, all else being equal:

- The higher the online availability of information within the system (variable *i_Online*), the higher the user satisfaction; and

- On the other hand, the more access to the information system is achieved via a web browser instead of through specific client or terminal applications (variable *i_BrowserB)*, the lower the user satisfaction.

Finally, as illustrated in Figure 16, model #3b, reinforces the above notions for application age (model #1) and online information (model #2b) and adds that (*et ceteris paribus*):

- The information systems with a higher total effort employed in their development and maintenance (variable *i_TotY*) tend to have lower user satisfaction.

Figure 14 Multiple linear regression findings for Model 1

Adjusted R^2 = .202

Project and
Organizational
characteristics

Testing approach
i_Tests

Formal training
i_Train

Application age
i_Age

β = .207+

β = −.282*

β = .353**

User satisfaction

User satisfaction
d_SAT

β = standardized coefficient
*** p < 0.001; ** p < 0.01;
* p < 0.05; + p < 0.1
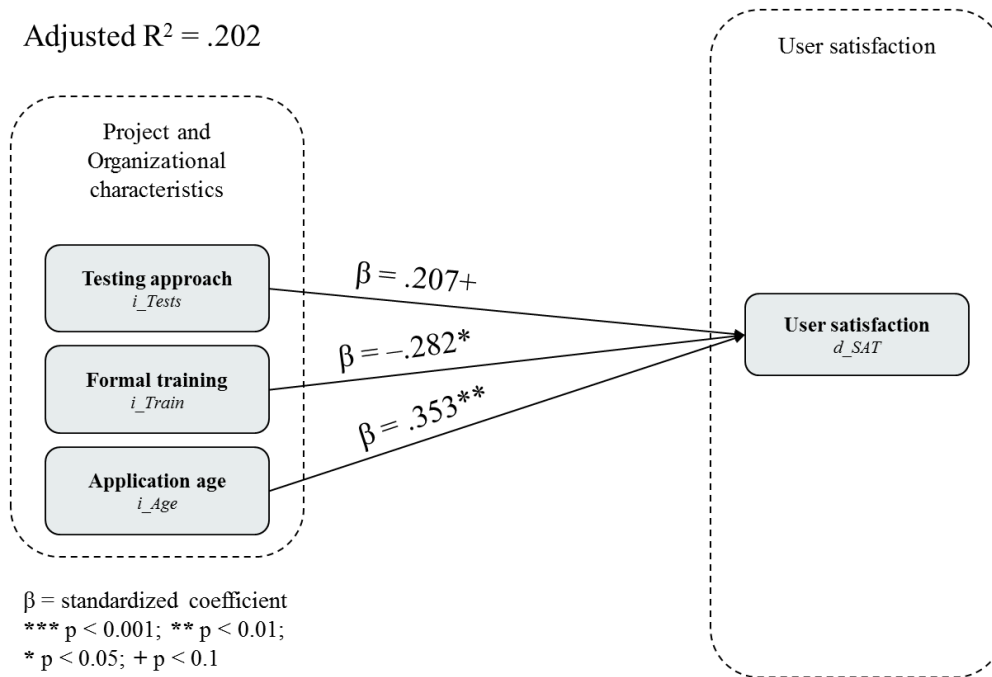
Figure 15 Multiple linear regression findings for Model 2b

