Motivation and Satisfaction of Software Engineers

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Abstract—*Context*: The proper management of people can help software organisations to achieve higher levels of success. However, the limited attention paid to the appropriate use of theories to underpin the research in this area leaves it unclear how to deal with human aspects of software engineers, such as motivation and satisfaction. *Objectives*: This article aims to expose what drives the motivation and satisfaction of software engineers at work. *Methods*: A multiple case study was conducted at four software organisations in Brazil. For 11 months, data was collected using semi-structured interviews, diary studies, and document analyses. *Results*: The Theory of Motivation and Satisfaction of Software Engineers (TMS-SE), presented in this article, combines elements from well established theories with new findings, and translates them into the software engineering context. *Conclusion*: The TMS-SE advances the understanding of people management in the software engineering field and presents a strong conceptual framework for future investigations in this area.

Index Terms—Work motivation, job satisfaction, human resource management, software engineering

1 Introduction

Software engineering can be described as a social-intensive activity, because beyond the technical aspects extensively studied in this field, there is a diversity of human [1] and social [2] aspects that may affect the performance of software engineers at work. A naïve account of software engineering work would tend to see human and technical aspects separately: the former including forms of interaction, behaviours, and organisation of people, while the latter addressing the use that individuals and teams make of technologies, methods, processes and tools for software development. However, in practice, it is difficult to disentangle the way people do things from the methods, techniques, and computing technologies they use [3].

One of these human aspects, the motivation of software engineers, is "*reported to have the single largest impact on productivity and software quality management, and continues to be undermined and problematic to manage*" [4, p. 10:2]. This paper presents a theory of work motivation and job satisfaction of software engineers (TMS-SE), developed initially from previously existing theories and enhanced and adapted for the software engineering context.

Motivation and job satisfaction have been objects of study for a long time, in many different fields [5]. In software engineering, in particular, they have been studied for more than thirty years [6]. In the last ten years, these phenomena have increasingly attracted attention from the software engineering community, due to previous research that claimed that a proper management of motivation and satisfaction at work could help software organisations achieve higher levels of productivity, and avoid human resource turnover, budget overflow, and delivery delays [7], [8]. All these impacts represent relevant contributions to the overall success of software development projects [9], [10].

Researchers in the organisational behaviour field have identified such a wide range of inter-connected factors and phenomena that it is challenging to reach an unequivocal understanding of what can be useful to the management of work motivation and job satisfaction. Therefore, over time, several theories of work motivation and job satisfaction have been developed, evaluated, questioned, and evolved, through a continuous cycle of interaction between theoretical and empirical research work. Some of these theories have been dismissed, such as Maslow's Hierarchy of Needs Theory [11], while others have endured, such as the Job Characteristics Theory [12].

However, there are two main reasons to question whether the existing theories of work motivation and job satisfaction developed in other fields are applicable in a software development environment. First, in the past, researchers have shown that software engineers hold in common specific personal characteristics, and what influences their work motivation and job satisfaction is likely to be different from other professionals [6]. Second, research has argued that software engineering work challenges even ongoing theories of motivation and satisfaction, because of its knowledge-intensive nature, bringing unexplored aspects that drive the behaviour of professionals in this field [13].

Nevertheless, the number of studies on this topic is relatively small, and it is only possible to find a few attempts to

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evaluate work motivation or job satisfaction theories or models in software engineering contexts. In addition, studies on motivation and satisfaction of software engineers are characterized by little concern with an adequate use of well-established theories to underpin their research designs [4]. And, empirical studies in this area are still concentrated in developed countries, so aspects such as international cultural differences challenge the transferability of their results to other countries.

All these issues, together, prevent the accumulation of knowledge, leaving still unclear several theoretical and practical aspects of work motivation and job satisfaction in the software context and, although some advance has been achieved, all research effort so far represents only an "*unconnected body of work*" [4].

The aim of this research is to generate a sensible and contemporaneous understanding of how the work motivation and job satisfaction of software engineers are influenced by workplace factors, and how these phenomena influence their work-related behaviour. For that purpose, we followed a process of building theory from case study research, suggested by Eisenhardt [14], [15]. A multi-case study was carried out in four software engineering settings, in Recife, Brazil. For 11 months, rich data was independently collected in those organisations, by means of semi-structured interviews, diary studies, and document analyses. Then, a cross-case comparison was carried out, leading to to the theory of work motivation and job satisfaction of software engineers (TMS-SE). Finally, the emerging theory was compared against similar and conflicting evidence from studies available in the literature.

The theory presented in this article builds on the understanding from Locke [16] that work motivation and job satisfaction are distinguishable phenomena, with distinct antecedents and outcomes. Job satisfaction refers to pleasurable emotions in reaction to the job, signalled mainly by the individuals' happiness at work, and influences attitudes towards the organisation (intention to stay, attendance, and others). Work motivation, in contrast, refers to the desire to work, is signalled by individuals' attitudes toward the work (engagement and focus), and directly influences individual work performance.

This theory contributes to the state of art in three complementary ways. First, it advances the knowledge on this topic by providing a solid framework through which the available knowledge in this field is integrated and evaluated. Second, it enlightens the management of software engineers by clarifying what aspects of the work and the workplace are relevant to work motivation and job satisfaction of this specific type of professional, as well as by pointing out practical challenges attached to the software development practices. Third, it suggests areas worthy of further investigation, serving as a basis for future research in this area.

The rest of this article is organised as follow: Section 2 reviews the concepts of work motivation and job satisfaction as represented in the most frequently cited theories of motivation. Then, in Section 3, a historical view of the research on motivation and satisfaction in software engineering is presented, as well as the current state of art and research gaps. The research method, data collection and analysis procedures are carefully explained in Section 4, as well as the research strategy and the threats to validity and reliability of our research design. Section 5 reports the results of the individual cases, the cross-case analysis, and then the TMS-SE. In Section 6, the TMS-SE is compared to the previous existing literature on this topic, and presents reflections about the challenges for software engineering practice. Finally, Section 7 presents some concluding remarks, and enumerates suggestions for future research endeavours.

2 A Brief History of Research About Work Motivation and Job Satisfaction

According to Steers et al. [5, p. 379], if it was possible to effectively synthesize the different concepts of motivation, they would have a common characteristic: "*They are all principally concerned with factors or events that energize, channel, and sustain human behaviour over time*." Job satisfaction, in contrast, has been defined as "*complex emotional reactions to the job*" [16]. Although the phenomena are connected, two critical characteristics make work motivation different from job satisfaction. First, motivation is future oriented, while satisfaction is past oriented [17], i.e., motivation is antecedent of performance, while satisfaction is a consequence of work events, including performance. Second, work motivation is about individuals' perception of the work and its intrinsic characteristics, while job satisfaction is about the perception of a broader set of elements present in the job, including but not limited to the work itself.

