Understanding the Software Development Effort Estimation in Chilean Small Enterprises

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***Abstract*.** During the last decade the software engineering community formally recognized that small software companies require to use particular software practices to support their developments, given that they have characteristics that make them different to medium-sized or large organizations. One of these practices is the software development effort estimation, which has been poorly studied in this type of companies. Trying to advance the knowledge in this particular domain, this article presents an empirical study that tries to identify the effort estimation techniques used in small software companies in Chile. Then, based on it we intend to understand both, the reasons behind this selection and the opportunities to improve that activity. The study findings indicate that all companies use expert-based estimation techniques, and such a decision is conditioned by the fact that most companies share human resources among their projects. This limits the capability of the companies to record trustworthy historical information and perform quality control of their estimations.

1. Introduction

There are several criteria to determine the size of companies, and different countries use different thresholds to classify them (Table 1). Given the large discrepancy existing in the classifications based on the companies' annual turnover, in Latin America most countries use the number of employees to determine the company size and compare their results with others countries in the region [Car12]. In this article we are particularly interested in studying the small software organizations (having between 10 and 50 employees [EC16, Chi14, Alv09, Ayy07]) due to several reasons: (1) they represent an important part of the software industry, (2) although most of them have overcome the startup stage, they are still fragile, and (3) in this evolution period, i.e., when they are small, they usually define the software practices that will allow them to grow and stabilize the business operation in the short-term.

Table 1. Classification of companies sizes.

	European Union [Ec16]		**Chile [Chi14]**	
Size	**Annual Turnover**	**# Employees**	**Annual Turnover**	**# Employees**
Micro	< EUR 2 million	< 10	< EUR 90 K	< 10
Small	EUR 2 - 10 million	10 - 50	EUR 90 - 900 K	10 - 49
Medium-sized	EUR 11 - 43 million	51 - 250	EUR 901 - 3,600 K	50 - 200

Small software companies (SSC, less than 50 people) represent about 70% of companies in Brazil [Wan06], 95% in the USA [Ara10], and over 80% in Canada [Lap08] and Chile [Var03, Ote05]. In Chile, these companies typically work on small projects (less than 6 months) involving small teams (3 to 6 people), count on scarce resources (human, technological and economical), most of their developers have a low level of expertise and training, their processes are typically informal and rather immature, they exhibit high informality in managing projects and coordinating the team members efforts, and they have an informal organizational structure [Gem15]. Although these characteristics seems to be a common denominator for small chilean companies, a recent study shows that they usually have different operation conditions depending on whether they are generalist or niche companies [Och17]. The former perform development projects in almost any business domain, which make them more fragile and difficult to get a stable operation condition. The latter work in specific business niches (or products) that make their operation more stable and less dependent of external factors, like the clients' involvement level or unrealistic deadlines.

Regardless the definition of small software company (SSC) taken into consideration, the effort estimation is a central activity for them, since project planning and management depend on it. Particularly, estimation errors in project budgets can put at risk their business operation or make them non-competitive [Jor14]. Both situations are hazardous for these companies, and even more considering their fragility. Therefore, this activity should be done properly by these companies in order to keep or improve their competitiveness, and avoid underestimations.

Several researchers indicate that there is 'no silver bullet' in estimations, and the current proposals represent only general guidelines that every company has to adjust considering their own reality; for instance, company size, culture, development strategy, and level of technical and business expertise [Mos00, Jor12, Boh17]. Most studies reported in the literature do not take into account these aspects, and particularly do not differentiate the results considering the company size. Therefore, it is not clear if the findings reported in these studies are representative of both, small software companies, and those working in particular regions, like in Latin America. In this sense, it is important to remark that most studies reported in the literature correspond to Western countries.

This article presents the result of an empirical study that tries to gain knowledge about the state-of-the-practice about software estimation in Chilean SSC. After an extensive search in the literature, we have found no work reporting these practices used in Chile or other similar countries of the region. Therefore, this study intends to address the following research questions:

RQ1: What practices are the most frequently used by Chilean SSC?
RQ2: Why do they use these practices?