Adjusted R^2 = .232

Information quality

Online info
i_Online

User satisfaction

β = .381**

User satisfaction
d_SAT

System quality

Browser access
i_BrowserB

β = −.303*

β = standardized coefficient
*** p < 0.001; ** p < 0.01;
* p < 0.05; + p < 0.1
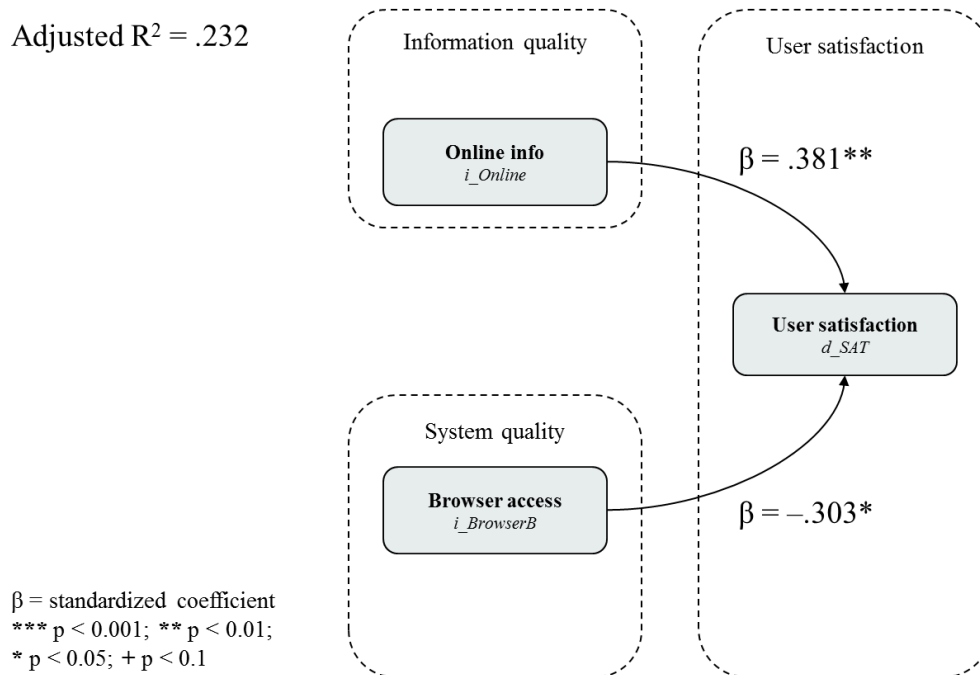
Figure 16 Multiple linear regression findings for Model 3b

Adjusted $R^2 = .522$

Project and Organizational characteristics

Information quality

User satisfaction

Online info
i_Online

$\beta = .459**$

Application age
i_Age

$\beta = .748***$

User satisfaction
d_SAT

System quality

Development effort
i_TotY

$\beta = -.466***$

β = standardized coefficient
*** $p < 0.001$; ** $p < 0.01$;
* $p < 0.05$; + $p < 0.1$
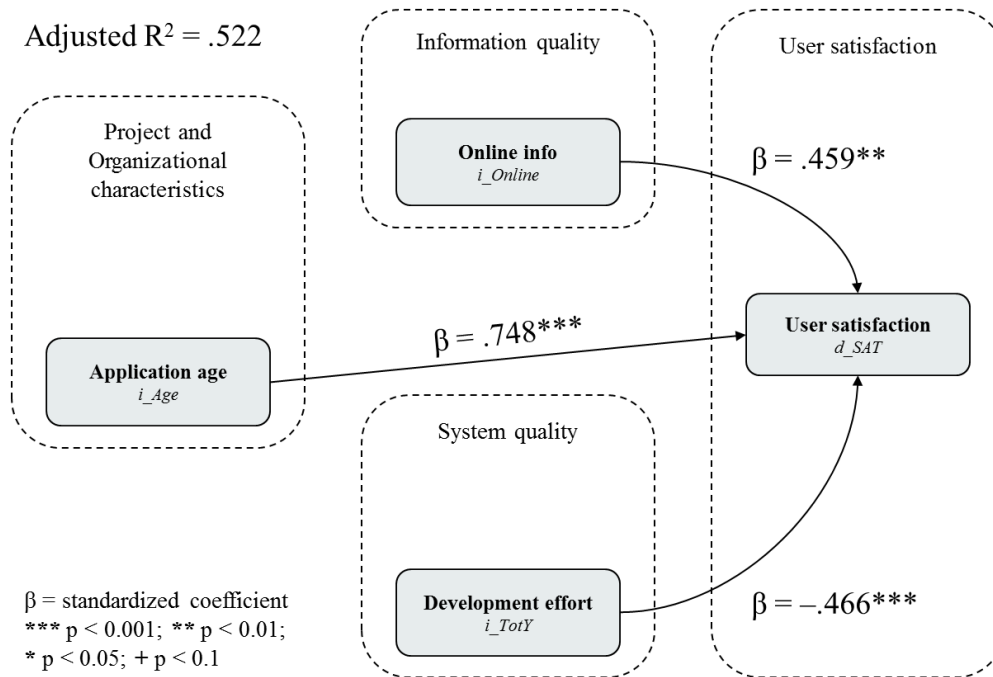
5 Discussion

This study aimed to deepen the understanding of the antecedents of user satisfaction with information systems, which is a proxy for IS success, particularly focusing on the characteristics of said information systems and their development processes that may have influence in user satisfaction. The previously presented results are discussed in this chapter in light of those objectives, grouped according to the organization of the theoretical and conceptual research models in Figure 5 and Figure 6 (on page 22).