The definitions of work motivation and job satisfaction have stimulated researchers from several fields, resulting in different competing and complementary theories [18]. Table 1 shows an overview of the most relevant theories of work motivation and job satisfaction found in the technical literature.

Locke [16] developed an extensive theoretical study to redefine the construct of job satisfaction. Since his definition was presented in 1969, it has become a consensus between academics from the organisational behaviour field [19] Locke suggests that job satisfaction and dissatisfaction are complex emotional reactions to the job. Such emotions are dependent upon an interaction between the person and his/her environment through the biological functions of cognition (sensations, perception), evaluation (consciously or subconsciously selection among alternative life-enhancing actions) and regulation (one's judgment of values). Job satisfaction is defined, thus, as a pleasurable emotional state resulting from the appraisal of one's job as achieving or facilitating the achievement of one's job values.

While the concept of job satisfaction has stabilized over time around the ideas of Locke, the understanding of work motivation has been less clear. Some of the motivation theories presented in Table 1 focus on motivation from a general decision-making process approach, that guide the rational choice of a determined behaviour, while other theories are interested in describing what aspects of the workplace may make people more or less "turned on" to work. All these theories are equally constrained by the approach they choose to take when looking at the motivation phenomenon.

In this research, we are specifically interested in software engineers' activity. Given that individuals motivated to work will perform at their best possible, we set out to investigate

TABLE 1
Overview of Work Motivation and Job Satisfaction Theories

Theory	Conceptual system	Empirical Support
Hierarchy of Needs Theory [40]	It is not possible to find an explicit definition of motivation and satisfaction in his articles. However, he implies a semantic difference between the words motivation, which refers to a state of need, and satisfaction, which refers to a state of no need.	Maslow does not present any data. Because of the difficulty in interpreting and operationalizing its concepts, the testability of this theory is limited [99]. Therefore, empirical assessments show generally weak or no support [86].
Motivation-Hygiene Theory [100]	It states that satisfied people are more productive, and job satisfaction is activated by two independent sets of factors: motivators (or satisfiers) are the primary cause of job satisfaction, and hygiene factors (or dissatisfiers) identified as primary cause of job dissatisfaction.	He shows no evidence on the relation between satisfaction and productivity [101]. Results are consistently supported only when Herzberg's basic methodology is used, including his classification scheme [102].
Expectancy Theory [83]	Satisfaction given by the convergence between subjective expectations and actual outcomes of an action. Motivation is the process of deciding whether an effort to perform a specific action is worthier than its available alternatives, and it is guided by the maximization of satisfaction experiences.	Empirical evaluations generally supported the predictive power of the expectancy theory in laboratory studies, but not in real settings given the existence of excessive uncontrollable factors [103], [104].
Goal Setting Theory [36]	Motivation is the willingness to strive for the goals of a particular organisation. The four elements that represent motivated behaviour in the Goal Setting theory are: Direction: goals direct attention and action; Effort: the amount of effort mobilized in proportion to the perceived requirements of the goal or task; Persistence: directed effort extended over time; Strategy development: the development of strategies or action plans for attaining one's goals.	There have been more than 500 studies of goal setting conducted by Locke, his colleagues, and others [105]. This is the longest stable theory of performance and task motivation, with the largest amount of empirical work supporting its claims.
Job Satisfaction Theory [16]	Job satisfaction is the pleasurable emotional state resulting from the subjective appraisal of one's job as achieving or facilitating the achievement of one's job values, providing these values are congruent with or help to fulfil one's basic needs. Subjective means pertaining only to individuals. Value is that which one acts to gain and/or to keep. Need refers to objective requirements to an organism wellbeing	Locke describes several empirical studies testing the existing correlation between subjective value-discrepancy and grades of job satisfaction. The results revealed a very similar level of correlation (+.70, +.69, -.61, -.81, and -.72 at $p<.01$).
Job Characteristics Theory [20]	Internal work motivation refers to "being turned on to one's work because of the positive internal feelings that are generated by performing well". Satisfaction is the degree to which the employee is happy with the job, or with specific aspects of the job.	This theory has found support on tests with more than one thousand people working on more than one hundred different jobs from real organisations, but relying on correlational instead causal analyses [75].

what elements of a software engineering workplace motivate these individuals to work.

One of the long-lasting approaches of work motivation refers to the motivating characteristics or potential of work related tasks, based on the ideas of Hackman and colleagues. According to Hackman's definition, work motivation refers to being turned on to one's work because of the positive internal feelings that are generated by performing well [20]. It is the individuals' willingness to work hard and well [12]. Hackman found three psychological states that are critical in determining if a person is internally motivated [20]:

- *Experienced Meaningfulness*: The degree to which the employee experiences the work as inherently meaningful, as something that counts in his/her own system of values [21].
- *Experienced Responsibility*: The degree to which the individual feels personally accountable and responsible for the results of the work he/she performs.
- *Knowledge of Results*: The degree to which the individual has confident knowledge about how well he/she is performing.

Hackman's Job Characteristics Theory (JCT) suggests therefore that the simultaneous presence of these three psychological states results in a set of favourable personal and work outcomes, such as work motivation and work performance. The JCT also identifies five objective characteristics of jobs that, when present, increase the chances that an employee will experience the three psychological states and, through them, shape the personal and work outcomes [21].

Experienced Meaningfulness is shaped by three job characteristics:

i. *Skill Variety* is the degree to which the job requires a number of different activities in carrying out the work, which involve the use of a number of different skills and talents of the individual. Work that stretches one's skills and abilities invariably is experienced as more meaningful than work that is simple and routine.
ii. *Task Identity* is the degree to which the job requires completion of a whole and identifiable piece of work, doing a job from beginning to end with a visible outcome. Putting together an entire product or providing a complete unit of service is inherently more meaningful than being responsible for only a small part of the work.
iii. *Task Significance* is the degree to which the work has a substantial impact on the lives of other people, whether in the immediate organisation or in the external environment. An activity that is consequential for the psychological or physical wellbeing of others is experienced as more meaningful than is work that makes little difference to anyone else.

Experienced Responsibility is shaped by the amount of autonomy the job provides:

iv. *Autonomy* is the degree to which the work is structured to provide the employee with substantial freedom, independence, and discretion in scheduling the work and in determining the procedures to be used in carrying it out.

