Preliminary Results from an Empirical Study in Market-Driven Software Companies

Carina Alves, Silvia Pereira, George Valença, João Pimentel, Rodolfo V. C. L. de Andrade

Centro de Informática, Universidade Federal de Pernambuco
{cfa,scp,gavs,jhcp,rvcla}@cin.ufpe.br

Abstract

In this paper we present initial findings from an empirical study that has been conducted with 13 market-driven software companies based in Recife, Brazil. The objective of the study is to explore the state of the practice in requirements engineering (RE) for commercial off-the-shelf software products. The study followed a qualitative research method using questionnaire and semi-structured interviews. The empirical study investigates key challenges faced by market-driven companies previously identified in a literature survey. Our goal was to gather empirical evidence from studied companies to evaluate specific facts concerning RE for software products identified in the literature.

1. Introduction

Market-driven software companies represent a powerful and rapidly developing segment of software industry. Packaged software solutions are developed to global markets instead of to specific and known clients. We conducted a literature survey to gather information about market-driven software development [1]. An important finding is that several authors argue that market-driven phenomenon brings major impact on the requirements engineering process [14][16][17][18]. A common argument found in the literature is that the diversity of clients and business environments require novel techniques, tools, and practices to overcome several difficulties and to take advantage of opportunities such environments entail. This observation suggests that established requirements engineering practices for bespoke software may not be suitable to market-driven software development.

The literature survey was the first stage of our research project that aims to explore the characteristics of market-driven requirements engineering. The initial results were summarized as a list of 10 hypotheses where we described the sources for each hypothesis, its technical and managerial implications. The second stage of the research was the empirical study conducted with 13 market-driven software companies in Recife, Brazil. The literature survey served as the theoretical basis for the design of the empirical study. Our goal is to gather empirical evidence from studied companies to confront facts identified in the literature.

This paper presents preliminary results from the empirical study. The objective of the study is to investigate current requirements engineering practices and challenges faced by the companies to improve their RE processes. The empirical study was carried out using a qualitative research method. We divided the study in two phases. In the first part, we applied a questionnaire to obtain generic information about the companies. Then, in the second phase we conducted an in-depth, semi-structured interview with one or two representatives from each company.

The findings from the empirical study are grouped following the structure of the 10 hypotheses raised by the literature survey. We present evidence concerning each hypothesis. Here, we need to stress an important point. In this paper, we do not aim to formally test the hypotheses. There are two main reasons for that. First, we do not have a statistically representative group of companies to reach a definitive conclusion concerning the issues explored by the literature study. Second, we need to conduct more in-depth qualitative analysis of the data in order to elaborate more complete observations [24]. In spite of these limitations, we believe the empirical study reported in this paper brings an important contribution to understand current practices and challenges faced by the Brazilian software industry. In particular, this study focuses on SMEs (Small Medium Enterprises). Such companies face hard financial and time constraints that severely impact on the software development process. Surprisingly, little research has targeted the requirements engineering challenges faced by SMEs from a practical perspective. This research aims to address such issues.

This paper is structured as follows. In section 2, we present the research method. In section 3, we describe the findings of the empirical study. Section 4 concludes the paper and presents directions for future research. The paper also includes an appendix with characterization of the thirteen companies, describing their products, requirements engineering processes and customers.

2. Research Method

A key benefit of using a qualitative research approach is because it allows in-depth analysis of complex situations, enabling a refined understanding of "why" and "how" questions [2][3][4]. According to [4][13], the phenomenon being studied is the principal factor to determine the choice of research method. As discussed in the previous section, the objective of this study is to investigate the state of practice in requirements engineering for commercial off-the-shelf software products. Given the explorative nature of our study, we believe that the qualitative research approach suits our needs.
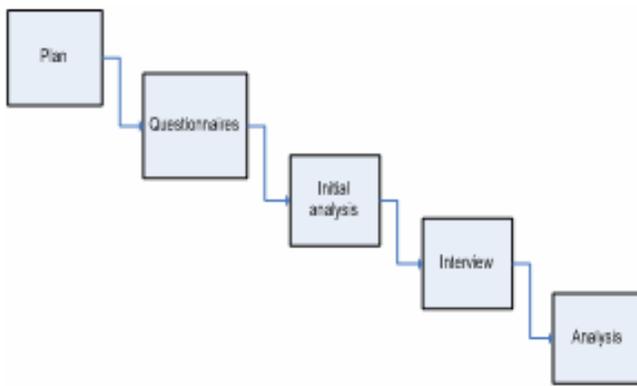
Figure 1. Main stages of the empirical study