5.1 Project and organizational characteristics as antecedents of user satisfaction

Within the scope of this case study, the most relevant project/organizational characteristic that appears to be a strong predictor of user satisfaction is age, i.e., the number of years since the earliest underlying system of a major application has been introduced at the Bank. By its very nature, if there is a causal relationship between the two, it is likely to be in the sense that *age influences satisfaction* (since the application age is a given and cannot, therefore, be influenced by user satisfaction), which is consistent with the findings of previous research related to the learning curve and the maturity effect in the life-cycle of most information systems, as is the case, among others, of the Enterprise Systems Success measurement model (Sedera and Gable 2004).

Another positive influencer of user satisfaction in this group, albeit with a relatively weaker correlation, is one of the aspects related to involvement of the users in the development of information systems, which is the testing approach, i.e., whether the end-users have formally participated in acceptance testing throughout the development of each application's underlying systems. This corroborates the notion that the more end-users are involved at all stages of an information system's development, the more likely is the success of that information system, at least as measured by the user's satisfaction towards it, which is also consistent with prior research (Guimaraes, Yoon and Clevenson 1996).

On the other hand, the other aspect of end-user involvement, which deals with training, in this case, the enrollment of the users in formal, class-based training prior to usage of the system commences, has proven to be negatively correlated with user satisfaction, which seems counter-intuitive, at first; nevertheless, while one would intuitively expect more training to lead to higher user satisfaction (Guimaraes, Yoon and Clevenson 1996), there is also considerable support for the opposite in the relevant literature, mostly due to it the being contingent on factors such as technical complexity and task inter-dependency (Sharma and Yetton 2007). The scope of this case study does not allow for further analysis of those factors, but there seems to be a broad indication of the presence of such effects.

5.2 Technology: information and system quality measures as antecedents of user satisfaction

The sole measure of Information Quality employed in this research, Online Information, i.e. the provision by an information system of access to its end-users to online, up-to-date information, instead of information which is only updated on a daily batch basis, has been shown by more than one of the regression models to significantly positively influence user satisfaction. This relationship is in line with several previously published research results which have shown that information quality is a key antecedent of user satisfaction and IS success (DeLone and McLean 2003; Gable et al. 2008; Gorla et al. 2010).

Conversely, both System Quality measures have proven to be negative predictors of user satisfaction in this case study, all other parameters being equal.

The first of those is the provision of a user interface via a web browser, which may lead to positing that the other user interfaces (those developed by the Bank for custom, dedicated client software) are preferred by users to the detriment of those designed to be accessed via a web browser. While interpreting these results, one has to bear in mind that the negative nature of this relationship is solely due to the arbitrary choice of

coding of this characteristic of the information systems in a dummy variable. Had the choice been to code, not the characteristic of "Browser-based access" (i.e., Browser = 1, Dedicated client = 0) but rather the characteristic of "Dedicated-client access" (i.e., Browser = 0, Dedicated client = 1), then the influence of the variable would have resulted in the opposite sign, i.e., it would have been positive.

Regarding the second measure, Development effort, i.e. the total number of person-years employed in the development and maintenance of the information system, it may seem counter-intuitive that the applications in which more person-years were spent in their development tend to have lower user satisfaction. Nevertheless, it may be that the causal relationship is in the inverse sense, i.e., that applications for which user satisfaction is low tend to have more development and maintenance work as an attempt to solve the Bank's issues that are leading to lower user satisfaction. Some anecdotal cases, such as the New Local System, concur to this idea, since there were considerable performance issues in the first releases which led to a significant overrun of an already large implementation project in order to attempt to solve them.

6   Conclusion

Considering the problem that this research proposed to investigate ("*Which characteristics of Information Systems and their development processes influence user satisfaction?*"), the basis for certain hypothesis was established, related to how certain information systems characteristics and certain approaches to their development lead to user satisfaction, which is a surrogate for Information Systems success, at least in the context of this case study.