In this study we used a case report approach to find the answer to the stated questions. The study involved ten SSC that provided qualitative and quantitative information through semi-structured interviews. The study findings indicate that all companies use expert-based techniques to conduct their estimation, and in most cases it is because they have no trustworthy historical information that allows them to use other techniques. Although it is not surprising that historical information play a key role in the estimation process, in this study we identified that the lack of this information is caused by the sharing of human resources among the projects of the company. This situation limits the capability of the SSC to determine and record properly the effort spent in their projects, and therefore their capability to estimate future projects without an expert, determine the quality of their estimations, and also improve the estimation process.

This article is structured as follows. Section 2 presents and discusses the related work. Section 3 introduces the study, presents and discusses the obtained results, and indicates the study limitations. Section 4 shows the answers to the RQs, and Section 5 presents the conclusions and future work.

2. Related Work

For various decades the academia and the industry have been proposing new ways to conduct the software estimations in order to make these activities more replicable, accurate and fast. An important part of this research has been focused on estimating large projects, since such a scenario has been the most challenging. However, during the last two decades there have been an increasing interest on estimation techniques to support agile and global software development, given the current popularity of these approaches [Bri14, Usm14].

The literature recognizes that the company size matters, since the particular characteristics of small software companies (SSC) make them different from medium-sized and large organizations [Fay00, Mos00, Ara07, Ric07]. Therefore, the SSC need to count on particular solutions designed to fit their own characteristics, being software estimation one of the practices that require such a support [Mos00, Mon06].

This study scenario (i.e., effort estimations in small software company) has been overlooked by the software engineering community; therefore, very few proposals were found for such an application domain. The closest work is the Bayesian statistical approach proposed by Moses and Clifford [Mos00], that considers the use of a Bayesian network and several influencing factors, like the problem and the solution domains, the knowledge of the stakeholders in these domains, and the project size and complexity. The values assumed by these factors are used to tune the estimations, adjusting them to particular projects and companies characteristics.

Provided that many small software companies use agile development approaches, we can infer that agile estimation methods can be suitable for them, and therefore they are also part of the related work. Typically, these methods involve expert opinion, analogy, disaggregation, and mixes of them [Coh06, Usm14, Usm15]. Examples of the methods are planning poker, T-shirt sizes, dot voting, the bucket system, affinity mapping, and ordering method [Coh06]. A field study conducted by Usman et al. [Usm15] about the use of agile software estimation techniques in the software industry, indicated that all methods used by the study sample involved the participation of an expert, and that poker planning was the most frequently used technique. In the study participated 60 companies from 5 continents and 16 countries. However, the study did not differentiate the results by company size or region. Therefore, it is not clear how representative can be these numbers for our study scenario.

From a broader perspective and after conducting several studies on European industrial settings, Jørgensen states that expert-based estimations are still the dominating approach, regardless of the extensive research done on formal estimation models [Jor14]. Several other studies also support this claim [Mos00, Tre08, Usm14]. However, no reports were found indicating the state-of-the-practice about the effort estimation approaches used in small software organizations.

Supporting the previous analysis, a recent survey conducted by Vera [Ver17] on taxonomies of software development effort estimation (SDEE) techniques indicates that context attributes (including the company size, culture, and in most cases the development approach) are not used in the literature as classification

criteria. This confirms the low relevance given by the software engineering research community to the companies size when they intend to determine the state-of-the-practice in SDEE techniques.

Provided this lack of information in the study domain, and also recognizing the diversity of software organizations, we conducted a field study that tries to understand the state-of-the-practice in Chilean small software companies. Next section introduces such a study.

3. Study Description

The study involved ten small software companies that participated in an individual and semi-structured interview. Next we briefly explain the participation minimum criteria, the company selection process, the information gathering process conducted during the interviews, and the obtained results. In the last subsections, we analyze these results and discuss the study limitations.

