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Survival studies based on ISO/IEC29110: Industrial experiences

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ABSTRACT

Very small organizations are suffering when they embark on software process improvement initiatives such as CMMI-DEV or ISO/IEC 15504-5. The ISO/IEC29110 basic profile has been defined as solution for these small companies, and literature related to this standard provides some insights on the potential results and benefits for VSEs. In this sense, two of the topics which have not been deeply studied yet are the survival analysis of VSEs, and an analysis of ISO/IEC29110 basic profile areas. In fact, this paper provides a survival analysis of 90 improvement initiatives, and an analysis of the ISO/IEC29110 basic profile areas. Non-parametric and semi parametric models are used in order to analyse survivability and we analyse project management and software implementation practices defined by ISO/IEC29110 basic profile

1. Introduction

CMMI-DEV [1] or ISO/IEC 15,504-5 [2] are some of the reference models which are widely used for software process improvement (SPI) initiatives [3,4,5]. The results and findings on SPI are quite diverse [6]. In fact, Dyba [6] carried out an empirical investigation in SPI initiatives in order to identify the organizational factors affecting a SPI initiative. Some research works are highlighting the fact that all these traditional reference models are not appropriated for these settings [7]. Several industrial [8,9] and research [10] works have been carried out in the realm of very small entities (VSE) as defined by the ISO/IEC 29,110 [11]. Other experiences have been reported in this sense such as [12] which identifies financial, skills, culture and reference models as the most common barriers for VSEs. In fact, VSEs are always hesitating to embark or not onto these improvement initiatives related to one specific reference model because they cannot foresee the expected results. The ISO/IEC29110 defines a Basic VSE Profile [18] which purpose is to *define a subset of processes and outcomes of ISO/IEC 12,207 and products of ISO/IEC 15,289:2006 for software implementation and project management*. From a holistic point of view, VSEs are dealing with project management issues and software implementation issues. Both aspects are the main two core areas of the ISO/IEC 29,110 basic profile [11].

From a resulting point of view, there is a wide variety of reasons related to why projects fail, such as [13] where authors indicate unclear objectives, unrealistic or unarticulated project goals or inaccurate estimates of needed resources. One of the most relevant aspects for these small organisations is the assessment and/or the expected results when they are applying a reference model. There are several discussions around reference models such as SPICE [14], or for improving processes and products [15] or even approaches for dealing with multiple reference models at the same time [16]. However, the financial aspect is not usually measured or reported. As identified by Larrucea et al. [12] the financial aspect and the associated reference models are some of the barriers for VSEs as stated previously. This financial aspect includes among other factors the time invested and required for implementing one of these initiatives in a VSE context. In its turn, this invested time depends on several factors such as organisations' size, resources involved for launching and carrying out these initiatives, their duration and several other factors. In this sense, an estimated duration for implementing these initiatives provides an overview of the time required by VSEs. In this sense, we have measured this "survival" time for VSEs for project management and software implementation practices. These elements are included in our current experience factory [12].

This paper aims to provide an empirical comparison of survival analysis of improvement initiatives including the analysis of the ISO/IEC 29,110 basic profile areas. We provide the survival analysis of 90 initiatives referenced by Larrucea et al. [12,17]. This statistical analysis helps VSEs to identify whether the improvement initiative is going to fail or not, and which ISO/IEC 29,110 basic profile areas are interrelated.

This paper is organised as follows. First, a brief background introduction to ISO/IEC 29,110 and survival methods are provided. Second, the research method, data collection and data analysis method are described. Finally, the main results are discussed in order to conclude this paper.

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2. Background

2.1. ISO/IEC29110

The ISO/IEC29110 [11] is defined for helping VSE to improve their quality through the use of profiles [18]. This standard allows VSEs to adapt smoothly the activities defined by these profiles into their organisations' needs. Some research works are aligned with these principles such as [19] which defines a framework called Rapid-Q predefining a set of processes that can be customized to the organization's needs. Some authors such as Pino et al. [20] have analysed the SPI efforts devoted by VSEs, and our paper contributes directly in this sense. In fact, VSEs require a clear and defined route [21] for launching and investing resources, and they need to estimate the required time to achieve a set of goals. Several contributions have been reported at different levels such as the assessments carried out [22], the project management activities [23], or the activities related to software engineering [19]. It is also relevant to mention that this standard has been used in the educational environment [24,25]. As identified by [26] there are six common problems observed in this kind of environments: poor project planning, poor measurements, poor cost estimating, poor change control, poor milestone tracking, and poor quality control. All these aspects can be managed under the ISO/IEC29110.