The study was conducted from August 2006 to December 2006. Figure 1 gives an overview of the study. The study was divided in the following stages. The first step involved planning meetings to establish the specific objectives of the study [5] as well as to identify the group of companies to be studied. The selection of companies was done with the support of SOFTEX-PE [6]. This research institute maintains a list of partner software companies. We sent invitations by e-mail to the companies and presented a seminar describing the objectives of our research. A key selection criterion was that all participating companies develop COTS software products. The chosen definition of COTS is a product that is ready-made and available for sale to the general public.

After this initial step, thirteen software companies agreed to participate on the study.

A questionnaire was elaborated to obtain general information about the companies. This research instrument involved questions concerning the identification of the respondents and their company, general information about the enterprise, developed products, as well as information about the requirements engineering process. A summary of the questionnaire responses is available in Appendix A. The questionnaire was pre-validated with academic researchers during WER 06. We also asked two staff working in software companies (different from the ones participating in the study) to answer the questionnaire. The questionnaire was adjusted to ensure all questions were clear and easy to understand. The questionnaire had 36 questions and respondents needed in average 30 min to answer it.

Once the questionnaire was ready, we asked each company to nominate a representative to answer the questionnaire. The roles of the respondents are mainly project managers, business managers and quality analysts. The answers were then summarized and analyzed. The questionnaire allowed us to get a characterization of the companies as well as a better understanding of the software development processes (with special emphasis on the requirements process) adopted by the companies.

In the next step of the study, we developed a semi-structured interview instrument. The interviews based on data analysis of questionnaires to better explore relevant issues previously found. The objective of the interview was to gather more specific information concerning the following issues: products developed by the companies, requirements engineering process, interaction with customers, marketing strategies, challenges faced during software development process and possible directions for process improvement. The interviews also had the purpose of broadening and complementing information gathered with the questionnaires.

The semi-structured interview instrument had twenty three questions. Depending on interviewees' answers, further questions were asked to clarify specific points. The interviews with conducted with the same subjects who answered the questionnaires.

All thirteen interviews were conducted at the companies´ site. This strategy helped to make interviewees feeling more comfortable. The interviewees agreed to record their interview. The interviews lasted in average 60 minutes. Two researchers participated of each interview. One was responsible for making questions and the other one was in charge of taking extensive notes and make transcriptions of the interview. Seven researchers participated on the interviews and the role of transcriber varied in a way that each person participated on 3 interviews (maximum). Two researchers revised all

transcripts to verify correctness and uniformity of the process.

The analysis was made through reading and discussing the transcripts. Each researcher was responsible to read and to underline relevant sections of all interviews. This strategy seems appropriate to eliminate group bias and brings out many different viewpoints. Afterwards, five meetings were carried out to discuss the results of the study and draw preliminary conclusions. In the next section, we present initial findings from the empirical study.

3. Analysis of Results

In this section we present 10 hypotheses raised in previous paper [1] and include several observations from the empirical study related to each hypothesis.

Hypothesis 1
Time to market is a key strategic objective of packaged software companies.

Observations
Present literature [11][16][17][18] suggest that companies that release frequent software packages must be very careful about this issue. Our findings confirm that time to market is really important for the studied companies. According to answers of the questionnaire, companies consider that time to market is a very important issue. The analysis of interviews also confirmed time to market as being a key objective for most companies, as illustrates this transcript: "I must give to the market what customers want and at the right time". We also found that companies delivering software packages directly to the market without any previous agreement with customers consider time to market less important than companies that establish a customization contract with customers

For those companies that distribute their products through intermediate channels and also for those ones that customize software for specific clients, time to market was actually found to be a key objective. The following excerpts from exemplify this concern: "…the market is in a pace faster than we can develop a solution", "time to market is very, very short, we need to be agile". It emphasizes companies need for high productivity and agile processes. Time constraint also influence findings related to hypotheses 4, 5 and 9.

Hypothesis 2
The biggest challenges to growth are management and marketing related instead of technical problems.

Observations
According to [20], some of the main difficulties found on companies going through early growth stages are obtaining a reasonable amount of cash for initial investments, getting customers and delivering products to them. These problems were often observed on researched companies.