3.1. Participation Minimum Criteria

First of all, we defined a list of inclusion and exclusion criteria to determine which companies should be invited to participate. The inclusion criteria considered that the organizations should be formally a Chilean company with the headquarter in Santiago city, have between 10 and 49 employees (i.e., small size), be at least three years old, develop software for third parties, have at least 75% of personnel participating in software development (any kind of participation), and perform effort estimations in their software projects.

On the other hand, the exclusion criteria considered IT companies with a size different to small, where software development was not in their main core business, where the people in charge of the estimations were not accessible. Moreover, the companies were also excluded when the person available to participate is in charge of the estimations but had less than 3 years in the company or less than one and a half years of experience estimating software in the organization.

3.2. Company Selection Process

Using the list of companies reported by Fernández [Fer17] and the previously defined participation minimum criteria, we performed a first preselection of software companies; i.e., we identified a preliminary set of candidates. Forty-four companies (out of 128) were invited by email to participate in the study. Fifteen companies accepted to participate. Then, they were briefly interviewed by email or phone to determine if they fit all participation minimum criteria. After analyzing their answers, ten of them were finally selected to participate in the study.

3.3. Information Gathering Process

The information gathering was performed through semi-structured interviews [Sin08], where the interviewer followed a predefined sequence of questions to obtain a certain knowledge. This allowed not only to answer the predefined questions, but also obtain contextual information that enriched the analysis and understanding of the information provided by the interviewed person. All interviews were individual (one per company) and recorded in audio under informed consent of the participants. The audio records were then listened more than once in order to characterize the way in which the company estimates. Such information and also several other comments given by the interviewees were stored in a spreadsheet, that was then used during the analysis of the results.

3.3.1. Interview Design

Following the guideline proposed by Singer et al. [Sin08], an estimator of each selected company was contacted to verify that the participant accomplish with the inclusion criteria indicated in Section 3.1. Then, the interview date was agreed with the participant. In the interview, the interviewee received and signed the informed consent, which was previously explained by the interviewer. Moreover, it was asked for the participant agreement to record the audio of the interview with the purpose to review such information more than once. The duration of the interviews was estimated in 30 to 45 minutes.

3.3.2. Designing Questions

The design of the questions included in the interview guide followed the process recommended by Kitchenham et al. [Kit08]. First we identified the knowledge to be obtained from the interviewee, and then we defined the set of questions that would allow us to gather such a knowledge, including the sequence in which the questions should be formulated. The questions were arranged in the following three groups according to the type of information to be retrieved:

- *About the organization and the interviewee*. These questions intend to characterize the organization and interviewee, gathering context information that is then used to enrich the analysis of the collected information. Examples of the questions belonging to the organization are the following: What is the company age? How many employees it has? How many people are involved in software development activities? and What business domains the company addresses? Concerning the interviewee we asked for instance: What is your role in the organization? and What is your seniority in the company?

- *About the projects*. Similar to the previous category, these questions are used to characterize the projects run by the company, and also the way in which they are addressed. Examples of questions about the projects are the following: What type of projects the company run? What are the most frequent ones? and What is the typical project duration? Concerning the development approach we asked for instance: What development strategy is typically used to address the projects? What is the typical team size? What are the main roles played by the team members? Are these team members shared with other projects?

- *About the effort estimation process*. The aim of these questions is to identify the way in which the estimations are conducted in the company. Particularly, we intend to understand the reasons behind the practices they use. Examples of these questions are the following: Who estimates the projects development effort in the company? What strategy is used to estimate? Why does the company use such a strategy? Do you support the estimation with historical information? and Are the estimations under control or there is space for improving them?

After writing the questions, and following the recommendation of Kitchenham et al. [Kit08], the items of the interview guide were reviewed by two other researchers to check that they were correctly formulated, the writing do not introduce a bias, and the questions are enough to gather the knowledge that the author want to retrieve from the interviewees. Unnecessary questions were removed, and the non-suitable ones were reformulated. No additional questions were identified as required to answer the RQs.