Knowledge of Results is shaped by the degree to which carrying out job-specified work activities provide the individual with direct and clear feedback:

v. *Feedback* is the information about the effectiveness of his/her performance. When someone receives information about his/her performance from the work itself (e.g., when a salesperson closes a deal and receives payment from a customer), that feedback is direct and immediate and, therefore, contributes substantially to his/her overall knowledge of results about work outcomes.

Then, jobs high on the five core dimensions were described as having high Motivation Potential Score.

Notice that other aspects related to factors external to the job (known elsewhere as extrinsic motivators [37]) are not regarded as constituents of work motivation according to Hackman's theory.

In the late 90's, Ambrose and Kulik [22] observed that research in the organisational behaviour field replaced interest in the construct "motivation" with other easier-to-measure performance outcomes, so that motivation was "*moving backstage as a largely unmeasured, but still theoretically relevant, mediating variable*" [22, p. 280]. However, in face of recent changes in the nature of work, such as more employees performing knowledge work, the central construct of motivation has recovered relevance, and continued effort should be placed on defining and measuring motivation.

3 Motivation and Satisfaction in Software Engineering

The influence of general human aspects on individual and collective performance of software engineers has been recognized since the early days of software engineering [1], [2], [23], [24].

In the software engineering field, the seminal work of Couger and Zawacki [6] has brought light to the issue that computer personnel could be a distinctive group from the average population, regarding individual needs and, for this reason, what motivated software engineers was likely to be different from what motivated the population in general.

Couger and Zawacki [6] carried out a nationwide survey in the United States, which was replicated over a decade in several countries such as Austria [25], Israel and Singapore [26], Australia [27], Hong Kong [28], Finland [29], Spain [30], Japan [31] and Egypt [32]. That effort accumulated enough data to argue that:

i. Software engineering settings generally suffered from a low level of feedback, which was later explained by the fact that software engineers have specific personality traits that limit their social interactions [26], [33], [34];
ii. Regardless of the cultural differences, populations of software engineers from all over the world exhibited similarities regarding their high growth needs (GNS) [35];
iii. Although job characteristics had some influence over the software engineers' motivation, other work-place factors should also be accounted in the equation, such as goal contents [36]. However, Couger and colleagues did not provide details on why or how other theories would add to the study of software engineers' work motivation.

After Couger and Zawacki's study, motivation kept being systematically studied in software engineering. Since then, researchers have addressed the problem of how to deal with the motivation of software engineers in several complementary ways. Two literature reviews [7], [8] searched relevant sources in software engineering, and systematically selected 140 studies about motivation and job satisfaction published in this field between 1980 and 2010. These reviews listed several factors that represent hypothetical motivators, demotivators, characteristics of software engineers, and outcomes of motivation.

Based on the results of the literature review, Sharp et al. [37] noticed that the pre-existing models of motivation in software engineering were being developed in isolation. Then, they delivered a proposal for an integrating model of motivation in software engineering, the MOCC model (acronym for Motivators, Outcomes, Characteristics and Context). This is an abstract, holistic model that enables researchers and practitioners to have a better understanding of the landscape of motivation, and provides a coherent framework for integrating research findings [37]. The MOCC model stands currently as the most relevant recent advance about the motivation of software engineers.

The systematic reviews and the MOCC model present a reasonable overview of factors that have been studied in this area. The number of studies on this subject has consistently increased overtime, authors are from at least 30 different countries, research focusing on emerging contexts such as agile methods and open source represent an important portion of the studies in the 2000's. In addition, studies often present empirical data with actual practitioners.

However, there is a gap in the theoretical underpinning of these studies, which prevents the accumulation of knowledge in this area. In order to be able to integrate different studies, learn from the differences, and advance our knowledge on this issue, we have to make sure that research efforts at least address the same phenomena. Nevertheless, there is no single notion of "work motivation" in software engineering research. From the 140 studies covered in the two literature reviews [7], [8], it is clear that these articles deal with a range of different objects of study (Table 2), from choosing IT as a career, to reasons for not leaving the organisation. In this article, in particular, we are interested in motivation to perform.

In addition, from the 67 empirical papers found in this list, only 35 effectively show evidence that support their claims (Table 2–Groups A to C), while the remaining papers are loose in their treatment of motivation or satisfaction, referring to other studies or to general knowledge, without clear evidence. Theoretical papers (Table 2 – Group D) generally argue about the importance of creating strategies to cope with the motivation of software engineers, present argumentation structures aiming to defend individual opinions of the authors, or propose improvements on existing models and theories without any empirical support.

TABLE 2
Typology of Studies Interested in Work Motivation and Job Satisfaction

Group	Type	Instances*
Group A: empirical studies explicitly interested in job satisfaction	Type A1: papers focused on antecedents of job satisfaction.	PS005, PS007, PS016, PS065, PS102, PS105, PS116, PS120, PS134
·	Type A2: papers focusing on intention to leave/stay in an organisation, as outcomes of job satisfaction.	PS007, PS014, PS036, PS037, PS045, PS050, PS052, PS066,PS076, PS086, P095, PS097, PS120
Group B: empirical studies that treat motivation as a decision-making process	Type B1: papers focused on reasons for choosing IT as a career	PS123, PS124
·	Type B2: papers focused on reasons for developing open source software	PS090, PS113, PS115, PS118, PS119, PS140
·	Type B3: papers focused on reasons for choosing an open source software to work for	PS113, PS115, PS136
	Type B4: papers focused on reasons for doing a specific task (e.g., refactoring)	PS131
Group C: empirical studies interested in work motivation	Type C1: papers focused on the antecedents of work motivation	PS016, PS056, PS100
·	Type C2: papers focused on assumed outcomes of work motivation (performance, productivity, proactive behaviour)	PS005, PS091, PS099,PS101
Group D – theoretical accounts	Type D1: theoretical papers focused on work motivation of software engineers	PS001, PS006, PS024, PS029, PS033, PS034, PS043, PS046, PS058, PS075, PS107, PS112, PS129

*see the list of the SLR primary studies (PS) on Appendix B, which can be found on the computer society digital library at http://doi.ieeecomputersociety.org/10.1109/TSE.2018.2842201.

It is even possible to notice a paradox in those studies based on the idea that software engineers are different from other professionals: they rely mainly on theories developed in other fields to underpin their recommendations about how to deal with software engineers' motivation. Often, theoretical studies call for clarifications about the antecedents of work motivation of software engineers.