SMEs are commonly challenged by lack of resources [11][21]. In particular, some of participating companies affirm that they could make better products if they had funds to invest on product development and software process improvement (SPI). Companies also complain that because of this lack of resources marketing strategies are not as effective as they should be. Without effective efforts in marketing, it is difficult to reach larger consumer markets. Each company needs to create its own way to break market barriers and establish a good image amongst potential consumers.

A particular company that develops technologically complex products considers that the problem of producing delivering products to clients is reasonably solved. This situation may be explained by the fact that the company develops solutions to very specific market niches, which means that potential customers can be easily identified.

Most participating companies share the characteristic of being founded by highly technically skilled people, but in many cases, companies do not have staff with solid knowledge in business and management matters [11]. Together with the lack of resources, this provokes management and marketing to be a key limitation to business growth. The following transcript indicates the view of a particular company concerning this hypothesis: "...commercial marketing is becoming top priority for us, because it is the way for us to grow...".

Hypothesis 3
Requirements are generally invented by developing companies.

Observations
According to [1][10][11], real users and customers will only emerge after the product is released in the market. Thus, needs and requirements will be only perceived when the enterprise is aware of its actual users and customers. Based on that, companies attempt to overcome this matter by inventing requirements instead of eliciting them directly from customers. This invention process is generally supported by techniques conducted with a small sample of potential users, such as market research, product review, interviews with potential customers and users, etc.

The facts exposed above are found in relevant literature references concerning COTS development and strongly support this hypothesis. Nevertheless, in the transcripts and in the questionnaires, there were some

cases that differed from what is usually stated in the references and, consequently, opposed the hypothesis. Therefore, this hypothesis did not show to be applicable to all the cases we analyzed based on the transcripts and on the questionnaires.

Firstly, it is important to highlight that users and customers may play different roles as stakeholders. According to [12] customer represents the stakeholder who demands and pays for the software while user is the one who actually uses it. In some companies, there is a clear separation between user and customer, while in others, they represent the same group.

Among the participating companies, three of them belong to the game industry. We observed frequent quotations to 'the publisher', someone who requests the game, distributes it and either pays entirely for it or makes a commercial agreement with the supplier. Then, in this market segment, customers are usually the publishers, who do not act as final users. Publishers may determine the features and functionalities of the games or decide if they agree with suggestions made by the supplier. On the other hand, not always the customer nor the publishers have a well defined idea of how the game must look like, but they know who the users are and the purpose of the software. Then, based on the characteristics of the final users, such as age, gender and preferences, the developing companies invent requirements, which will be approved or not by the customer, who can also add new things.

In one company, requirements definition follows a mix of invention based on market opportunities and demands made by the clients. Another one does not develop applications, but modules that are integrated into a suite application developed by a partner/customer who request the product functionalities. Some companies reported that when they develop a solution for one client, they make an effort to turn it into a generic solution in a way that it is adequate for other customers as long as it undergoes some adaptations if necessary.

Hence, when the customer is defined during the requirements elicitation phase for a new version of the product, it is likely that she will actively take part in the requirements definition, unless she does not know exactly what she wants. When the customer is not known, then the supplier must invent requirements, as we had noticed in some of the interviewed company. This invention process is more common when customers and users represent the same group of stakeholders. For companies that face this lack of real customers in the initial phases of development, market research, communication through email with potential users and brainstorming sessions with the developing team were quoted as sources of information that helped the invention of requirements. In one particular interview, the interviewee affirmed that beta tests were used with potential users to validate previously invented requirements. During these beta tests,

users test a prototype with basic functionalities and suggest changes to be carried out in the software.

In some studied companies, the requirements definition phase may include either an invention process or an elicitation one with the customer. Other companies use invention and elicitation simultaneously as a way to define innovative functionalities

Hypothesis 4
Requirements are rarely documented.

Observations
According to [10], it is of limited value having the traditional requirements documentation in market-driven companies. Dahlstedt [16] argues that requirements documents are seldom read by customers and users in COTS development. This suggests that market-driven companies should explore more flexible and simpler ways to define and communicate requirements. Even though, several researchers have emphasized the importance of requirements documentation to deal with the steady stream of new requirements and record change requests, and to support traceability of requirements.

Most studied companies follow their own requirements documentation approach, which is mainly textual. Analysts include information they believe is important to their business processes and product development. Companies developing domain specific products may include particular details, such as behavior of characters and sound effects. A particular company separates the documentation into product requirements document and project requirements document; the first one is a description of the product features and the second one focuses on changes made in the current product version – this seems an interesting approach to help requirements traceability.