3.3.3. Interview Documentation

The 20 questions defined to guide the interviews were included in a form that was used by the interviewer as a guide during the interviews. The form also included space to identify and characterize the companies and the participants, and a place to write the answers to the questions if the participants do not allow us to record the audio of the interview. The information in the form was then transcribed and added anonymized to the spreadsheet used in the analysis of the results. The spreadsheet included not only the coded answers to the questions, but also qualitative information that allowed us to enrich the analysis of results. The qualitative information were mainly comments from the interviewees or the answer to some additional question made by the interviewer to clarify some point.

3.3.4. Process of Analysing Interview Data

Every audio record was listen at least once to be sure that important information was recorded in the spreadsheet, and also to identify contradictory or potentially false information. Clarifications were asked to the interviewees when required.

Once the spreadsheet was completed, the obtained results were analyzed by track; i.e. considering the information about the organization, the development projects and the estimation process. The potential findings were written, justified using other qualitative or quantitative information gathered in the interviews, and finally validated with two external researchers in a face-to-face meeting. This data processing strategy adheres to the guidelines given in Seaman [Sea99].

Then, the information inter-track was analyzed manually, using several criteria to arrange the information of the spreadsheet as a way to identify similarities and correlations. The process followed to identify and validate the findings of this study was the same than the one used for the tracks. Finally, the RQs were answered using the findings and the additional information recorded in the spreadsheet.

3.4. Obtained Results

In this section, we present the interviews results considering the already mentioned tracks; i.e., organization, development projects and estimation process. A cross-case analysis was defined for each track, considering the grouping variables as recommended by Eisenhardt [Eis89]. Next we present the results by track.

3.4.1. About the organization and the interviewee

The information used to try classify the software companies was the company age expressed in years, the rate of developers versus estimators expressed in three categories (low, medium and high), and the role that the interviewee plays in the organization which corresponds to: founder, chief executive officer (CEO), chief operating officer (COO), chief architect officer (CAO) and team leader. Concerning the rate of developers versus estimators, it is considered high when such a rate is between 60% and 100% of the company's personnel, medium when it is between 30% and 60%, and low in other case. Table 2 summarizes the obtained results in this track.

Table 2. Characterization of the organizations and interviewees.

	About the organization and interviewee								
Principal Variables	Company's seniority	**Role of the interviewee**					Estimators vs developers		
Value / Copany	Value	Founder	CEO	Leader	COO	CAO	High	Medium	Low
company 1	3	x							x
company 2	25		x						x
company 3	7				x				x
company 4	5	x						x	
company 5	4	x					x		
company 6	8			x			x		
company 7	6	x					x		
company 8	10					x	x		
company 9	3	x						x	
company 10	7				x			x	
Summary	**AVG=7.8**	**5**	**1**	**1**	**2**	**1**	**4**	**3**	**3**

The mean of the companies age was 7.8 years, with a mode of 3 years and a median of 6.5 years. These numbers show that the companies have overcome the startup phase. Half of the interviewees were founders, 2 participants were team leaders, and there was a chief executive officer, a chief operating officer and a chief architect officer. The last grouping variable in Table 2 shows the rate between the developers and estimators. The results on this aspect does not provide interesting information when they are analyzed in isolation; therefore this information should be correlated with information of the other tracks to try understand the reasons behind this distribution.

3.4.2. About the projects

The variables in this track characterize the projects performed by the companies and the way in which they conduct these developments. The variables used to represent these characterizations include the *development life cycle* that usually consider structured (waterfall), agile, and ad hoc (typically it is an informal and quite random process), the *team size* specified in number of members, and the *shared human resources* that indicates whether the team members participate full-time in a single project (low sharing), in two projects simultaneously (medium sharing), or in three or more projects (high sharing).