Moreover, a significant part of the SLR studies (40/140) do not explicitly mention any theory of motivation or satisfaction. It does not mean that the remaining portion of studies have properly used a theory. Only seven papers effectively used the theory to either test or discuss the empirical findings. Notice, for example, that there are only three papers focusing on the antecedents of work motivation for software engineers (Type C1), two of which ([38], [39]) are not underpinned by any classical theory of motivation. Thus, as Hall et al. [4, p.10:25] concluded: "*studies of motivation in software engineering (...) should be more rigorously based on existing theory*."

Other studies (Type C2) assume outcomes such as performance or productivity, and use them as proxies to draw conclusions about work motivation or job satisfaction. However, it is not possible to infer from these studies how those factors are responsible for the work motivation or job satisfaction of software engineers. According to Maslow [40], human behaviour is determined by a set of antecedents, of which motivation represents only one.

Roznowski and Hulin [41, p. 124], suggests that all there is to know about job satisfaction is already known. This is borne out by the fact that the studies explicitly interested in antecedents of job satisfaction in software engineering fit perfectly in those of Locke's classification scheme (see Table 3).

Work motivation and job satisfaction of software engineers in the context of agile methods, and more recently in the context of distributed software development (DSD) practice, are two common focal problems. Šteinberga [43] and Šteinberga and Šmite [44] are mainly concerned with employee turnover resulting from lack of job satisfaction of software engineers in the context of offshore projects, because of the additional complexity that globally distributed projects bring to managers. El Khatib et al. [45], in contrast, focus on the subjective characteristics of DSD practice that influence work motivation and, as a consequence, performance.

In terms of practical effects of motivation and satisfaction over performance, Graziotin et al. [46] reported a quasi-experiment containing evidence that happy software developers performed better at solving problems than non-happy developers; but found no difference between them when it comes to creativity tasks. They conclude by calling for further studies to understand why that happens.

With respect to theoretical frameworks, other recent papers such as De Farias Junior et al. [47] and Hernández-Lopez [48] underpin their work with outdated theories, such as Maslow's Hierarchy of Needs and Herzberg's Motivation-Hygiene Theory. The use of these theories is discouraged in the organisational behaviour field, partly because of their limited validity and partly because of the large amount of knowledge that has been developed after these theories were first delivered [49].

Finally, we have not been able to effectively answer research questions related to work motivation and job satisfaction in software engineering because of a lack of an appropriate theoretical framework. Given the growing relevance of the problem, and based on the limitations of the state of art pointed out in this Section, in the next Section we present

TABLE 3
What is Known About Job Satisfaction Factors in Software Engineering

Factors	What the literature says*
The work itself	Seven studies [PS005, PS016, PS102, PS105, PS116, PS120, PS134] support the relationship between the characteristics of the work (autonomy, identity, variety, significance, and feedback) and job satisfaction of software developers. The relationship between autonomy and satisfaction is disputed in two articles [PS102, PS116], the relationship between task identity and job satisfaction was not supported in two [PS005, PS065]. PS065 also found no support for the effects of task significance and feedback over job satisfaction.
Pay & Benefits	Three articles provide evidence showing that both a good salary [PS016, PS134] and a good variable remuneration [PS102] relates to the job satisfaction of software engineers.
Recognition	Two articles [PS016, PS102] support the relationship between recognition and job satisfaction of software engineers.
Promotion	Three papers [PS016, PS105, PS120] support the relationship between opportunities for promotion and job satisfaction. In only one study [PS102] was this relationship not supported.
Working conditions	Only one paper [PS016] addressed the relationship between working conditions and job satisfaction, and found support for this relationship in the data. If the relationship between the developer and the users is included in this category, then there is another study [PS102] that supports it.
Company	One study [PS016] finds a positive relationship between job security and job satisfaction, while another study [PS102] does not. In the second article, the authors asked the participants from what job aspects they get most satisfaction. Therefore, it is understandable that job security, being a hygienic factor, does not appear in their list.
Supervisors	Four studies [PS005, PS065, PS120, PS134] support the relationship between satisfaction with supervisory behaviour and job satisfaction.
Co-workers	Sense of belonging appears related to job satisfaction in one article [PS120], while working with other people in a team appear related to job satisfaction in two other [PS102, PS134].
The self	*None*

*see the list of the SLR primary studies (PS) on Appendix B, available online.

our methodological approach, designed to advance and consolidate our current knowledge in this area, and further to contribute towards closing the gaps related to this problem.

4 Methods

4.1 Design of the Research Method

In this research, we are interested in building a theory of work motivation and job satisfaction that accounts for specific characteristics of software engineering work. We built this theory based on the understanding of how individual software engineers experience work motivation and job satisfaction, and why certain combinations of workplace factors lead to more or less motivated behaviour and job satisfaction. The following research question guided the investigation: *How do workplace factors influence the work motivation and job satisfaction of software engineers?*

Workplace factors here refer not only to job characteristics but also to any other constituent element of the worklife that exhibits a relationship with the two constructs being studied.

Given the current state of the art described in the previous section, we believe that a new theory of work motivation and job satisfaction for software engineers that explicitly separates these two factors would represent a substantial contribution to research and practice. For the former, a theory would expand our knowledge of the investigated phenomena and also show directions for further research. For the latter, a theory may offer guidance to managers and individuals about how to build and sustain a better work environment.

In pursuit of this new theory of motivation and job satisfaction of software engineers, we followed the roadmap proposed by Eisenhardt [14] to build theories from multiple case study research. Eisenhardt and Graebner [15] comment that "*Theory building from case studies is an increasingly popular and relevant research strategy that forms the basis of a disproportionately large number of influential studies*". In our research, case studies are understood as "*in-depth description and analysis of a bounded system*" [50], focused on "*understanding the dynamics present within those settings*" [14]. Based on Eisenhardt's [14] suggested procedure, a research protocol was designed to collect and make sense of data from four independent holistic case studies from a selection of organisations. Eisenhardt's [14] process is summarized in the following set of ordered activities:

1. *Getting started*: involves defining research question(s) and selection of constructs of interest;
2. *Selecting Cases*: comprises defining the population of interest and selection strategies to assure theoretical sampling;
3. *Crafting instruments and protocols*: regards the choices for data collection methods, design of instruments, strategies for triangulation of evidence, participation of multiple investigators and the documentation of the research protocol;
4. *Entering the field*: concerns the actual data collection, as well as the overlap between data collection and analysis, to allow adjustments in the data collection;
5. *Analyzing data*: includes the within-cases analyses to gain familiarity with data and preliminary theory generation, and the cross-case pattern search to look at evidence through multiple lenses;
6. *Shaping hypotheses*: concerns an iterative tabulation of evidence for each emerging construct, to find hypothesized relationships between the constructs of the emerging theory, and then test them back against the data from the individual cases;
7. *Enfolding literature*: comprises comparing the emerging theory with similar and conflicting literature to build internal validity, raise theoretical level, and sharpen generalizability;

8. *Reaching closure*: achieve theoretical saturation when possible.