Other companies use requirements management tools to support their documentation process. However, the high costs to acquire and use commercial requirements management tools is still a limitation for companies to adopt such tools, as exemplifies the following excerpt: "…we started a project to evaluate commercial requirements management but we had to review this matter of costs… then we decided to abort the project. We believe that an open source tool would be easier and cheaper to integrate with our company's requirements process". The strategy followed by other companies is to develop templates of documents and use cases to support the requirements documentation phase.

According to [22], maintaining requirements documentation is usually perceived as an overhead – this observation was confirmed by participating companies. Another common reason for a lack of well defined requirements documentation is the fact that companies consider their product requirements very simple, as shows

this excerpt from an interview: "…the requirements are so elementary. It is not worth drawing detailed use cases or complex documentation, we simply write the requirements…".

Our findings suggest that requirements documentation for market-driven software doesn't seem to be as important as for bespoke software. This is mainly due to the fact that requirements documentation does not act as a formal contract between supplier and customer. In most cases, the product is ready when customers approach the suppliers.

Hypothesis 5
Requirements selection and release planning are crucial processes to obtain competitive advantage.

Observations
These activities are considered very important for the studied companies. When requirements are invented by analysts of the companies, it is generally necessary to eliminate too inventive requirements. Otherwise, time to market would be negatively affected. This situation may happen because of two main reasons. First, the large amplitude of the scope needs to be better delimited. Second, there is large number of complex requirements to be implemented and companies have to prioritize the most important ones. In both situations it is necessary to obtain an optimum tradeoff between market desires and acceptable software development productivity. Some of requirements that usually get top priority are related to legal issues, bug fixes and critical functionalities that are shared between one or more products.

In companies that offer COTS customizations for specific clients, there are several requirements requests that may not be possible to implement because of time constraints. In these cases, requirements prioritization and negotiation are particularly important, and companies leave some requirements to be implemented in future versions.

Some of the studied companies develop its products using agile methods, either adopting eXtreme Programming (XP) or using SCRUM framework. In these cases, requirements selection is made iteratively during development process. In the beginning of each iteration there is a meeting among the analysts to select the requirements that will be implemented next [19].

Hypothesis 6
Relationship between suppliers and customers is generally long but with limited proximity.

Observations
Based on [14][15], if the customer is not defined before the product is released, suppliers have to use techniques such as market research and product reviews instead of direct interaction with customers as a way to elicit requirements. In addition, keeping close contact with customers during new releases seems to be a tough goal to achieve. These arguments support this hypothesis, confirming the distance that exists between customers and suppliers. However, it did not show to be true in all the companies we analyzed during the first phase of the study.

When customer and user are different groups of stakeholders, the customer is defined and committed for distributing the product, there is, indeed, a limited proximity between supplier and users but this is not the case between supplier and customer. Generally, customers take part in the development of the software since the beginning, defining requirements and approving or not suggestions made by suppliers. In one interview, there was a complaint about the fact that distributors of the product sometimes conceal information about final users, making it unavailable to the supplier. Therefore, one solution appointed by another interviewee for this situation was trying to check the opinion of the users in specialized forums on the web. Although this source of information may not be very reliable, it may be a good source of information about diverse and geographically distant groups of stakeholders who are difficult to contact directly. A particular company has difficulties in establishing direct communication, as its users and customers are not only the same stakeholders but also undefined before the software is released. Thus, they can do nothing more than interact with a small sample of identified potential customers/users.

Customization and parameterization of packaged software is made by part of the companies. Such situation demands direct interaction between customer and supplier. This process occurs either to adapt a core product with specific functionalities to a new customer or to produce new versions of the product for those who already use it. The changes made in the software due to customization can be made available to other customers if they wish depending on the specificity of the request. A particular company states that changes that are too specific are rarely distributed to other clients, whereas those that are generic are distributed, as these new features can improve the overall quality of the product.

Six companies said in the questionnaires they had a CRM (Customer Relationship Management) program. The frequent ways of contact are email, forms in websites, telephone, interviews, frequent meetings, workshops, printed materials, events to release new products or new versions, etc. Some companies have employees that are constantly visiting the client with the purpose of solving problems, detecting novel needs and suggesting solutions that may be included as new features in future versions. One company has a group of employees with technical expertise (called farmers) interacting directly with customers to ensure their solutions are successfully

integrated by the customer organization. This frequent interaction is specially needed when customers have different application domain, as one interviewee reported.