The project characterization also considers the *level of business knowledge* that typically have the development team (high, medium, low), the *project duration* expressed in weeks and the *budget acceptance rate* that indicates the relationship between the number of budgets delivered to clients and those accepted by them (i.e., projects estimated versus run), in a scale that ranges from very high (80% of acceptance, high (60-80%), medium (30-60%), and low (below 30%). We also considered the *project type,* that indicates if the company works mainly on a particular type of product/service, if it develops diverse types of solutions depending on the clients needs, or if they work on both categories. Table 3 shows this characterization, and includes the previous one to help enrich the analysis of such information.

Table 3. Variables about the projects.

	About the organization and interviewee									About the development projects																				
Principal Variables	Company's seniority	Role of the interviewee					Estimators vs developers			Development life cycle			Project type			Shared human resources			Business knowledge				Project duration	Team size	Budget acceptance rate			
Value / Copany	Value	Founder	CEO	Leader	COO	CAO	High	Medium	Low	Waterfall	Agile	Other	Product Oriented	Genereal Develop.	Mix	High	Medium	Low	Low	Medium	High	Very High	Value	Value	Low	Medium	High	Very high
company 1	3	x							x	x			x				x		x				12	6		x		
company 2	25		x						x	x			x				x			x			12	3		x		
company 3	7				x				x	x				x			x			x			12	3		x		
company 4	5	x						x		x			x			x					x		12	3		x		
company 5	4	x					x				x		x					x				x	16	3			x	
company 6	8			x			x				x				x			x				x	12	3	x			
company 7	6	x					x				x		x					x				x	2	3				x
company 8	10					x	x				x				x			x				x	24	6		x		
company 9	3	x						x				x	x			x					x		2	2				x
company 10	7				x			x				x		x		x				x			16	3				x
Summary	**AVG=7.8**	**5**	**1**	**1**	**2**	**1**	**4**	**3**	**3**	**4**	**4**	**2**	**6**	**2**	**2**	**3**	**3**	**4**	**1**	**3**	**2**	**4**	**AVG=12**	**AVG=3.5**	**1**	**5**	**1**	**3**

The results indicate that most companies work on project of 3 to 4 months of duration, where 40% of the companies use a structured development method, 40% use agile and the rest use an ad hoc process. This distribution helps understand the already discussed rate of estimators versus developers. According to the interview records, in structured developments there is only one person that estimate in the organization, whereas in agile developments many people estimates through collaborative strategies. This explains why in the first case the rate is typically low and in the second is high. The companies that use an ad hoc process typically involve two people in the estimations. Although the companies in this category have a high budget acceptance rate, the interviewees declared that it is because their projects are usually not expensive more than because they are using an ad hoc development approach. They use an ad hoc process and low budgets to try to access a larger number of clients.

The results show that 60% of the companies are focused on the product-based developments, that usually represents lower risk and more benefits for these organization; the other 40% are generalists or combine both types of developments. In this sense, there seems to be no relationship between this variable and the life cycle used by the organization or their budget acceptance rate. Similarly, the time spent for the companies to conduct the estimation does not help them to get projects; the final price does. However, spending time in the estimations usually help companies to reduce risks in the projects.

In the companies using agile development, the people present two features: they have an important knowledge about the business domain being addressed, and they work in a single project at a time. The first feature is promoted because the development methodology they use makes the knowledge flows among team members, thus allowing all participants to have an understanding of the processes, context and goals of the project. The second feature makes the use of such a knowledge to be more effective since the developers do not have to address frequent context changes.

In the case of companies using structured development, mainly the project leaders knows about the business domain which becomes these persons a bottleneck, a point of fail and the only ones able to generate estimates. The level of sharing of human resources is medium or high (people work in 2-3 projects simultaneously) which usually indicates low productivity and effectiveness of the teams.

