An Empirical Study about the Influence of Project Manager Personality in Software Project Effort

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Abstract: Project effort is a main concern on software organizations. The project budget is derived from project effort which in turn is based on the software engineers' effort cost. Project manager is responsible for planning and controlling this effort estimation. Some researches relate how project manager can influence the project success, specially when considering project manager personality. This research aims to evaluate the influence between project manager personality and teamwork behavior over project's effort deviation. A case study was performed with 65 real projects collected from a software company dedicated to develop software projects for its local government. Unlike previous researches our results show no statistically significant influence of project manager personality, assesed by MBTI test, over project's effort deviation. However, our results show the project manager teamwork behavior, assesed by Belbin's BTRSPI, has a statistically significant influence on the project's effort deviation.

1 INTRODUCTION

Over the last few decades only under half of software projects end up in success, i.e., they are delivered on time, on budget and with all required features. CHAOS Manifesto (Standish Group International, 2013), which has a database of 80.000 real software and IT projects since 1997, shows that in 2012, 39% of projects achieved success; 18% of projects are either cancelled prior to completion or delivered and never used; and 43% of projects are delivered late, over budget and/or with less required features. For the last case, problems with budget overrun increased from 46% in 2010 to 59% in 2012.

A software project budget has as its main element the amount of software engineers involved (PMI, 2013). After project scope is set out with client, the estimated delivery date of a software project is dimensioned according to the effort of every engineer in the project. Project budget is estimated from engineers' effort cost. Project manager is responsible for planning and controlling

these estimations, and for selecting engineers from company that will compose the project's software team.

Acuña and Juristo (2004) performed a study about the influence of assigning people to predetermined functional roles in software development process. Personality was assessed by the projective 16PF personality test (Russell and Karol, 1994) that measures 16 primary personality traits identified by Cattell et al. (1993). Acuña and Juristo (2004) study's premise was that personal behavioral competencies and characteristics of professional conduct has influence in the effectiveness and efficiency of software development. The result showed that assignin people to functional roles according to their capabilities, based on behavior and characteristics, and habilities demanded by software project role can help organization to develop systematic long-term competences.

Cruz et al. (2011) performed a systematic literature review about the influence of individual personalities on individual tasks and team work in the software engineering. Data were extracted from

42 studies published between 1970 and 2010. Results showed that pair programming and team building were the most recurrent topics surveyed and that MBTI (Myers-Briggs Type Indicator) personality test was the most used.

Karn and Cowling (2006) carried out a study about the effects of personality on performance of software engineering teams. In their conclusions, the authors reinforced in their results the notion that the psychological type is an important factor to consider in software development teams' performance.

Wang and Li (2009) studied the effects of software project manager personality in 116 real software development projects in Shanghai's software companies. In this work, personality was assessed by Neo-Five-Factor Inventory (Costa and McCrae, 1992) for the Five Factor Personality Model (FFM or Big Five) (Goldberg, 1992). Their results showed that software project manager's personality is one of the indicators for software project success and it also influences in success through mediating effects of the leadership.

Previous works emphasized the importance of studying personality in software engineering and how it affects software project success. This paper attempts to answer if software project manager personality influences on software project effort. Moreover, we also study if software project manager teamwork behavior influences software project effort and their software development performance, according to the work developed by Belbin (2010a). This study was performed based on a dataset of 65 real projects of a government software development company. Thus, project result based on effort deviation was assessed with project manager's MBTI psychological test and Belbin's team role. This analysis is important to verify if the difference between the planned and actual effort can be related by project manager behaviors.

This paper is organized as follows: Section 2 presents concepts of personality types and their relation with software engineering. Section 3 describes research method used in this study and data sample characterization. In Section 4, study results and evidence obtained are presented and analyzed. Section 5 describes threats to validity related to this research. Finally, in Section 6 conclusions and opportunities for future work are presented.

2 HUMAN FACTORS IN SOFTWARE ENGINEERING

Researches relating human factors with software engineering have been increasing over years, according to Cruz et al. (2011). Some of these researches aim to identify the appropriate psychological types for specific activities in software development (Acuña and Juristo, 2004). França and Silva (2007), Wang and Li (2009), Brewer (2005) and Acuña and Juristo (2004) researches are based on different psychological theories to study human behavior and characteristics in software engineering. This work will focus on two specific psychological theories: theory of personality based on Myer Briggs Type Indicator (MBTI, 2014), and theory of team roles based on Belbin's work (Belbin, 2010a). In next sections, we will present concepts related to each one of these theories and how they have been studied within software engineering context.