In another company, there is a specific tool aimed at establishing communication with its customers. This resource allows clients to give their opinion and propose new ideas about the products. So, when customers suggest something regarded as amazing, they are awarded a prize that may be a trip, a weekend in some hotel or even an airline ticket. These cases differ from the stated hypothesis, as the companies have established a close relationship between supplier and customer.

Hypothesis 7

The failure of product launches is largely due to the product not meeting customer needs.

Observations

In this initial data analysis, we were not able to identify evidence directly related to this hypothesis. However, there are some interesting findings regarding the importance to design product features that satisfy real market needs.

There is evidence that the companies develop products based on real and identified market demands, as this transcript illustrates: "Functionality demands are evaluated accordingly to business opportunities that they can generate". According to the literature, this is an essential strategy for successful product launches [9][23]. Some companies use market research techniques to elicit and validate requirements. These techniques are considered the most common source of user requirements for COTS development [11][16].

A particular company states that *post mortem* analysis of one unsuccessful project revealed that a bigger effort dispended on market and user research could have changed the product requirements in order to produce better results. Some findings indicate the importance of conducting early acceptance tests with clients or potential clients. This reduces re-work effort during implementation and increases likelihood of product successful acceptance.

One of the studied companies produces a high-level requirements document, which should be read and validated by the clients who request product customization. However, the interviewer complains that clients are very reluctant in providing a formal acceptance of that document. This lack of formal agreement is believed to increase requirements creep. As described in hypothesis 6, some of the companies desire a deeper understanding of their clients, in order to satisfy their demands.

Hypothesis 8

Requirements are only validated after the product is released in the market.

Observations

According to our literature survey [1], the lack of real customers before the first release of the product turns requirements validation into a hard task to be accomplished. Thus, the acceptance of the software is generally measured after the product is already released, in terms of sales revenue, product reviews and market share.

However, our findings from studied companies show different situations. Some companies affirmed their customers approve the requirements of the product, having the possibility of suggesting new things. This is possible when customers are defined since early stages of development. Thus, in this case, requirements validation happens before the product is launched. The feedback provided by the customers is aimed at validating the product, in a way that it is also suitable for those companies that require COTS customization.

According to [11], the use of beta tests and prototypes helps the validation phase. Some companies we interviewed said they make use of these techniques. One company has only potential customers/users before the first release and usually makes beta tests with randomly selected groups of beta testers to verify if the requirements they invented satisfy user needs. Prior to these tests, the company pre-validates the products with an employee who is specialized in the domain application.

Hypothesis 9

Packaged software suppliers generally have an ad-hoc requirements engineering process.

Observations

Factors like time to market and lack of sufficient budget for product development constraints the requirements process. Companies are likely to follow a very simple requirements engineering process, underestimating (or even ignoring) the benefits brought from a well defined RE process. On the other hand, we found well defined requirements engineering processes in three companies. These companies obtained quality certifications and have quite mature software processes.

There is a general lack of awareness in the studied companies concerning the benefits of requirements engineering to software process improvement [25]. Some companies believe that an improved requirements process may increase the quality of their processes and products. However, these companies do not have much knowledge about the available requirements methods, techniques and tools and how to integrate them with their development processes.

An excerpt from the transcripts states the reasons why it is difficult to have a suitable requirements engineering process: "…we are interested in having a well defined

process… a process that fits with our reality… but I don't have much knowledge for doing this". We believe that knowledge transfer of best practices in requirements engineering can help such companies to develop better products.

Hypothesis 10
Market-driven development presents fundamental differences to the RE process such that traditional RE practices cannot be used as-is.

Observations
Several researchers consider that market-driven software development involves different challenges from custom-made solutions. Sawyer [11] argues the major differences in market-driven and customer-specific requirements engineering are the characteristics of stakeholding and time to market. We found evidence in our empirical study that confirms the relevance of these issues. For instance, we observed that companies tend to use agile approaches to deal with time constraints. Companies also reported they need/adopt a lightweight requirements engineering process because they do not have sufficient resources to use too complex processes.

Our study also confirms the differences concerning the nature of stakeholder interactions in market-driven development. Concerning this matter, some companies have very limited contact with users and customers hold information about final users. As a result, companies need indirect strategies to communicate with users.