3.4.3. About the effort estimations

Concerning the effort estimations conducted by the companies, and similar to the previous tracks, we used several variables to characterize the way in which the companies conduct their estimations. First of all we considered if *historical data* is formally or informally used in the estimations and also if the estimations are done considering the available *people* or the required *roles*. In this latter case, the company assumes that the resources are already available or obtainable in some way. Moreover, the *effort spent* by the people during the estimations ranges from high to low (more than 12 hours, between 4 and 12 hours, and less than 4 hours respectively). In some cases, the company uses a multiplier to *overestimate* the projects and thus reduces development risks. The estimations given to the client have an *expiration* date (typically one month), but according to the participants such a date is informal and the budget is kept by the provider for more than that. Finally we asked the companies if they get *estimation feedback* (i.e., if they evaluate the quality of their estimation after a project), and what is the *Mean Magnitude of Relative Error* (MMRE) in their projects (expressed as known or unknown). Table 4 shows a summary of this information in the last category (with red borders).

Table 4. Variables considered about the estimations.

	About the organization and interviewee									About the development projects																						About the estimations																			
Principal Variables	Company's seniority	Role of the interviewee					Estimators vs developers			Development life cycle			Project type			Shared human resources			Business knowledge				Project duration	Team size	Budget acceptance rate				Historical data			Estimates using role or people		Effort spent for estimations			Commercial overestimation		Estimations expire		Get estimation feedback		MMRE	
Value / Copany	Value	Founder	CEO	Leader	COO	CAO	High	Medium	Low	Waterfall	Agile	Other	Product Oriented	Genereal Develop.	Mix	High	Medium	Low	Low	Medium	High	Very High	Value	Value	Low	Medium	High	Very high	Formal	Informal	None	Role	Person	High	Medium	Low	Yes	No	No Expire	Expire	Yes	No	Know	Unknown
company 1	3	x							x	x			x				x		x				12	6		x				x				x		x		x			x		x
company 2	25		x						x	x			x				x			x			12	3		x				x	x			x		x		x			x		x
company 3	7				x				x	x				x			x			x			12	3		x				x				x		x		x			x		x
company 4	5	x					x			x			x			x					x		12	3		x				x					x		x			x		20%	x
company 5	4	x					x				x		x					x				x	16	3			x			x			x			x			x		25%	
company 6	8			x			x				x				x			x				x	12	3	x				x				x			x			x		25%	
company 7	6	x					x				x		x					x				x	2	3				x		x			x			x			x		20%	
company 8	10					x	x				x				x			x				x	24	6		x				x			x			x			x		20%	
company 9	3	x						x				x	x			x					x		2	2				x		x			x			x			x		60%	x
company 10	7				x			x				x		x		x			x				16	3				x		x			x			x			x		20%	x
Summary	AVG=7.8	5	1	1	2	1	4	3	3	4	4	2	6	2	2	3	3	4	1	3	2	4	AVG=12	AVG=3.5	1	5	1	3	2	8	0	7	3	4	3	3	4	6	9	1	4	6	7	6

As mentioned before, most participants use expert-judgement mainly supported with informal information to estimate, and two companies use formally recorded information. In this last case, the participants prefer that an expert interprets such information, because that gives them more confidence.

The characterization also indicates that most companies estimate based on roles, almost half of them overestimate the projects effort, and their budgets do not expire in the short time. Typically, companies using agile methods spend more time in performing the estimations than those using structured or ad hoc processes simply because the former involve a more important number of people in the activity. This characterization shows something that we can foresee from this type of company. However, the last two variables of the characterization show unexpected information.

Most of the companies do not get estimation feedback, and consequently they do not know the level of error of their estimations (MMRE). Particularly, companies 4, 9 and 10 in such a category, record the deviation between the expected and real product deployment date, but they do not know the effort required to develop the product. The companies having the estimations under control seem to be those using agile developments.