2.1 Personality Theory

Each person has his own behavior when dealing with same stimuli during his social life, such as impulsive people, people with difficulties in communication or people who make emotional decisions. These observed behaviors may only be a situational reaction, but Morin and Aubé (2009) state that it can also be derived from his personality. Bloch (2002) et al. apud Morin and Aubé (2009) conceptualized personality as a set of relatively stable affective, emotional and dynamic characteristics; these characteristics are the person's usual way of being.

Personality systematic study has been done since late 1930s through surveys of Henry Murray and Gordon Allport reseaches at Harvard University and also by contributions of the Swiss psychiatrist Carl Jung (Schultz and Schultz, 2002 and Morin and Aubé, 2009).

Jung in his studies describes that much of perception and reaction to environment is determined by opposing mental attitudes of extraversion and introversion. These attitudes relate primarily to how energies are directed in certain situations. Extroversion behaviors are characterized by an orientation to outside world and people, while introversion is characterized by a preference to its own ideas and feelings (Schultz and Schultz, 2002). Realizing the differences between extrovert and introvert people, Jung proposed a separation of these

behaviors in psychological functions (Morin and Aubé, 2009).

Psychological functions refer to the way the individual's energy is organized and structured. These functions are divided by Jung in sensation, intuition, thinking and feeling.

Sensation and intuition were classified as non-rational functions because their actions are based on fact interpretation and world perception. The sensation function feels "what is happening" and reacts through this external stimuli and previous experiences. Intuition function emphasizes inspiration and world perception, and their possible impacts into the future (Morin and Aubé, 2009).

Jung classified thinking and feeling functions as rational because of how they are related to evaluation of previous experiences. The thinking function assigns to the individual the judgment based on principles, rules, or laws, that are considered relevant to logic and situational analysis. In opposite, the feeling function allows the individual to evaluate situations based on the involved personal values and consequences, such as embarrassment or future conflicts.

Although the functions described by Jung follow a pattern of duality, this does not mean that these functions are mutual exclusive. Jung uses the concept of dominant function, which exists in the conscious and rules the majority of human behavior, and secondary function, which has influence on the personal unconscious and can affect behavior in certain occasions (Morin and Aubé, 2009).

2.2 Myers-Briggs Type Indicator (MBTI)

Katharine Briggs and Isabel Briggs Myers continued in the 30s the work begun by Jung. They introduced a new psychological function in addition to those previously described. Another important contribution of their work was the creation of an assessment test of those functions. The result of this assessment indicates the individual's psychological type. These kinds of tests are also known as inventories in psychology (Morin and Aubé, 2009).

The Myers-Briggs Type Indicator (MBTI) integrates Jung's theory with Myers-Briggs's concept of "lifestyle" . Currently, MBTI is used by research community as well as in industry, where it has been already used by 89 organizations that compose the Fortune 100 (Ash, 2013).

MBTI test result indicates one of 16 possible psychological types. Each possible type has a structure that combines the four different psychological functions: one attitude function (introversion or extroversion), one rational or judgment function (thinking or feeling), one non-rational or worldview perception function (sensation or intuition) and one lifestyle function, which is the new dimension described by Myers-Briggs. This new dimension aims to assess in the lifestyle of individual's behavior the dominant dimension between judgment and perception.

The psychological type, indicated by an MBTI test, is represented by a four-letter combination, where each letter describes one psychological function. As an example, consider a person with psychological type INTP. This acronym can say that this person has an attitude of introversion (I), and uses intuition (N) as non-rational function, has thinking as rational function (T) and a lifestyle based on perception (P). Morin and Aubé (2009) describe all the 16 possible psychological types, also know as profiles, and their noticeable characteristics.

2.3 Belbin's Team Role Theory

In the late 60s, Meredith Belbin began studies of people's behavior at teamwork when developing business games. During the execution of these business games, Belbin observed that the results could be influenced by individual's behavior, i.e., by the relationship with other team members and the way they contributed to the team (Belbin, 2010a).

Belbin defined team role as the person characteristic behavior in the context of teamwork (Belbin, 2010b). Belbin's team role theory states that in teamwork individuals tend to play different type of roles beyond the usual functional roles associated with his technical activities (Fernandes and Silva, 2007).

Belbin's team role identification is accomplished through an inventory called Belbin's Team Role Self-Perception Inventory (BTRSPI). The BTRSPI design aims to assess the behavioral characteristics of individuals when working in a team (Belbin Associates, 2013).