In addition, some limitations of this type of study were clearly understood and strategies for overcoming them emerge as suggestions for future research.

6.1   Implications for research

The reported findings support the notion that user satisfaction in this case study is a proxy of Information Systems success, since it was shown to be significantly influenced by several variables which can be seen as its antecedents. This is consistent with previous research (Iivari 2005; Petter et al. 2008).

Among those antecedents, the maturity of the Information System (i.e., the time since it has been introduced) stands out as a relevant predictor of user satisfaction, as does the online nature of the information within it. These conclusions lead to the proposal of two hypotheses as suggestions for future research.

> H1: The maturity of an Information System positively influences its users'
> satisfaction.

> H2: Users exhibit more satisfaction towards online updated Information Systems
> than towards those with batch-based update of information.

Conversely, support was found for the idea that training is not in itself a stand-alone measure for increasing user-satisfaction. This suggests that understanding of the

moderators of training's influence on IS success in the same or a similar scope as that of this case study would provide an interesting research path.

Finally, evidence was found that, at least in this case study, browser-based user interfaces are generally associated with lower user satisfaction. This could be a manifestation of the effect of some of the shortcomings of this kind of user interfaces, such as response times, which have been shown to decrease user satisfaction (Hoxmeier and DiCesare 2000), and which could be confirmed by further research.

Since no characteristics of the IS organization or governance could be structured in a way that could be included in this analysis, no conclusions can be made regarding the Bank's IS management decisions in that realm and the way those may have influenced user satisfaction. Since some measures of overall satisfaction with the IS Department services are also present in the yearly survey, it may be interesting for the Bank, or a researcher or research team with its sponsorship to study those decisions in detail in order to look for similarly significant influencers of user satisfaction in the organizational dimension.

6.2 Implications for practice

The most natural application of this study's conclusions to the practice of Information Systems management is by the actual Bank which was studied, given that, even if the results cannot be generalized (a limitation of the case study approach), they are, by their nature, fully applicable to the subject.

It is apparent from the conclusions that there may be a case to be made for decreasing the rate of introduction of new systems at the Bank (thereby increasing the average maturity of the existing ones), increasing the existing trend to have online information systems (in detriment of batch-based ones) and dedicating more resources to the crafting of the applications in a way that less formal user training is required.

Further, the Bank could look to eliciting more detailed information on the nature of the effort employed in the development and maintenance of its information systems, since this may prove useful to understand the direction of an eventual causal inverse relationship between person-years spent on an application and user satisfaction.

These conclusions may also apply to other similar organizations, since many of them are supportive of previous research and general practice, but naturally a careful examination of the real context should be undertaken prior to any decisions being made.

6.3   Limitations

The exploratory nature of the research prevented the establishment of *a priori* hypothesis to be tested as well as the identification of evidence of actual causality relationships between the variables.

Further, the use of the Bank's user satisfaction surveys as a source for the user satisfaction data, even if a comprehensive and invaluable one, instead of an instrument that was purposely designed to support this research, has limited the ability to further explore other dimensions of the users' perceptions in addition to their effective satisfaction with the Bank's information systems.

In addition, the quantitative nature of the analysis techniques in the research design limited the ability to explore in-depth some subjects which require a more subjective approach or that cannot be structured to fit the dependent variable as operationalized here, i.e., the satisfaction of the users with each of the Bank's information systems.

Finally, because the case study approach was followed, these results cannot be reliably generalized for the wider population of Information Systems functions in other banks and organizations.

7 References

AL-MASKARI, A. AND M. SANDERSON A review of factors influencing user satisfaction in information retrieval. Journal of the American Society for Information Science and Technology, 2010, 61(5), 859-868.

BAILEY, J. E. AND S. W. PEARSON Development of a Tool for Measuring and Analyzing Computer User Satisfaction. Management Science, May 1983, 29(5), 530-545.

BAROUDI, J. J., M. H. OLSON AND B. IVES An Empirical Study of the Impact of User Involvement on System Usage and Information Satisfaction. Communications of the ACM, March 1986, 29(3), 232-238.

BHARADWAJ, A. S. A resource-based perspective on information technology capability and firm performance: an empirical investigation. MIS quarterly, 2000, 169-196.