In the following paragraphs, our implementation of each step is properly detailed.

Getting started: The research design in the present work established two a priori constructs of interest: job satisfaction and work motivation. In the beginning, we were interested in understanding how workplace factors affected the motivation of software engineers, and what the perceived outcomes of motivation were. In [51], we reported a meta-ethnographical synthesis [52] of two case studies. In that work, motivation and satisfaction were considered as a single construct as perceived by the study participants, which has been a common practice in previous research on motivation in the software engineering field (see Section 3).

However, the more sophisticated understanding of work motivation and job satisfaction that we acquired from that experience, led us to question whether participants from different cases had a consistent understanding of the terms "motivation" and "satisfaction" or were they in fact expressing their opinions and experiences about several other distinct phenomena (see [53] for more details).

After that, we decided to reanalyse the data with a more up to date and consistent theoretical framework, and selected the following two theories to approach our constructs of interest: (1) Hackman's Job Characteristics Theory, which defines work motivation as "*being turned on to one's work because of the positive internal feelings that are generated by performing well*"; and (2) Locke's Job Satisfaction Theory, which defines job satisfaction as the "*pleasurable emotional state resulting from the subjective appraisal of one's job*" (see Section 2 for a more detailed discussion on these theories).

To accommodate this new frame of mind, we needed a precise empirical basis, to enable us to identify clearly the data chunks in which participants were talking about work motivation or job satisfaction, and to discard more easily anything that wasn't relevant, thus assuring theoretical consistency with the constructs in question. Therefore, we adopted three more specific questions to guide our reanalysis of the data from the case studies:

RQ1. Which behavioural descriptors characterise the work motivation and job satisfaction of software engineers?
RQ2. Which workplace factors influence the behavioural descriptors of work motivation and job satisfaction of software engineers?
RQ3. What are the outcomes of work motivation and job satisfaction of software engineers?

This approach addressed any potential inconsistencies in the participants' understanding because we could use the answer for RQ1 to establish an empirical basis to enable the investigation of RQ2 and RQ3.

Selecting Cases: In the first level of sampling, cases to be investigated were selected. The rationale for choosing cases based on Yin's [54] replication logic was used here. In the cases level, we sought variation in sizes of organisations (large and small, having respectively more and fewer than 50 workers), and in their business nature (private/public). In Brazil, the contractual rules are different between private and public organisations and we wanted to collect views from both perspectives. A similar overall context is important to enable the integration of findings, so the four chosen participant organisations are from Recife, in Brazil.

Then, in the second level of sampling, participants and other sources of data needed to be sampled within each case. We aimed for a good coverage of age, background, education, years of employment in the organisation, participation in different projects in the organisation, and work on different activities in software development and maintenance, to ensure a potentially fertile sample.

Crafting instruments and protocols: The non-observable nature of work motivation and job satisfaction as internal states, led us to the decision to use interviews. However, as Sohn et al. [55] highlight, interviews rely on participants' memories and there is always the risk of the interviewee not remembering something relevant to the research. Therefore, our interviews were complemented with diary data, collected right in the moment when relevant events happen. All data collection was conducted in Brazilian Portuguese, with the premise that it is easier to express opinions, feelings, and emotions in one's native language. Finally, we mined organisational documents related to human resources and norms that regulate employee-organisation relationships to verify and corroborate evidence raised in interviews and diary studies about organisational characteristics and policies. The instruments for collecting data in the interviews and in the diary studies are detailed below.

- *Interview scripts*: A semi-structured interview script was used, composed of open-ended questions. The questions were initially based on the dimensions of the MOCC model (motivators, outcomes, characteristics and context) [37]. It was then expanded to include questions aimed at exploring experiences, behaviour, opinions, values, feelings, knowledge and background, all of which are indicative of motivation and job satisfaction. The script was designed in a funnel format [56], beginning with general questions and moving towards more specific ones. All positive questions (e.g., 'what do you like about…?') had a corresponding negative one (e.g., 'what do you dislike about …?'). The guide was pre-tested with two pilot interviews and minor changes were identified to improve the interview guides, such as better wording of some questions. Therefore, the final version of the script had 43 questions, a sample of which is in Table 4.
- *Diary Study*: A diary study is a data collection method in which "participants are asked to record their daily activities on a pre-structured log form" [57]. It is a way to understand participant behaviour and intent, in situ, which minimizes the effects of observers or interviewers on participants [58]. Diary data was collected for a period of two weeks. At the beginning of each week, our selected participants received a blank notepad (paper), which they annotated with information about any event that affected (positively or negatively) their motivation or satisfaction at the moment the event occurred; At the end of every workday, participants completed an on-line form, with a list of all relevant events in that day, and provided detailed information about how and why the events affected their work. The notepad

TABLE 4
Examples of Interview Questions Translated to English (Original Ones Were in Brazilian Portuguese (PT_br))

Q1. Tell me about yourself, your education, professional trajectory, etc.
Q2. Why did you decide (or what has brought you) to work as a software engineer?
. . .
Q12. Among your daily activities, what are those you like most?
Q13. What is it about these activities (Q12) that makes you like them the most?
. . .
Q36. What does the organisation do, or offer, to stimulate the software engineers' motivation?
Q37. How do these actions/offers affect your particular work?
. . .
Q40. What could the organisation do (but currently does not do) to stimulate the software engineers' motivation?
Q41. Projecting your career five years towards the future, what do you hope you will be doing?
. . .
Q43. What does the term motivation mean to you?

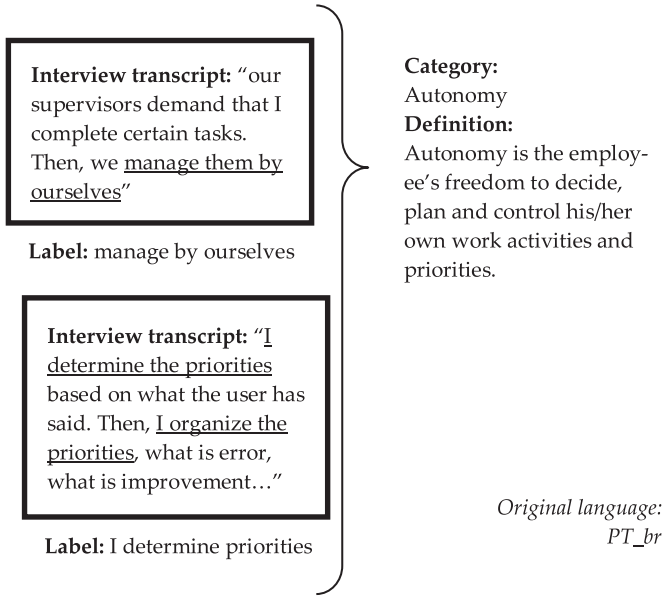

Fig. 1. Category building example in the individual case studies.

information acted as an aide memoire for events to enter in the online form.