BTRSPI is a form composed by a situational-based questions and alternative answers. Individuals when participating must distribute a total of ten points over the alternatives answers that are closer of his own behavior. To assess the test, the total points for each Belbin's team role is calculated. From the distribution of percentile scores, the BTRSPI proposes to each team role one of four possible values: *"Very High"*, *"High"*, *"Average"* and *"Low"* (Riding and Rayner, 2001). The values *"Very High"* and *"High"* indicates that the individual has the

descriptive characteristics of that Belbin's team role, which describes their strengths and weaknesses in teamwork.

Belbin's team roles has the following classification (Belbin, 2010b):

- *Completer Finisher (CF)* is meticulous, has self-control and self-discipline, look for errors and omissions in his own work and try to finish it without any delays.
- *Implementer (IMP)* is disciplined, trustable and know how to turns ideas into pratical, pragmatic and efficient actions. He tends to be inflexible and slow to respond to new possibilities.
- *Teamworker (TW)* is cooperative, friendly, diplomatic, non-competitive, compliant and has good perception.
- *Monitor evaluator (ME)* is sober, strategic, and is able to visualize options and judge them accurately.
- *Co-ordinator (CO)* is dominant, confident explainer of goals to others and delegates well the tasks. He is also considered the leading role for teams.
- *Plant (PL)* is creative, unorthodox, confident and have radical thinking. He has difficulties in expressing himself because he is too focused in his thoughts.
- *Shaper (SH)* is challenging, dynamic, impatient, self-confident, thrives under pressure and has courage to overcome obstacles. He may offend people's feelings because he is susceptible to provocations. He is also considered a leadership role with an aggressive style.
- *Resource Investigator (RI)* is extroverted, communicative, flexible and like to explore opportunities. He tends to be optimistic and to quickly lose interest of everything after an initial enthusiasm.
- *Specialist (SP)* is not interested in any other team member. He is focused, self-motivated, dedicated and likes to discuss only technical issues.

In the latest BTRSPI revision some roles were renamed and a new one was included, the *Specialist (SP)* role, as was described above. This study used an BTRSPI version, where this new role was not present and therefore it was not evaluated in this research.

Belbin's team role theory, beyond describe the team roles, also proposed grouping them according to common characteristics (Belbin, 2010b):

leadership (Co-ordinator, and Shaper), creativity (Plant and Resource Investigator), execution (Teamworker and Implementer) and *balance (Monitor Evaluator and Completer Finisher)*.

2.4 Personality Studies in Software Engineering

The influence of personality in software engineering is a recurrent topic covered by several studies. We highlight the studies of Gorla and Lam (2004), Brewer (2005), França and Silva (2007) and the systematic mapping study performed by Cruz et al. (2011).

Gorla and Lam (2004) studied the effects of project leader's personality in relation to the project outcome. Project result's metrics were based on six project's effectiveness measures: staff workload, quality of work, efficiency of team operations, effectiveness of user interaction, frequency of schedule adherence and frequency of budget adherence. These metrics were collected through questionnaire-based surveys answered by team members, based on their perception, of 20 software development teams in Hong Kong. This study performed the application of survey and the MBTI personality test to those software teams. Their results evidenced that project leaders with NF (intuition-feeling) dimensions obtained better project outcomes than the others. Furthermore, it was also observed that functional role of systems analyst is influenced by judgment (thinking-feeling) dimension, while energy (introversion-extroversion) dimension is crucial for developers.

Brewer (2005) analyzes whether a person can be trained for the project manager role or if he already has the skills necessary and how these skills can be improved. Beyond knowledge they also studied the impact of project manager's behavior. MBTI psychological test is one inventory considered for this work to assess project manager personality. Their results suggest the ENTJ and ESTJ psychological types as ideal for the role of project management. Another psychological test is refered at this paper, named FIRO-B (Waterman and Rogers, 2004), but no suggestion of this psychological assessment was presented.

França and Silva (2007) studied the influence of RUP functional roles and Belbin's team role on software factories. This research evaluates system analyst, software architect, project manager and implementer roles characteristics and the expected psychological behavior of each one. The characteristics of project manager's functional role

considered in this work were decision, communication, leadership, time management and goal orientation. As result, França and Silva (2007) suggest that project manager must be *Co-ordinator* (CO) but *Resource Investigator* (RI) and *Teamworker* (TW) roles could also have positive results.

Considering the importance of this topic and diversity of papers published in the last 50 years, Cruz et al. (2011) carried out a systematic mapping study, which we can highlight some of its main findings:

- Most studies carried out experiments;
- Type of participant were well balanced between students and professionals;
- The main topics found were pair programming, effectiveness of development teams and individual performance;
- The top personality tests used were MBTI and Big Five (Goldberg, 1992);

In this systematic mapping, the effectiveness of the software project manager related to his psychological type was a topic within the lowest quantity of studies. This finding indicates the need for further research that relate human factors of the project manager and the results achieved by its software project.