BOTELHO, M. D. C., T. CALAPEZ AND M. RAMOS The effect of shape: comparing different presentations of response. Proc. 58th World Statistical Congress, 2011.

CARIFIO, J. AND R. J. PERLA Ten Common Misunderstandings, Misconceptions, Persistent Myths and Urban Legends about Likert Scales and Likert Response Formats and their Antidotes. Journal of Social Sciences, 2007, 3(3), 106-116.

CMMI PRODUCT TEAM. CMMI for Development, version 1.3 - Improving processes for developing better products and services. 2010. CMU/SEI-2010-TR-033.

CRESWELL, J. W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Edtion ed.: SAGE Publications, 2002. ISBN 9780761924425.

DELONE, W. H. AND E. R. MCLEAN Information Systems Success: The Quest for the Dependent Variable. Information Systems Research, 1992, 3(1), 60-95.

DELONE, W. H. AND E. R. MCLEAN The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. Journal of Management Information Systems, 2003, 19(4), 9-30.

DOLL, W. J. AND G. TORKZADEH The Measurement of End-user Computing Satisfaction. MIS quarterly, 1988, 12(2), 259-274.

DOLL, W. J. AND G. TORKZADEH A Discrepancy Model of End-User Computing Involvement. Management Science, October 1989, 35(10), 1151-1171.

DOLL, W. J. AND G. TORKZADEH The measurement of end-user computing satisfaction: theoretical and methodological issues. MIS Quarterly, 1991, 15(1), 5-10.

DOLL, W. J., W. XIA AND G. TORKZADEH A Confirmatory Factor Analysis of the End-User Computing Satisfaction Instrument. MIS Quarterly, 1994, 453-461.

FARRELL, D., L. MENDONÇA, M. NEVENS, J. MANYICA, et al. How IT Enables Productivity Growth - The US experience across three sectors in the 1990s. San Francisco: I. MCKINSEY & COMPANY, 2002.

GABLE, G. G., D. SEDERA AND T. CHAN Re-conceptualizing information system success: the IS-impact measurement model. Journal of the Association for Information Systems, 2008, 9(7), 377-408.

GALLETTA, D. F. AND A. L. LEDERER Some Cautions on the Measurement of User Information Satisfaction*. Decision Sciences, 1989, 20(3), 419-434.

GOPALAN, S., G. JAIN, G. KALANI AND J. TAN. Breakthrough IT banking. 2012. India: McKinsey & Company, McKinsey on Business Technology.

GORLA, N., T. M. SOMERS AND B. WONG Organizational impact of system quality, information quality, and service quality. The Journal of Strategic Information Systems, 2010, 19(3), 207-228.

GROVER, V., S. R. JEONG AND A. H. SEGARS Information systems effectiveness: The construct space and patterns of application. Information & Management, 1996, 31(4), 177-191.

GUIMARAES, T., Y. YOON AND A. CLEVENSON Factors important to expert systems success a field test. Information & Management, 1996, 30(3), 119-130.

GÖB, R., C. MCCOLLIN AND M. F. RAMALHOTO Ordinal methodology in the analysis of Likert scales. Quality & Quantity, 2007, 41(5), 601-626.

HAYES, B. E. *Measuring Customer Satisfaction: Survey Design, Use, and Statistical Analysis Methods*. Edtion ed.: ASQ Quality Press, 1998. 278 p. ISBN 087389362X.

HEIDMANN, M. Overhauling banks' IT systems. In *McKinsey Quarterly*. Frankfurt, Germany: McKinsey & Company, 2010.

HOXMEIER, J. A. AND C. DICESARE. System response time and user satisfaction: An experimental study of browser-based applications. In *Proceedings of the Association of Information Systems Americas Conference.* Citeseer, 2000, p. 10-13.

IIVARI, J. An empirical test of the DeLone-McLean model of information system success. SIGMIS Database, 2005, 36(2), 8-27.

IVES, B., M. H. OLSON AND J. J. BAROUDI The measurement of user information satisfaction. Commun. ACM, 1983, 26(10), 785-793.

JIANG, J. J., G. KLEIN, H.-G. HWANG, J. HUANG, et al. An exploration of the relationship between software development process maturity and project performance. Information & Management, 2004, 41, 279-288.