3.5. Analysis of Results

In order to understand the rationale behind these results, we conducted a more in depth analysis of this information. Table 5 shows three highly cohesive clusters of companies, formed considering the type of development strategy the companies use. In yellow are the companies that use a structured software process (usually waterfall), in red those using agile methods, and in green are the companies performed deadline-oriented developments. In this last category, the process used by the organizations is whatever they need to reach the deadlines. The company 4 is an outlier that shares features with the first and the last type of company.

Table 5. Characterization of companies by cluster.

	About the organization and interviewee									About the development projects																	About the estimations																			
Principal Variables	Company's seniority	Role of the interviewee					Estimators vs developers			Development life cycle			Project type		Shared human resources			Business knowledge				Project duration	Team size	Budget acceptance rate				Historical data			Estimates using role or people		Effort spent for estimations			Commercial overestimation		Estimations expire		Get estimation feedback		MMRE	
Value / Copany	Value	Founder	CEO	Leader	COO	CAO	High	Medium	Low	Waterfall	Agile	Other	Product Oriented	General Develop	Mix	High	Medium	Low	Low	Medium	High	Very High	Value	Value	Low	Medium	High	Very high	Formal	Informal	None	Role	Person	High	Medium	Low	Yes	No	No Expire	Expire	Yes	No	Know	Unknown
company 1	3	x							x	x			x			x		x		x			12	6		x				x			x			x		x	x			x		x
company 2	25		x						x	x			x			x			x				12	3		x				x			x			x		x	x			x		x
company 3	7				x				x	x				x		x			x				12	3		x				x			x				x		x				x		x
company 4	5	x						x		x			x			x					x		12	3		x				x			x				x		x				x	20%	x
company 5	4	x					x				x		x					x				x	16	3			x			x			x			x		x			x		25%	
company 6	8			x			x				x				x			x				x	12	3	x				x				x			x		x			x		25%	
company 7	6	x					x				x		x					x				x	2	3				x		x			x			x		x			x		20%	
company 8	10					x	x				x				x			x				x	24	6		x			x				x			x		x			x		20%	
company 9	3	x						x				x	x			x					x		2	2				x		x			x			x			x			x	60%	x
company 10	7				x			x				x		x		x			x				16	3				x		x			x			x			x			x	20%	x
Summary	**AVG=7.8**	**5**	**1**	**1**	**2**	**1**	**4**	**3**	**3**	**4**	**4**	**2**	**6**	**2**	**2**	**3**	**3**	**4**	**1**	**3**	**2**	**4**	**AVG=12**	**AVG=3.5**	**1**	**5**	**1**	**3**	**2**	**8**	**0**	**7**	**3**	**4**	**3**	**3**	**4**	**6**	**9**	**1**	**4**	**6**	**7**	**6**

A preliminary analysis of these results seems to indicate that companies using agile developments tend to produce more accurate estimations and have the process under control. However, a more in depth analysis shows that this characteristic is not proper of the development approach used by the organization, but instead a consequence of keeping the development capability under control. In this case, people in the agile teams work in a single project at a time, which gives them more capability to control the effort effectively spent in their projects.

This leads us to the next finding: *sharing human resources among projects jeopardizes the capability of the companies to keep a record about the effort spent in their projects, and therefore, to record trustworthy historical information and perform quality control of their estimations*. Supporting this finding in Table 5 we can see that companies in red (where people participate in a single project) produce suitable estimations and know their estimation error, whereas the rest of the companies (that share resource among projects) are able to estimate in the best case the project deadline, but not the development effort or the estimation error in an accurate way. This finding also helps explain why *all participating companies use expert-based estimation techniques.*

The analysis of information also indicates that *although the companies have ample space to improve their estimation strategies, the way in which they are conducting such an activity today is enough to keep their business operation*. All participating companies are conscious that their estimation technique need to be improved, however they mentioned that they do not know how to do it properly or that they are afraid to change something that is already working.

3.6. Limitations of the Study

This study includes threats to construction, internal and external validity. Next we explain each of them.