3 CASE STUDY

This present study was based on the following research question: does the personality of the project manager can influence the outcome of a software project, with respect to the project's effort deviation? Such research question has two main goals: to evaluate the influence of the MBTI psychological type and also evaluate Belbin's team role of the software project manager in relation to the planned project effort. In order to evaluate these goals we propose the following null hypothesis H01 and H02, contrasted by the alternative hypothesis HA1 and HA2:

- H01 = MBTI psychological types don't affect the planned project effort.
- HA1 = MBTI psychological types affect the planned project effort.
- H02 = Belbin's team roles don't affect the planned project effort.
- HA2 = Belbin's team roles affect the planned project effort.

These hypothesis were analyzed considering a

dependent variable (project's effort deviation) and independent variables (MBTI psychological type and Belbin's team role). The instuments used to collect independent variables were psychological type, assessed by an online MBTI based personality test, and Belbin's team role, assessed by an based Belbin's Team Role Self-Perception Inventory (BTRSPI) assessment.

We performed an in vivo study in the context of a real software development company, in order to assess the statistical significance of the relationship between these variables.

3.1 Research Procedures

This case study was performed with projects collected from the project management system of a software development company dedicated to develop software projetcs for its local government. In this system the company records project data such as schedules, estimated dates and estimated hours needed to perform each task, hours consumed by the task and the employees involved, and the assigned functional role of each employee. The effort consumed for a task is the result of daily record made by each software team member of how much time was spent and the description of the activities performed. All these daily records represent, at the end of the project, the actual project effort.

All team members who participated in the software projects that we studied participated in a presentation about human factors in software projects and its uses in software engineering. This was done aiming to contextualize them into the concepts of the this present study. In this presentation the MBTI psychological test and the Belbin's team role theory were presented. Later the participants were instructed to identify their personality types. This identification of psychological type was done according to a based on MBTI test, using the form available on the site *http://www.inpiira.org,* and Belbin's team roles, based on the Belbin self-perception inventory (BTRSPI). Participants were instructed to send by e-mail the results of their assessments.

After collecting all data, we calculated the effort deviation of each project. This calculation is the difference between the total hours actually consumed and the total hours estimated for the entire project. As projects differ on size, we proceed with the normalization of the scale using the ratio between that difference calculated and estimated hours of the project. The formula used is presented below:

$$Effort\ Dev. = \frac{Hrs.\ Consumed - Hrs.\ Estimated}{Hrs.\ Estimated}$$

After each project's effort deviation calculated, we grouped all the projects according to the MBTI dimensions of the project manager. We also grouped according to the Belbin's team role. For each group obtained we calculated the mean and variance of the project's effort deviations.

We used Kruskal-Wallis statistical test (Siegel and Castellan, 1988) in order to compare the project's effort deviation between the groups obtained, first for groups acordding to the MBTI psychological test and then according to Belbin's team roles,. This non-parametric test evaluates whether the groups provided have homogenity in variance, i.e., test if the variance of groups come from the same distribution and because of this we can consider the groups having no statistically difference between their means and variances. This test was chosen because our sample data does not follow the normal distribution according to Shapiro-Wilk test (Shapiro and Wilk, 1965; Razali and Wah, 2011). Finally, we performed all these statistical analysis using the SPSS software (IBM, 2013).

In following subsections we will present in more detail the sample characteristics, the metrics used for evaluation, and in the next section we present the results obtained.

3.2 Sample Characterization

This research was performed in a technology company with ISO 9001/2000 certification who acts as an agency for perform the information technology government policies. This company is responsible for the majority of software systems developed and currently in use by the state executive branch. The company's portfolio includes software systems for education, human resources, public safety, administration, government's strategic planning and public health.

3.2.1 Projects

This empirical study evaluated data from 65 projects, allowed by the company, started after March 2011 and completed by March 2012 by a domain expert team in developing software solutions for the government. This time period for analyzed projetcs was established by the company. These projects have been chosen because they have common characteristics, such as the same application domain, the same customer, they were based on the same programming language and the

same technology. There were no further process for selecting or rejecting the data collected, thus all collected projects were used for this study. These projects involve goals like the development of new modules of a management system, corrective maintenance, perfective maintenance and new software projects.

To better study all projects collected, they were classified in respect of their duration in order to finish. The classification system was created with the help of the supervisor of these projects. He was reponsible for coordinate the software teams of these projects. He proposed the following classification:

Figure 1: Histogram of project distribution according to size classification proposed by company's supervisor.