LAUREANO, R. M. S. *Teste de hipóteses com o SPSS: O meu manual de consulta rápida*. Edtion ed. Lisbon, Portugal: Edições Sílabo, 2011.

LEAVITT, H. J. AND J. G. MARCH *Applied Organizational Change in Industry: Structural, Technological and Humanistic Approaches*. Edtion ed.: Carnegie Institute of Technology, Graduate School of Industrial Administration, 1962.

LIN, B.-W. Information technology capability and value creation: Evidence from the US banking industry. Technology in Society, 1// 2007, 29(1), 93-106.

MELONE, N. P. A theoretical Assessment of the User-Satisfaction Construct in Information Systems Research. Management Science, 1990, 36(1), 76-91.

PANDEY, S. AND W. ELLIOTT Suppressor variables in social work research: Ways to identify in multiple regression models. Journal of the Society for Social Work and Research, 2010, 1(1), 28-40.

PESTANA, M. H. AND J. N. GAGEIRO *Análise de dados para ciências sociais: a complementaridade do SPSS*. Edtion ed. Lisbon, Portugal: Edições Sílabo, 2008. 694 p. ISBN 9789726184980.

PETTER, S., W. DELONE AND E. MCLEAN Measuring information systems success: models, dimensions, measures, and interrelationships. European Journal of Information Systems, 2008, 17(3), 236-263.

PETTER, S., W. DELONE AND E. R. MCLEAN Information Systems Success: The Quest for the Independent Variables. Journal of Management Information Systems, 2013, 29(4), 7-62.

SAARINEN, T. An expanded instrument for evaluating information system success. Information & Management, 1996, 31(2), 103-118.

SEDDON, P. B. A Respecification and Extension of the DeLone and McLean Model of IS Success. Information Systems Research, 1997, 8(3), 240-253.

SEDERA, D. AND G. G. GABLE. A factor and structural equation analysis of the enterprise systems success measurement model. In.: Association for Information Systems, 2004.

SEDERA, D. AND F. TAN. User Satisfaction: An Overarching Measure of Enterprise System Success. In *Pacific Asia Conference on Information Systems.* Bangkok, Thailand: Association for Information Systems, 2005, p. 963-976.

SHANG, S. AND P. B. SEDDON Assessing and managing the benefits of enterprise systems: the business manager's perspective. Information Systems Journal, 2002, 12(4), 271-299.

SHARMA, R. AND P. YETTON The contingent effects of training, technical complexity, and task interdependence on successful information systems implementation. Mis Quarterly, 2007, 219-238.

SHIRANI, A., M. AIKEN AND B. REITHEL A Model of User Information Satisfaction. SIGMIS DATA BASE for Advances in Information Systems, November 1994, 25(4), 17-23.

STEVENS, J. *Applied multivariate statistics for the social sciences*. Edtion ed. Mahwah, New Jersey: Lawrence Erlbaum, 1996. 659 p. ISBN 0805816712.

TAIT, P. AND I. VESSEY The Effect of User Involvement on System Success: A Contingency Approach. MIS Quarterly, 1988, 12(1), 91-108.

THONG, J. Y. L. AND C.-S. YAP Information Systems Effectiveness: A User Satisfaction Approach. Information Processing & Management, 1996, 32(5), 601-610.

URBACH, N., S. SMOLNIK AND G. RIEMPP The state of research on information systems success – A Review of Existing Multidimensional Approaches. Business & Information Systems Engineering, 2009, 1(4), 315-325.

VENKATESH, V. AND F. D. DAVIS A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. Management Science, February 2000, 46(2), 186-204.

VENKATESH, V., M. G. MORRIS, G. B. DAVIS AND F. D. DAVIS User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly, 2003, 27(3), 425-478.

WIXOM, B. H. AND P. A. TODD A Theoretical Integration of User Satisfaction and Technology Acceptance. Information Systems Research, March 2005, 16(1), 85-102.

WOHLWEND, H. AND S. ROSENBAUM 1993. Software Improvements in an International Company. In *Proceedings of the 15th International Conference on Software Engineering*, Baltimore, Maryland, United States1993 IEEE Computer Society Press, 212-220.