Entering the field: Over a period of one year between 2010 and 2011, four Masters' students carried out the data collection, each one in a distinct organisation, under the supervision of the authors of this article. Potential participants were initially contacted by e-mail, and invited to participate; participation was voluntary. Those who agreed were required to sign an Informed Consent Form, which guaranteed confidentiality of the data, and the right to withdraw from the research at any moment. They were formally allowed by their line managers to use work hours for the interviews and diary studies. All interview sessions were audio recorded with formal consent of the participants. The interviews were scheduled and conducted individually, at the organisation's own offices. Participants in the diary studies were chosen from those that participated in the interviews. At the end of the diary study, researchers carried out a short retrospective interview to clarify and complement information submitted in the online form and collected the notepads that had been completed during the week.

Analyzing data: For the first research question (RQ1), analysis was based on the data collected from interviews, focusing on two interview questions: "How would you describe a clearly motivated colleague?" (Q25) and "How would you describe a clearly demotivated colleague?" (Q31). Then, adjective sets describing motivated and demotivated engineers were identified. These adjective sets are referred to as behavioural descriptors throughout the analysis. This first step provided the grounds needed to properly scrutinize the full data from interviews and diaries to answer RQ2 and RQ3. The behavioural descriptors arising from RQ1 were used as pre-formed codes to identify the useful chunks of data that contributed to answer RQ2 and RQ3, as previously explained.

We used techniques of grounded theory [59] to code, categorize, and synthesize data. Initially, all audio from the interviews was transcribed verbatim. QSR NVivo 8[1] was used to support the data analysis and synthesis. Data analysis began with open coding of the transcripts. Post-formed codes were constructed as the coding progressed and were attached to particular pieces of the text. Diary data was also coded alongside interviews. All steps were carried out by two researchers, and conflicts were discussed in face-to-face meetings until full agreement was achieved. From the constant comparison of the codes, we grouped codes into categories that represent factors affecting work motivation and job satisfaction behaviours (for RQ2), and their outcomes (for RQ3). Fig. 1 shows an example of the category building process. Results from individual cases were presented at national and international conferences to validate the rigour of the partial results, and can be seen in França et al. [60], [61], [62].

Then, the cross-case analysis method was chosen to guide our case comparison [63]. We followed a standard process of content analysis based on the semantic similarity between the constructs emerging from different cases, to group them in categories that were more general. The categories were carefully labelled in order to properly represent all constructs in the group. We adopted tabular displays to present the integrative data, maintaining original meanings for each individual case study in a different column [64]. Cross-case tables were constructed for each research question, and the categories were analysed according to the specificities of each case, in order to shape the answers to our research questions.

Shaping hypotheses: The constructs resulting from the data analysis were revisited, in order to make sense of their relationships. Moderators of these relationships were also identified, and propositions were built to sustain the emerging theory. Then, a model of work motivation and job satisfaction was designed.

Enfolding literature: Finally, the emerging theory was compared to already existing concepts from scienfic literature. After that, the resulting theory was compared to previous studies with purposes similar to the present research: Couger and Zawacki [6] and Sharp et al. [37], and other relevant papers selected from the references of the systematic literature studies [7], [8].

1. http://www.qsrinternational.com/

TABLE 5
Participants and Amount of Data

CASE I: Government organisation	CASE II: Private not-for-profit organisation
Six participants from the headquarters were selected to participate in the interviews, which were conducted between August and December of 2010. The audio recorded from the interviews summed up to 4 hours and 57 minutes. One participant completed the diary, between February and March of 2011, reporting a total of 17 relevant events during the period of 15 days. **Profile of the participants:** *System analysts:* 3 males, 1 female; Ages: 27, 29, 32 and 39 years. *Developers:* 2 males; Ages: 29 and 32 years.	Six participants were selected from this organisation. The interviews were carried out between September and November of 2010, and summed up to 4 hours and 5 minutes of audio recorded. Two people participated in the diary data collection, which happened between February and March of 2011, and yielded 32 relevant events. **Profile of the participants:** *System analysts:* 2 males; Ages: 36 and 32 years. *Developers:* 3 males; Ages: 25, 29 and 28 years. *Tester:* 1 male; Age: 25 years.
CASE III: Small software development company	**CASE IV: IT department of a University**
For this case, we conducted 10 in-situ interviews during May 2011, which summed up to 6 hours and 40 minutes of audio. People from both types of project (external and internal products) participated in this research. From these, 3 participants opted to collaborate with the diary studies, during June 2011, bringing 10 relevant events during the period of two weeks of data collection. **Profile of the participants:** *Developers:* 7 males; Ages: 21, 23, 26, 26, 27, 28 and 29 years. *Tester:* 1 male, 1 female; Ages: 21 and 23 years. *Designer:* 1 male; Age: 22 years.	During February and March of 2011, ten participants were selected for interviews and the audio records summed up to 8 hours and 58 minutes. Two people took part in the diary study for a fifteen-day period between March and April of 2011, bringing 32 entries for relevant events. **Profile of the participants:** *System analysts:* 3 male; Ages: 27, 27, 29 years. *Developers:* 5 male, 2 female; Ages: 21, 23, 23, 25, 26, 31, 40 years.

Reaching closure: It was not possible to achieve theoretical saturation in this study, which is properly discussed, together with other threats to validity and reliability of this method, in the next section.

4.2 Threats to Validity and Reliability

According to Merriam [50], three issues are commonly pointed out in qualitative research: how to provide evidence that the findings are credible? Are the findings consistent with the data collected? And what is the possibility of someone else transferring the results to other similar contexts?

From the point of view of credibility (also referred to as Internal Validity), we collected data from a number of participants with mixed roles and profiles, and used multiple data collection techniques inside each case, including document analysis to confirm formal issues when needed. The low number of contributions in the research diaries is a possible limitation.