Construction validity. Concerning the ten companies selected for this study, although the number is small, all participants addressed the inclusion and exclusion criteria indicated in Section 3.1. Moreover, in the interviews we were aware of detecting information indicating that some of the participant should be excluded due to reasons not considered initially in this study. However, no controversial information was detected, therefore, we assume the sample is cohesive and appropriate to try understand the estimation process in the target population. Moreover, we did not detect contradictory information in the participant responses. In the data gathering process and the design of the interview, we followed the guidelines indicated by Singer et al. [Sin08] and Kitchenham et al. [Kit08].

Internal validity. In the processing and analysis of the study results we followed the guidelines of Seaman [Sea99] and Eisenhardt [Eis89]. All participants signed the informed consent, which allowed us to record the audio of the interviews, and therefore, to listen to those audio recordings more than once to retrieve accurate and contextualized information.

External validity. Concerning the generalization of the findings, the selected sample is cohesive and remains the characteristics of the target population; however a confirmatory study is required to determine its representativeness, and therefore, the capability to generalize these findings. Moreover, the information used in this study was given by estimators of each company, which could be not completely true. However, no contradictory information was detected, and the answers of estimators of companies belonging to the same track were quite similar. This indicates that the collected information is probably trustworthy.

4. Evaluation of RQs

Concerning the first research question (*RQ1: What practices are the most frequently used by Chilean SSC?)* the results indicate that all companies use expert judgement; however, the reasons behind such a decision shows various interesting causes. Therefore, and concerning the second research question (*RQ2: Why do they use these practices?*) we can say that most companies use these techniques because the have no trustworthy historical information to support their estimations. This is a consequence of their inability to control the effort spent in their projects, because they share human resources among projects without conducting formal tracking of that.

On the other hand, there are a couple of companies (both agile) that formally record this information. They decided to use experts in the estimations not only because it is quite natural for this development approach, but also because the information is quite sparse and its level of validity change over time. In this case the experts can interpret such information and consider it according to the project context being estimated.

Finally, all participants understand that their estimation strategies can be improved, and they would like to do it. However, there are two limitations that represent a stumbling block for conducting these improvements: (1) they do not know how to improve their estimations in a safe way, and (2) they are afraid to change something that is working for them. Addressing the second limitation seems to be more difficult than the first one.

5. Conclusions and Future Work

It is recognized that micro and small software companies represent most of the software development capability worldwide, and their features make them different to medium or large software organizations, therefore they need particular practices and software estimations is one of them [Mos00, Jor12, Boh17]. However, few research work has been reported particularly about this target population; therefore it is not easy to determine the state-of-the-art and state-of-the-practice in this study domain. Moreover, the few papers available about it report the reality of Western countries, and as a consequence, it is not clear the validity of those findings when they want to be used in other cultural context, like in Chile.

Given this lack of information, and particularly about the state-of-the-practice in Chile, we conducted a case report that tries to understand what estimation strategies the Chilean SSC use?, and why do they use that? The study results indicate that all of them use expert judgement mainly because their inability to count on trustworthy historical information. The main cause of this situation is because they share human resources among projects according the project needs, and therefore it is difficult to keep a tracking of the effort already assigned to each project. This also limits the capability of the company to determine the quality of their estimations and eventually improve the approach used. On the other hand, the two companies having such information need that experts interpret and contextualize such information before using it.

This is the first report on software estimation in Chilean SSC, and one of the few ones conducted in small software companies in general. We expect these study findings help advance the state-of-the-art in the study domain, and also illustrate the state-of-the-practice in Chilean SSC. The next steps in this initiative consider corroborating the study findings using a new sample of companies in the same domain, and also supporting some SSC to improve their estimation processes in order to determine the main limitations for conducting such improvements. Although the software industry can take advantage of the reported findings, the study results also show that the SSC prefer to keep the status quo than conduct an improvement that is initially uncertain for them. This attitude can be explained due to the fragility of these companies, however, we hypothesize that this is a challenge that can be addressed with a major order in the developments and some supporting tools.

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