Our study suggests that market-driven requirements engineering presents several new challenges that do not occur in customer-specific RE. However, the results obtained from the initial analysis of the empirical study are not sufficient to confirm whether traditional requirements approaches fit the market-driven paradigm. More studies are needed to further investigate this issue.

4. Conclusions and Future Work

This paper presents initial results from an empirical study conducted with thirteen software companies based in Recife, Brazil. This objective of this study is to explore how the requirements engineering process has been conducted by the studied companies. We obtained interesting findings that confirm issues identified in our literature survey.

The qualitative research suggests that hypotheses formulation based on literature survey can be the starting point to conduct the empirical study. However, the researcher also needs to analyse the empirical data without considering a priori knowledge as such data may disguise the discovery of new information besides the ones already known. Therefore, more in-depth analysis of the

interviews is still being carried out. We are using the software Nudist for qualitative data analysis and research, to help us with the analysis of interview transcripts.

The next phase of our research includes further studies with market-driven companies. In this phase, four companies among the thirteen participating companies will be selected of includes a requirements engineering process improvement program. The objective of the program is to investigate which methods, techniques and approaches can improve the state of practice in requirements engineering of the studied companies. The requirements engineering improvement program will be designed based on the results of the empirical study and best RE practices published in the literature.

5. Acknowledgements

6. References

1. Alves, C., Castro, J., A Study in Market-Driven Requirements Engineering. 9th Workshop of Requirements Engineering, 2006.
2. Oliveira, S. Tratado de Metodologia Científica: projetos de pesquisa, TGI, TCC, monografias, dissertações e teses. 1.ed. São Paulo: Pioneira, 1997.
3. Ragin, C., Nagel, J., White, P. Workshop on Scientific Foundations of Qualitative Research. National Science Foundation, 2004.
4. Flick, U. An Introduction to Qualitative Research. 2nd edition., Bookman Editora, 2004.
5. Kitchenham, B. Pfleeger, S. Principles of Survey Research – Part 2: Designing a Survey. ACM SIGSOFT Software Engineering Notes, Volume 27 Issue 1, Pages 18-20. 2002.
6. SOFTEX - www.softex.org.br
7. Kitchenham, B. Pfleeger, S. Principles of Survey Research – Part 3: Constructing a Survey Instrument. ACM SIGSOFT Software Engineering Notes, Volume 27, Issue 2, Pages 20-24, 2002.
8. Kitchenham, B. Pfleeger, S. Principles of Survey Research – Part 4: Questionnaire Evaluation. ACM SIGSOFT Software Engineering Notes, Volume 27, Issue 3, Pages 20-23, 2002.
9. Burkett, M., McGovem, J., Karofsky, E. The CIO's Guide to the Perfect Product Launch. AMR Research, June 2005.
10. Karlsson, L. Dahlstedt, A. Johan Natt och Dag Challenges in Market-Driven Requirements Engineering – an Industrial Interview Study. Eighth International Workshop on Requirements Engineering: Foundation for Software Quality. 2002.

11. Sawyer, P. Sommerville, I. and Kotonya, G. Improving Market-Driven RE Processes. International Conference on Product Focused Software Process Improvement, 1999.
12. Kujala, S. User Studies: A Practical Approach to User Involvement for Gathering User Needs and Requirements. PhD thesis of Philosophy. Helsinki University of Technology, 2002.
13. Richardson, R. J. Pesquisa Social: Métodos e Técnicas. ISBN 85-224-2111-0. São Paulo: Atlas, 1999.
14. Sawyer, S. A Market-Based Perspective on Information Systems Development. Communications of the ACM, volume 44, issue 11, pp97-102, 2001.
15. Keil. M. Camel, E. Customer-developer Links in software development. Communications of ACM. 38 (5) 1995.
16. Dahlstedt, A. Study of Current Practices in Market-Driven Requirements Engineering. Third Conference for the Promotion of Research in IT at New Universities and University Colleges in Sweden. 2003.
17. Karlsson, J. and Gurd, A. Increasing Product Success: Market-Driven Product Management. Telelogic White Paper. 2006.
18. Natt och Dag, J. Elicitation and Management of User Requirements in Market-Driven Software Development, Department of Communication Systems Lund Institute of Technology, Licentiate Thesis, 2002.
19. Datar, S. Jordan, C. Kekre, S. Rajiv, S. Srinivasan, K. New Product Development Structures and Time-to-Market, Management Science, 1997.
20. Churchill, N. Lewis, V. The Five Stages of Small Business Growth, Harvard Business Review, 1983.
21. Fayad, M. Laitinen, M. Ward, R. Thinking objectively: software engineering in the small, Communications of the ACM, 2000.
22. Dahlstedt, Å. Karlsson, L. Persson, A. Natt, J. Regnell, B. Market-Driven Requirements Engineering Process for Software Products – a Report on Current Practices. In International Workshop on COTS and Product Software: RECOTS, 2003.
23. Carlshamre, P. Regnell, B. Requirements Lifecycle Management and Release Planning in Market-Driven Requirements Engineering Processes. DEXA Workshop, 2000.
24. Carver, J. Voorhis, J. Basili, V. Understanding the Impact of Assumptions on Experimental Validity. International Symposium on Empirical Software Engineering, 2004.