To increase consistency (also referred to as Reliability), we also kept research diaries and process logs that were constantly used as audit trails. In addition, two strategies were employed to enhance transferability (External Validity): first, detailed descriptions of the research method, context in which the research was performed, and the results themselves are provided here; second, cases and participants were sampled to achieve maximum variation since this helps to provide richer data and a more robust resulting theory.

Dey [65], advocates that instead of theoretical saturation, it is better to guarantee that categories are consistently built from the data, i.e., to look for theoretical sufficiency instead of saturation. This also agrees with the understanding of Charmaz [66]. In this research, at both levels of individual cases and cross-case, all the analyses were performed by at least two researchers, an audit trail was generated, and multiple sources of data were collected and used. According to Merriam [50], these procedures are enough to assure confidence, consistency and, thus, the theoretical sufficiency for our findings. Therefore, although theoretical saturation was not tested, we are confident that theoretical sufficiency has been achieved and that enough evidence is provided for the reader to decide the extent to which the findings can be applied to other situations.

5 Results

5.1 Individual Case Studies

In this section, we present the results pertaining to each case study. First, we describe the context of each case. Table 5 summarizes the number of participants in interviews and diary studies, the amount of data, and time periods in which the data was collected.

In the following subsections, we comment on the descriptors attributed by the participants to engineers with high motivation or high job satisfaction and those with low motivation or low job satisfaction (RQ1); the workplace factors that were found to influence work motivation and job satisfaction (RQ2) and the perceived outcomes of work motivation and job satisfaction (RQ3). The data here is presented in summarized tables, but more details can be found in Appendix A available online, with examples of interview excerpts or diary data to illustrate the meaning of each descriptor.

Case I: The government organisation. The first case study was carried out in a government software organisation situated in Recife, Brazil, established in 1969 by the Government of the State of Pernambuco. Its core mission was to provide Information Technology services to internal customers in several levels of the State Government administration and to the citizens of the State. As a government owned organisation, it was regulated under the laws and norms of the Brazilian public sector, which had two characteristics that were relevant for this study. First, since the Brazilian Constitution of 1998, public employees must be hired through an open process with universal access, based on objective criteria. This rules out subjective interviews, personality and behavioural assessment, references from other people, and other forms of employee selection found in the private sector. On the other hand, it slows down the process of hiring new employees and, therefore, makes it difficult to produce timely replacement when someone leaves the organisation. Second, all public employees have job stability after a probation period of 3 years of working in the public sector (State Law N°. 6.123/68).

At the time the research was conducted, the organisation was structured in 14 offices distributed in different locations

TABLE 6
Behavioural Descriptors and Workplace Factors (Case I)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR (RQ1)	WORKPLACE FACTORS (RQ2)
WORK MOTIVATION	• Focus	• Well defined work • Fair workload
	• Commitment	• Being updated • Different domains
	• Hard-work	• Engagement of co-workers • Social relevance • Confidence
	• Interest	• Creativity • Problem solving
JOB SATISFACTION	• Excitement • Mood	• Success • Recognition

throughout the State. Its employees, including software engineers, were distributed in the main management units and in over 60 other public administration buildings. At the-time thisresearch was performed, the organisation had 2,580 employees.

Regarding software development methods and practices, this organisation used traditional, process-oriented methods, with a command and control style of management in most software projects, although some small and isolated agile initiatives could also be found.

When describing work motivation and job satisfaction of software engineers, participants used the list of positive and negative adjectives in Table 6 (RQ1). The workplace factors linked with high motivation and high job satisfaction are also listed in Table 6 (RQ2). Our analysis identified the perceived outcomes of work motivation and job satisfaction listed in Table 7 (RQ3).

Case II: A private not-for-profit organisation. The second case study was carried out in a private and not-for-profit software development organisation, which had branches in three states of Brazil. The organisation's headquarters were located in the Porto Digital Science Park [67], in Recife, Brazil. This organisation was created through the merging of two research foundations, the first one created in 1994. It operated in many different areas, such as Information Technology, Telecommunications, Industrial Automation, Solutions for the Public Sector, and Energy, by providing support services, workforce supply for third-parties, development of software and hardware products, software factory, product certification tests, and research and development of technological innovative products. The organisation had a SW-CMMi level 2 certificate and was targeting the SW-CMMi level 3 at the time of the development of the case study.

TABLE 7
Outcomes of Work Motivation and Job Satisfaction (Case I)

CONSTRUCT	OUTCOMES (RQ3)	
	WHEN HIGH, CAUSES...	WHEN LOW, CAUSES...
WORK MOTIVATION	• Productivity • Communication • Proactivity	• Laziness • Isolation
JOB SATISFACTION	• Punctuality	• Absence • Troublemaking

TABLE 8
Behavioural Descriptors and Workplace Factors (Case II)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR (RQ1)	WORKPLACE FACTORS (RQ2)
WORK MOTIVATION	Focus	• Clear requirements • Balanced workload • Quiet environment
	Engagement	• Technical skill development • Project variety • Team expertise • Knowledge exchange
	Hard work	• Useful product • Brainwork • Research • Commitment of co-workers
JOB SATISFACTION	Mood	• Work success • Recognition

The management processes broadly followed the PMBOK guide [68], and managers were certified Project Management Professionals (PMP); some projects had been adopting SCRUM agile management practices. At the time that this research was carried out, the organisation had about 300 professionals, 85 percent of whom were technical and 15 percent performed administrative tasks. This case study was limited to the Recife branch, with 40 professionals.

This branch had both hardware and software development projects, but only software professionals were selected to participate in this research, which included people working on web, mobile, and embedded systems, using technologies such as .NET and Java. In this branch, there was no specific human resource management, and project managers performed the activities related to human resources management.

Table 8 contains the set of adjectives originated from the analysis of the behavioural descriptors used by the participants in this case (RQ1), as well as details about the workplace factors that influence work motivation and job satisfaction raised in Case II (RQ2). As for outcomes of work motivation, participants reported the outcomes listed in Table 9 (RQ3).