- **Very small projects**: lasting up to 7 days;
- **Small projects**: lasting more than 7 through 10 days;
- **Medium projects**: lasting more than 10 through 50 days;
- **Big projects**: duration greater than 50 days.

Figure 1 shows the software project distribution studied in this research, according to the classification described. This histogram shows a balance in this project distribution according to size, which allows a proper analysis of the results obtained.

3.2.2 Project Effort's Metrics

Software organizations need to evaluate their projects in order to continuously improve their internal processes to achieve better results. This evaluation has some perspectives, such as customer perspective and organization perspective.

Customer perspective usually considers a success when the software project are delivered on time, on

budget and with all features requested. In this company, if any replanning with customer occurs during project execution, the delivery date and features will reflect this latest agreement.

When evaluating collected data, from the customer perspective, we noticed that the majority of the projects had little or no delay on project's delivery date. To investigate this we plotted a graph showing the distribution of the difference between date actually delivered and date estimated from the last replanning. These data were normalized by a ratio between the difference above explained and project's estimated date, so that projects can be compared regardless of its duration. We called this metric as delivery date deviation where negative values represent that the project was completed ahead of schedule and positive values indicate delays in the project.
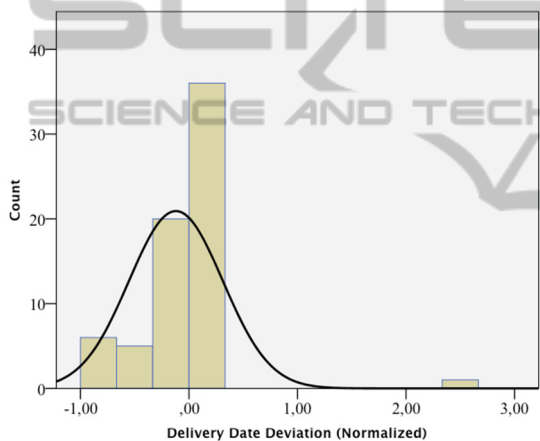

Figure 2: *Histogram* of the projects distribution in respect of deadline deviations.

Figure 2 shows the histogram of delivery date deviation calculated from all collected projects. In this figure we can confirm that almost all projectes were delivery on date, and this was probably caused by this project replanning, where the date estimation was renegotiated and commited into the company's project management system. Because of this internal project's cost overrun can be hidden from the customer perspective.

Organization perspective evaluates internal development process and cost overrun. Cost management allows to track the internal resources involved in the project and the final project price for customer. These data, in the company's project management system, are not affected by any project replanning realized with the customer. These internal resources are related to the project's effort planned and the amount of software engineers planned for the project. To evaluate the organization's perspective, we assume project's effort deviation as our main variable.
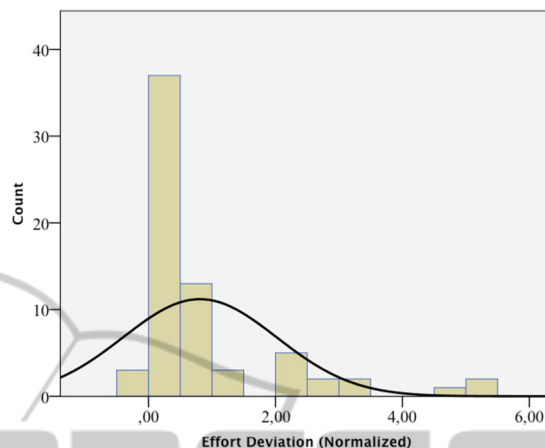

Figure 3: *Histogram* of project's effort deviations.

The project effort deviation is calculated from the difference between the total hours worked and the total hours estimated for the project. This metric evaluates the quality of the estimate made in the original planning phase.

Figure 3 shows the histogram of project effort deviation. The existence of negative project effort deviations. This negative effort deviation represents projects that took less time than estimated and a positive deviation effort indicates projects that has used more hours than was originally estimated. These values are presented with the normalization of the scale using the ratio between the actually realized and estimated, in this way all projects can be compared regardless of its actual duration.

These metrics when evaluated together allow the company to assess the final status of their projects. This kind of evaluation gives possibility of new analysis, such as identify projects completed on time but generated loss by allocating more resources than planned. This work focuses on organization perspective aiming to improve internal proccess and avoid financial losses for the company.

3.2.3 Participants

The software team selected cosisted of 22 software engineers, being 16 men and 6 women. These engineers were assigned in these project for functional roles such as software project manager, systems analyst, developer and tester. The software project manager in this company, despite being directly responsible for the coordination and implementation of the project, has no direct

authority over resource allocation. The company supervisor was responsible for the distribution of engineers between projects and for assigning their functional roles. Each of the software engineers could be involved in more than one project simultaneously by playing different functional roles.