2.2. Survival methods

In this paper we define "survival time" as the time required until an organization has achieved a set of activities prescribed by a reference model. In our context we are considering to meet requirements defined by ISO/IEC 29,110. This achievement can be measured by a traditional assessment or by a more light-weight approaches. Survival methods [27] are defined in the realm of statistical methods which have been applied to several domains such as health sector [28], or in economics [29]. The survival data refers to the observations related to the time required to a certain event [30]. This approach is similar to [31] where the survival time is a positive event and it is the duration time until an event has occurred. Traditionally, the survival methods cover parametric (e.g. lognormal, Weibull, etc), non-parametric (or semi-parametric) approaches (e.g. Kaplan–Meier), semi parametric (e.g. Cox Proportional Hazard Regression model) among others. In our context we use the semi-parametric approach called Cox Proportional Hazard Regression (CPHR) model because the distribution is unknown, and the time to the event is not fully observed. In fact, CPHR is a blend model mixing time dependent variables and categorical data. Process improvement assessments are usually carried out at a certain interval. In addition, some initiatives are abandoned or failed during this interval of observation. Therefore, we have censored the data falling outside the limits of our study. The events occurred before the starting times are called left truncated data. And the events occurred after the ending times are called right censored data.

3. Survival analysis

There is a wide set of survival methods for analyzing "time to event" approaches. This section provides an overview of the non-parametric models and a semi-parametric model such as the Cox Proportional Hazards Regression (CPHR) model [27]. As stated before we are going to use CPHR because SPI assessments rely on time dependent variables and categorical data. The first step is to introduce the non-parametric models. Afterwards we need to interpret and adapt the Cox Proportional Hazard Regression model to our study. Third we analyse the scenario, and we need to specify which SPI initiatives are taken into account or not.

3.1. Non parametric models

Kaplan–Meier [32] and Nelson-Aalen estimators are some of the most well-known non-parametric models. Kaplan-Meier defined a product-limit estimator (PLE) (formulae 1) which is based on a product of the conditional survival probabilities. Based on a set of items called r we have an associated t_r' which can be a positive or a negative event. After N observations $0 \leq t_1' \leq t_2' \leq t_3' \leq \ldots t_N'$ we have the following PLE:

$$\widehat{P}(t) = \prod_{r=t_r'}^{t_r} [(N-r)/(N-r+1)]. \tag{1}$$

Nelson–Aalen (formulae 2) is used when we consider estimating the cumulative hazard of the survival functions:

$$\widehat{\mathrm{A}}(t_i) = \sum_{j=1}^{i} \frac{d_j}{r_j}. \tag{2}$$

where d_j is the number of individuals who experience an event at t_i, and r_j is the number of individuals at risk before t_i. This function accumulates (sum) the hazard from time = 1 to time = i at it increments $\frac{d_j}{r_j}$ during the time observed.

Both functions are used in our study for comparing survivability of SPI initiatives.

3.2. Semi-parametric model: cox proportional hazard regression model

The cox proportional hazard model [27] is a semi–parametric proportional hazards regression model which is an extension of the Kaplan–Meier estimator. This model uses numerical variables, and it assumes that the complete distribution over the time is not known. Its formulae is:

$$h_i(t) = h_0(t)^*\exp(\beta^*\mathrm{X(t)}) \tag{3}$$

where $h_i(t)$ is a hazard rate for a subject "i", $h_0(t)$ depends on time (not on the covariates) with unspecified baseline hazard function that describes the instantaneous risk of experiencing an event at some time, t, when the values of all covariates are zero. exp(β*X(t)) depends on the covariates (not the time). X(t) is a vector of possibly time-independent covariates that are collected at each event occurrence that may or may not have predictive power over the time to the event. In our SPI initiatives context, this vector is composed by several parameters which are common in several reference models such as the ISO/IEC 29,110 basic profile elements. β is a vector of regression coefficients (i.e., one coefficient for each covariate). Our purpose is to analyze their survival rates and to compare different initiatives. The main difference between 2 subjects under study (two SPI initiatives) only depends on their covariate values. This difference is calculated as described in formulae 4.

$$\frac{h_i(t)}{h_j(t)} = \frac{h_0(t)^*\exp(\beta^* X_i(\mathrm{t}))}{h_0(t)^*\exp(\beta^* X_j(\mathrm{t}))} = \exp(\beta^*(X_i(\mathrm{t}) - X_j(\mathrm{t}))) \tag{4}$$

For representing the results use the R studio [33] and the Cox's model implementation in the R package survival [34].

4. Survival study in small settings

4.1. Research method

Recent research works such as [35] where authors outline a research agenda, or [36] where authors provide an approach for predicting delays of issues with due dates, are suggesting that there is an evident need for setting a grounded theory [37] in this sense. As stated before we have analyzed 90 improvements initiatives stemming from our experience factory [38] which has been published in Tecnalia's website (https://tinyurl.com/larnc8q). In fact, the aforementioned