25. Hofmann, H. Lehner, F. Requirements engineering as a success factor in software projects. IEEE Software July/August 2001.

Appendix A: Companies Characterization

TABLE 1	Company A	Company B
Role of the interviewee(s)	Director	Business and Technology Director
Company's Age (years)	3	14
Total number of employees	30	20
Number of employees involved in the software process	10	9
Application domain	Information security	Financial, legal and political management.
Products Description	Application suite for Digital Certification.	Information system for associations and trade unions
Number of software products developed by the company	4	35
Licensing	User license or contract for pre-defined period	Contract for pre-defined period
Key challenges faced during the development	Specialised workforce in development and requirements specification for an immature market	Updating documentation, prioritising requirements change requests and standardisation of routines
Overview of Requirements Engineering process	The company doesn't have a well-defined Requirements Engineering process. The following activities are carried out: market research, total adherence to open standards and technical norms, aspects about technological innovation. An in-house tool supports the system's documentation.	The company doesn't have a well-defined Requirements Engineering process and requirements are not properly documented.
Number of customers	6	75
Customers	Companies and corporations that use digital certification in their businesses	Trade unions and associations

TABLE 2	Company C	Company D
Role of the interviewee(s)	Quality Analyst	Quality Analyst
Company's Age (years)	11	19
Total number of employees	24	258
Number of employees involved in the software process	12	130
Application domain	Administrative, communication, commercial (wholesaler and retailer) and educative	Healthcare
Products Description	virtual community manager, content manager	Healthcare and hospital information system
Number of software products developed by the company	4	7
Licensing	User license or property transfer contract.	User license
Key challenges faced during the development	Gathering requirements desired by the customer, working out correctly the time needed for a project and meeting the deadlines	Deadlines, deadlines and deadlines
Overview of Requirements Engineering process	There is a standardised questionnaire for interviews to elicit customer requirements. After that, a requirements document is shown to the customer, so that it can be approved or not.	Requirements elicitation is conducted by a business analyst from the hospital. Afterwards, a business analyst creates the functional specification of the solution. This specification is approved by the customer so that a systems analyst can make the technical specification of the solution, finishing the Requirements Engineering process. The requirements are documented during the functional specification. However, the company found out that this documentation is not suitable and created a new documentation standard.
Number of customers	3	150
Customers	Government	Hospitals

TABLE 3	Company E	Company F
Role of the interviewee(s)	Technical Consultant	Project Director
Company's Age (years)	1,5	7
Total number of employees	15	100
Number of employees involved in the software development process	12	60
Application domain	Image Recognition Software, specially images of documents and signatures.	Administrative, communication, foods and drinks commercial (wholesalers and retailers), pharmaceutical, telecommunications.
Products description	pattern recognition software components	The products vary according to the following areas: information, web, intelligent and real time systems.
Number of software products developed by the company	4	-
Licensing	User license or contract for a pre-defined period	Property transfer contract. (customized development)
Key challenges faced during the development	Due to the kind of the operation, a big challenge is agreeing on a tight chronogram. Broadly speaking, project management for smart systems and specialised workforce.	Quality assurance and meeting the deadlines without exceeding costs.
Overview of Requirements Engineering process	The characteristics of the application show that the requirements are simple to be modelled. For instance, developing a system that recognises the written value in a cheque. In this system, the input is the image of the cheque and the output is a real number that represents the recognized value. The software Mantis is used to create simple requirements documentation. However, requirements are rarely fully documented.	Starts with scope definition, then requirements analysis is performed. Artifacts and documents are created and updated during the development process.
Number of customers	0	-
Customers	The customer are software integrators	-