For a software engineer to be selected as a project manager some criterias were used, such as the current work overload and degree of knowledge about business processes involved in the product to be developed. In cases where projects had innovative business processes, this criteria included project management in-house experience

Project manager main duties in this company are based on a predictive model for project management (PMI, 2013): scope management, time management, quality management, risk management, allocation of tasks to the selected team, stakeholder management and communication management.

After collected, the software engineers MBTI test results were analysed and the distribution of the 22 participants were:

- **Source of Energy**: 60% *introversion (I)* and 40% *extroversion (E)*;
- **Worldview Perception**: 75% *Sensation (S)* and 25% *Intuition (N)*;
- **Evaluation**: 55% *Thinking (T)* and 45% *Feeling (F)*;
- **Lifestyle**: 75% *Judgement (J)* and 25% *Perception (P)*.

Figure 4 shows the distribution of MBTI psychological types of the participants who took project manager functional role on the 65 projects analyzed. In this distribuition, the same participant can appear multiple times as much as he was assigned to the project manager functional role.
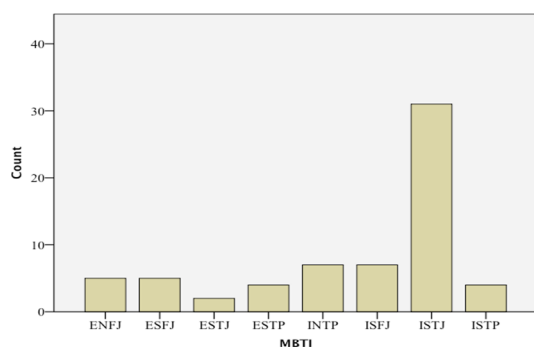
Figure 4: *Histogram* of project manager MBTI psychological type for each project collected.

Figure 5 show the distribution of same project managers according to their Belbin's team role. This histogram is based on the dominant role of each project manager, i.e., where his final test score of BTRSPI shows the level *"Very High (VH)"*. We assumed only the "*Very High*" level because it better highlights the dominant characterics of each role.

During selecting the dominant role, in some cases we had more than one role with *"Very High (VH)"* level for the same project manager. In these cases we duplicated the project record for each Belbin's team role identified with "*Very Hig*" of its project manager.
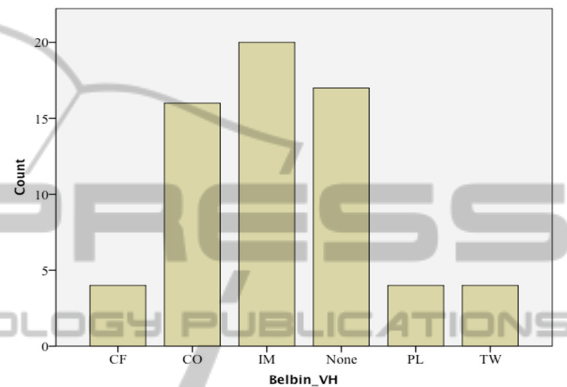
Figure 5: *Histogram* of project managers according to Belbin's team role with score at the *"Very High (VH)"*.

In Figure 5, the *"None"* category describes managers who did not have any score level with *"Very High (VH)"* in any of Belbin's team role.

4 RESULTS

To answer the research question (does the personality of the project manager can influence the outcome of a software project, with respect to project planned effort?), we adopted the following criteria for analysis:

- As dependent variable of experiments, we take the project effort deviation;
- As explanatory variable (factor), we analyzed the following characteristics:
  - MBTI psychological type;
  - Belbin's team role.

As we can not assure the assumption of distribution normality of the samples collected, then we do not use the statistical test Analysis of Variance (ANOVA) to compare the influence of the factors (MBTI psychological type and Belbin's team role) on the project effort deviation. We adopt the non-parametric Kruskal-Wallis statistical test (Siegel

and Castellan, 1988).

Figure 6 shows the project effort deviation distribution related for each personality type assessed by the MBTI of each software project managers. With this *boxplot* we can notice the difference for each psychological type.
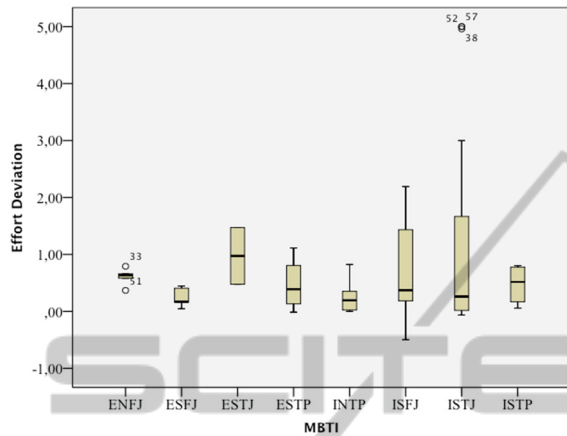

Figure 6: *Boxplot* with project effort deviation related to the MBTI pscyhological type.