YIN, R. K. *Case Study Research: Design and Methods*. Edtion ed. Thousand Oaks: SAGE Publications, 2002. 181 p. ISBN 9780761925538.

A. Appendix – Primary data on Projects

Year	Project Code	ATM_SOFTW	CENTRALNET	COLLECTION	COMMERCIAL	CONTCENTER	CUST_INFO	EMAIL	FINMARKETS	IMPARITY	INTERNAT	INTRANET	INET_MAIL	LOCAL_LEG	LOCAL_NEW	MIS	ONLINEBANK	PAY_CARDS	PAY_POS	PROFILE	SCAN_SIGN
2007	PR07004	•	•																	•	
2007	PR07005				•											•					
2007	PR07007													•							
2007	PR07008																			•	
2007	PR07009																			•	
2007	PR07011										•									•	
2007	PR07012																			•	
2007	PR07013																			•	
2007	PR07016																	•		•	
2007	PR07017																			•	
2007	PR07022													•							
2007	PR07023																			•	
2007	PR07025																•				
2007	PR07026																			•	
2007	PR07027																			•	
2007	PR07028																			•	
2007	PR07029								•												
2007	PR07030																•				
2007	PR07031																•				
2007	PR07032	•																			
2007	PR07033																			•	
2007	PR07034																			•	
2007	PR07035																			•	
2007	PR07036																	•		•	
2007	PR07037																			•	
2007	PR07042																		•		
2007	PR07043																			•	
2008	PR08001																•				
2008	PR08002				•																
2008	PR08003														•						
2008	PR08004																			•	

Year	Project Code	ATM_SOFTW	CENTRALNET	COLLECTION	COMMERCIAL	CONTCENTER	CUST_INFO	EMAIL	FINMARKETS	IMPARITY	INTERNAT	INTRANET	INET_MAIL	LOCAL_LEG	LOCAL_NEW	MIS	ONLINEBANK	PAY_CARDS	PAY_POS	PROFILE	SCAN_SIGN
2008	PR08005																•				
2008	PR08006																			•	
2008	PR08007				•																
2008	PR08009																			•	
2008	PR08012														•						
2008	PR08014								•												
2008	PR08015											•								•	
2008	PR08017																	•		•	
2009	PR09001								•												
2009	PR09003																	•		•	
2009	PR09004								•												
2009	PR09005															•					
2009	PR09007																			•	
2009	PR09010																		•		
2009	PR09016																			•	
2009	PR09017			•																	
2009	PR09018											•									
2009	PR09020								•												
2009	PR09023								•												
2009	PR09026																	•		•	
2009	PR09027																	•		•	
2010	PR10002										•										
2010	PR10003															•					
2010	PR10004								•												
2010	PR10010								•												
2010	PR10011				•																
2010	PR10013														•						
2010	PR10014									•											
2010	PR10015														•						
2010	PR10016															•					
2010	PR10018																	•		•	
2011	PR11003																			•	
2011	PR11004										•										
2011	PR11005																			•	

Year	Project Code	ATM_SOFTW	CENTRALNET	COLLECTION	COMMERCIAL	CONTCENTER	CUST_INFO	EMAIL	FINMARKETS	IMPARITY	INTERNAT	INTRANET	INET_MAIL	LOCAL_LEG	LOCAL_NEW	MIS	ONLINEBANK	PAY_CARDS	PAY_POS	PROFILE	SCAN_SIGN
2011	**PR11006**															•					
2011	**PR11008**														•						
2011	**PR11009**													•							
2011	**PR11010**										•										
2011	**PR11012**																			•	
2011	**PR11019**								•												
2012	**PR12002**															•					
2012	**PR12003**															•					
2012	**PR12007**																•				
2012	**PR12008**															•					
2012	**PR12009**								•												
2012	**PR12010**																•				
2012	**PR12013**						•														
2012	**PR12014**																	•		•	
2012	**PR12015**														•		•				
2012	**PT12001**																			•	
2012	**PT12004**														•						

Spine

ISCTE IUL
University Institute of Lisbon

Attributes of information systems design leading to user satisfaction – A banking case study

Bruno Padinha

October
2014

ISCTE IUL
University Institute of Lisbon

Attributes of information systems design leading to user satisfaction – A banking case study, Bruno Padinha

October, 2014