TABLE 4	Company G	Company H
Role of the interviewee(s)	Quality Director	Technology Director
Company's Age (years)	13	6
Total number of employees	41	10
Number of employees involved in the software process	38	5
Application domain	Maintenance management software	Educational and entertainment
Products Description	maintenance management system and laboratorial information system.	The company develops products like a guitar chord dictionary, drums player and guitar course. Together, they help the customer to learn how to play a specific audio (in mp3 format) on the guitar.
Number of software products developed by the company	3	8
Licensing	User license.	User license.
Key challenges faced during the development	The company faces problems related to marketing. Their plan to solve the lack of a marketing strategy is moving people from the operational area of the company to the marketing area.	Product that makes use of extremely innovative technologies, which means that there is not much experience in the market.
Overview of Requirements Engineering process	The requirements management process includes four processes: planning requirements management, requirements identification, traceability management, requirements changing management.	The creation processo of a new product starts with a market researches with users, to identify tendencies. Those researches bring drafts of new products, after validated by clients.
Number of customers	5	-
Customers	Public organizations	The customers are users that listen to digital music, musicians, and music students.

TABLE 5	Company I	Company L
Role of the interviewee(s)	Systems Analyst	Business Manager
Company's Age (years)	34	3
Total number of employees	95	3
Number of employees involved in the software process	28	3
Application domain	Information management system	Administrative, food and drink, commercial (wholesaler and retailer), financial
Products Description	Enterprise Resource Planning product	One of the products developed by the company includes features like: FAQ, performance reports, and service team productivity. The other includes stock control.
Number of software products developed by the company	1	2
Licensing	User license.	User license.
Key challenges faced during the development	Obtaining all requirements of the version process, making the requirements documentation easy to understand for all the teams involved in the dev project (tests, documentation etc) and managing projects that involve many people from distinct fields, paying close attention to the quality of the product and to the punctuality of the projects.	Documentation of the results, technological outdate, requirements elicitation etc
Overview of Requirements Engineering process	The project requirements are specified, internally validated and after validated with the client. Once they have been validated, the requirements are designed to the development team and further changes are managed.	At first, scenario technique is carried out. After this, the system features are specified and, at the same time, validated by the customer. This way, the system is gradually developed.
Number of customers	187 contracts and 340 customers.	5
Customers	-	Customers from different areas

TABLE 6	Company J	Company K
Role of the interviewee(s)	Project Manager	Systems Engineer
Company's Age (years)	6	3
Total number of employees	27	65
Number of employees involved in the software process	20	40
Application domain	Educational and entertainment	Entertainment
Products Description	Games for desktop platform	Games for desktop platform
Number of software products developed by the company	-	-
Licensing	Contract for pre-defined period and property transfer contract	Business modelling specific to mobile market.
Key challenges faced during the development	Time constraints	Product Definition, management of complex configuration and strict time-to-market
Overview of Requirements Engineering process	The first step is creating the GDS (Game Design Specification). Afterwards, prototypes are developed, gradually validated and improved.	The requirements definition is made internally, making their management easy.
Number of customers	Each product developed so far had one client.	The value chain of the mobile game is large, with customers in several hierarchy levels.
Customers	The customers are companies in general and advertisement agencies – specially the second ones.	The customers are especially game publishers and mobile operators.

TABLE 7	Company M	Company N
Role of the interviewee(s)	Producer/ Partner Manager	Quality manager
Company's Age (years)	3	8
Total number of employees	Contracted for each project	600
Number of employees involved in the software process	9	50
Application domain	Entertainment, simulation	ECM – Enterprise Content Management
Products Description	The company develops games for desktop platform.	Features included in the products are: documentation's electronic management, documentation's physical management etc.
Number of software products developed by the company	8	3
Licensing	Depends on the contract.	User license, contract for a pre-defined period, property transfer contract.
Key challenges faced during the development	Follow the time schedule – the deadlines are very short. Restructure resources. Flawed planning and weak method.	Keep the concept of "product", do not create too many versions without control etc.
Overview of Requirements Engineering process	The features of the products developed are defined based on market research (at sites or special magazines). The requirements are documented, but not formally, in the game design phase.	The requirements are, at first, elicited. After this, its analyzed if it will be an specific customization or if the core product will be modified.
Number of customers	4	More than 100.
Customers	game publishers	banks and the Government of the state of Pernambuco.