To determine if there is a significant difference between the MBTI psychological types in the variance of project effort deviation, we applied the non-parametric Kruskal-Wallis test (Siegel and Castellan, 1988) using $\alpha = 0.05$ as confidence level. As a result, we obtained a *p-value* of *0.691*, thus rejecting the alternative hypothesis, so that nothing can be stated about the effects of the MBTI psychological type on the project effort deviation on our sample.

We also analyzed the influence of Belbin's team roles of project managers on the project effort deviation using our sample.
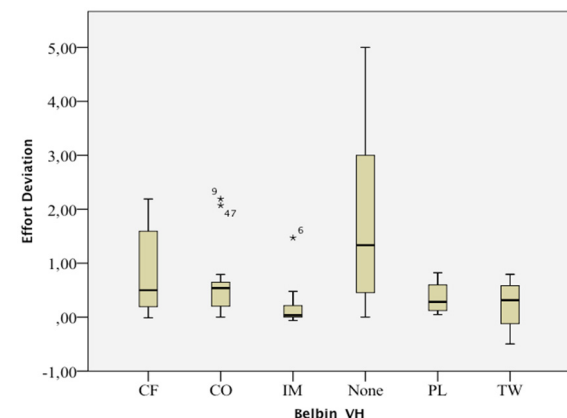

Figure 7: *Boxplot* with project effort deviation related to Belbin's team roles.

From Figure 7, we notice these group distributions, according to Belbin's team role scored at *"Very High (VH)"*, have visually large differences on variance in the project effort deviation.

To determine if this differences were significant, we applied the non-parametric Kruskal-Wallis test (Siegel and Castellan, 1988) again using a confidence level of $\alpha = 0.05$ confidence. As a result, we obtained a *p-value* equal to *0.000*, thus rejecting the null hypothesis and accepting that there is no homogeneity of variances, i.e., the variance and mean have significant difference. Therefore, we can assume that the variance should be the effect of one of the Belbin's team roles on the project effort deviation, and this variance does not occur by chance in our sample.

Table 1 provides a ranking of variance by dominant Belbin's team roles. This table shows that some roles have less variance with respect to project effort deviation than others. Table 1 also shows that in our sample the role of *Co-ordinator (CO)*, indicated by Belbin as one role of leadership, was not determinant in order to obtain smaller variances of project effort deviation. Additionally, we notice the prominence of the roles *Plant (PL)* and *Implementer (IMP)*, with the smallest variances of only *0.113* and *0.119* respectively.

Table 1: Ranking of Belbin's team roles with respective effort deviation variance.

Belbin's team role	Variance
Plant (PL)	0,113
Implementer (IMP)	0,119
Teamworker (TW)	0,289
Co-ordinator (CO)	0,401
Completer Finisher (CF)	0,847
NONE	3,209

4.1 Result's Discussion

In this section we discuss our findings and contributions with this research. For this analysis, by assessing the personality of the manager of the project, we can compare our research with studies by Brewer (2005), and Gorla and Lam (2004).

Brewer (2005) discusses whether a person can be trained for the project manager role and if he already has the skills necessary, then how its skills can be improved. Brewer's work (2005) highlights the

ENTJ and ESTJ psychological types as ideal for the role of project management. ENTJ psychological type refers to people with strong leadership characteristics. ESTJ psychological type refers to people aware with rules. Their result was concluded by comparing the necessary skills for such a function and characteristics of the psychological type. Despite the proposed recommendation, no evidence was presented to support the proposed statement was presented. Our work differs from Brewer (2005) because he do not observe the influence between MBTI psychological type and project's effort deviation. Thus, we can not assume that ENTJ and ESTJ influence whole project management activities.

Gorla and Lam (2004) evaluated the influence of the project manager personality, based on the MBTI psychological type, on team performance. Their results, based on assessement of 20 teams from Hong Kong, identified the relations of MBTI psychological type with theirs software project's success metrics used. Gorla and Lam (2004) indicate the relevance of the MBTI psychological ENFJ type in the project's success using qualitative measures of success. ENFJ psychological type refers to charismatic people with guiding people skill. Therefore differently from our study, no statistically signifcant result of these relations were presented and no quantitative metrics for effort deviation were reserached. Our findings, based on used sample, differs from them indicating that there is no influence between MBTI psychological type and project's effort deviation. Thus, we can not assume ENFJ as a main psychological type to manage projec's effort deviation.

Another result obtained in our research refers to the influence of Belbin's team role of the software project manager. This research identified evidence of the relationship between the role of the Belbin's *Plant (PL)* and *Implementer (IMP)* role of project manager and project's effort deviation.

Belbin's (2010b) *Plant (PL)* role, classified as a creativity role, has as its main characteristic the ability to solve problems. Although not classified by Belbin as a role with coordination skills, its creativity may have been important for obtaining a minor variance in project's effort deviation. As hypothesis from this result we think that in scenarios with problems during software development which could cause an increase in project's effort, the role *Plant (PL)* may have find fast or simple solutions which avoided the increased the project's effort.

Belbin's (2010b) *Implementer (IMP)* role, classified as an execution role, has as important

characteristics discipline, inflexibility and the ability to turn ideas into pratical actions. Our results also show that this team role achieved a small variance on effort deviation. We think that is possible that its skills may also have contributed to better align the project's scope originally designed, influencing positively on the project's effort deviation.

França and Silva (2007) evaluated the relation between RUP functional roles, including project manager, and Belbin's team role. Franca and Silva (2004) considered characteristics as communication, leadership, time management and goal oriented for project managers. In order to reach these skills, the researchers suggested *Co-ordinator* (CO), *Resource Investigator* (RI) and *Teamworker* (TW) Belbin's team roles. Our work also show evidence between project manager Belbin's team role and project effort deviation. However, our findings differs from França and Silva (2004) on the suggested roles. This result can be explained because project's effort deviation is a subset of a project managerial activity, requiring specifics skills for this.

Thus, the evidence obtained shows that the Belbin's team role of the software project manager can influence the effort deviation in a software project. Furthermore, our results suggest that characteristics such as creativity and the ability to turn ideas into pratical actions, from the Belbin's team roles *Plant (PL)* and *Implementer (IMP)* are important factors. This indicates that during the project, in relation to the deviation effort, these characteristics maybe more relevant than just the ability to delegate tasks or challenge the team, like the Belbin's team roles of coordination.

5 THREATS TO VALIDITY

Running a case study brings threats that can affect the validity of its results (Castello Branco et al, 2012). Below we discuss the threats to validity for this case study.

One threat to validity of the results obtained in this study is about the amount of participants, projects and company in the sample. This threat causes can prevent the findings obtained to not be generalized outside the same scope our sample. Regarding the sample of software projects used in this study, the results reflect an analysis over a year of activity provided by the software company.

Another threat to validity is that these software projects maybe influenced by cyclical processes that may affect the sample. Also about these projects, another limitation of this study refers to data quality

according to hours informed to complete project's tasks and consequently it can affect the metric effort deviation. This information is obtained directly from the declaration of each team member, so there is a little possibility that certain values may not reflect the reality.

Other threat to validity is if the distribution of Belbin's team roles of participants of this study does not reflect the distribution found in society. The accuracy of personalty identification is another possible threat of this work. This limitation occurs because the assesment of tests used in this study was not accompanied by a psychologist. Another possible factor that may have influenced the personality identification in this study was the presentation made for explaining how the tests should be used. Additionally, the MBTI psychological types identification and Belbin's team role assesment were carried out by participants in a non-monitored way without the accompaniment of a researcher.

6 CONCLUSIONS

This research aims to contribute for the assessment of human factors in software engineering. To achieve this goal, we studied how to relate MBTI psychological types and Belbin's team role of the software project manager in relation to the project effort deviation.

The results obtained, based on our sample, showed evidence that the effort deviation is not statistically significant in relation to the project manager's personality, assesed by MBTI psychological test. This indicates that MBTI dimensions like source of energy, worldview perception, evaluation and lifestyle do not impact on in project's planned effort.

The results obtained also give evidence that the way the software project manager behaves in teamwork, according to Belbin's team roles theory, has a statistically significant impact on the variance of project effort deviation. This result is important because Belbin (2010b) highlights for management activities only the roles *Co-odinator (CO)* and *Shaper (SH)*. However, our results suggest that characteristics such as creativity and ability to turn ideas into pratical actions, of the roles *Plant (PL)* and *Implementer (IMP)* respectively influenced the variance reduction of the effort deviation in our software projects sample.

As future work, we can suggest studies to identify if the variance of the Belbin's team roles has the same characteristic when it relates to the project size. Furthermore, this study can be extended to the assessment of psychological personality using other instruments such as the *Big Five* (Goldberg, 1992).

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