Case III: A small software development company. The third case study was carried out in a software company formally established in 2006 by the initiative of five entrepreneurs from the Information Technology sector in Recife, Brazil. Its

TABLE 9
Outcomes of Work Motivation and Job Satisfaction (Case II)

CONSTRUCT	OUTCOMES (RQ3)	
	WHEN HIGH, CAUSES...	WHEN LOW, CAUSES...
WORK MOTIVATION	• Participation • Help others • Proactivity • Integration • Productivity	• Quiet/reserved • Laziness • Passivity
JOB SATISFACTION	-	• Lack of commitment

TABLE 10
Behavioural Descriptors and Workplace Factors (Case III)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR (RQ1)	WORKPLACE FACTORS (RQ2)
WORK MOTIVATION	• Focus	• Clear requirements • Goal-driven responsibilities • One project at a time
	• Care • Engagement	• Helping others • Domain variety • Intellectual challenge • Motivation of co-workers • Technical confidence • Continuous learning
JOB SATISFACTION	• Mood	• Performance • Recognition • Customer feedback

TABLE 11
Outcomes of Work Motivation and Job Satisfaction (Case III)

CONSTRUCT	OUTCOMES (RQ3)	
	WHEN HIGH, CAUSES...	WHEN LOW, CAUSES...
WORK MOTIVATION	• Interactivity • Help others • Proactivity • Productivity	• Laziness • Isolation • Passivity • Low productivity
JOB SATISFACTION	• Commitment • Calm	• Absence

core mission was to support the development of people and organisations with software tools, by means of technical excellence and innovation.

This company specialized in software development for different platforms, with expertise in different programming languages (such as .NET Framework, Java family, LUA programming language, and others).

It focused on the on-demand development of information systems, operating in areas such as management, finance, mining, health, and others. In addition, it also developed its own products. Its flagship product was a corporate social network, aimed at providing support to intra-organisational innovation management. At the time of this research, the company served national and international customers, mostly medium and large companies.

The company followed an agile software development process, broadly adopting practices such as regular delivery of software, adaptive management style (SCRUM based), small teams, face-to-face meetings, and customer authority. The organisational structure was flat, and the directors often worked as part of the development teams. The directors themselves, who have software engineering backgrounds, managed all organisational issues, including human resources. At the time that the case study was carried out, the company was composed of 27 people, each of whom was younger than 30 years (directors included), and occupied functions in one of three types of team: software development, research and design. Some of them had been in the organisation for less than six months, while others had been with the team for more than 3 years. As an organisational strategy, the company had close ties to academia, both physically (its location is near a University) and operationally, since its employees were undergraduate students (trainees) as well as graduates in software engineering. We sampled participants representing all groups.

In this case study, work motivation and job satisfaction of engineers were described as detailed in Table 10 (RQ1), where the conditions for each component of work motivation and job satisfaction are also listed (RQ2). The outcomes of work motivation that resulted from this case are described in Table 11 (RQ3).

Case IV: IT department of a University. The fourth case study was carried out in the Information Technology department of a federal university in Recife. The department was responsible for the maintenance and evolution of the information systems of the University (such as academic and assets management information). Its core product was released in the early 2000's, and since then was continuously evolved and adapted. Although this organization works only with this single product, it is a large piece of software. The product is a web-based system, written in Java, with about 840 features, organized in several software modules, which sum up to more than one million Lines of Code, and at the time this case study was carried out, it received about four thousand hits per month.

The department was mainly organized in three sectors: one responsible for the inception of new features to improve the information processing procedures in the university; one responsible for the maintenance of the largest software module of the product, the academic administration module; and a third sector responsible for the elaboration and development of any new modules. Regarding the software development process, this department followed an agile SCRUM-based approach. Internal procedures were defined and continuously improved by a study group, which aimed to make these internal processes comply with the MPS.br model [69].

The development process was well defined regarding the configuration management, project management, requirements management, portfolio management and quality assurance. Some initiatives served as pilot studies for procedures such as acquisition, measurement, validation and verification. This department had 37 professionals, working under three different types of contract: eighteen public employees, eleven employees from third-parties and eight internships. The first category is composed of government employees who therefore had the same rights as described in Case I. Third-party employees were regular employees of another organisation that was responsible for supplying workforce to many departments in the university, so they had a regular private employment contract with the third-party organisation, but they were fully allocated to the University. Interns were contracted under a standard educational internship contract, with less responsibility and less work time in the organisation. The data collection included professionals with each of the three different types of job contract.

For the participants of this case study, software engineers' work motivation and job satisfaction are described as seen in Table 12 (RQ1). Table 12 also shows the workplace factors pointed out as conditions for work motivation and job satisfaction (RQ2). Our analysis showed the outcomes of work motivation and job satisfaction of software engineers as in Table 13 (RQ3).

TABLE 12
Behavioural Descriptors and Workplace Factors (Case IV)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR (RQ1)	WORKPLACE FACTORS (RQ2)
WORK MOTIVATION	• Focus	• Clear processes • Clear customer needs • Clear goals • Fair work load
	• Care	• Useful products • Authorship
	• Engagement	• Learning opportunities • Learning about the product • Engagement of co-workers • Project variety • Maturity of co-workers • Variety of work
	• Hardwork	• Intellectual challenge • Self confidence
JOB SATISFACTION	• Excitement	• Accomplishment • Practical impact
	• Mood	• Recognition

TABLE 13
Outcomes of Work Motivation and Job Satisfaction (Case IV)

	OUTCOMES (RQ3)	
CONSTRUCT	WHEN HIGH, CAUSES...	WHEN LOW, CAUSES...
WORK MOTIVATION	• Proactivity • Interactivity • Mutual help • Productivity	• Laziness • Passivity • Social isolation • Helpless • Lack of productivity
JOB SATISFACTION	• Responsibility • Calm	• Pessimism • Absenteeism • Irresponsibility

5.2 Cross-Case Analysis

RQ1 - What behaviours characterise the work motivation and job satisfaction of software engineers?

Table 14 brings together the behavioural descriptors evidenced from the four case studies, as detailed in the previous section. This shows that six descriptors characterize work motivation of software engineers, but that the descriptors Focus and Engagement are strongly evident in all four case studies. Focus is interpreted as the expressed level of attention, while engagement refers to the expressed level of effort, both applied to a task. On closer inspection of the data, and after several rounds of discussion, we concluded that the other four descriptors (Care, Commitment, Hardwork and Interest) could be viewed as sub-categories of these two central descriptors. For example, carelessness occurs when someone is distracted from the task, and hence not focused; someone engaged in the work will also be interested in the outcome. While the exact relationship between these descriptors could be argued, we decided to adopt the label Focus to unite focus and care, and the label Engagement to represent commitment, hard-working, and interest. Observe that both descriptors comprise behaviours that are perceivable before and during the execution of a task.

Job satisfaction was described in terms of mood in all case studies, while in Cases I and IV, excitement was also an evident signal of job satisfaction. We followed the same rationale as above and concluded that mood and excitement are sub-categories of a new descriptor Happiness, as shown in Table 18.

RQ2 - Which workplace factors influence the work motivation and job satisfaction of software engineers?

Table 15 shows the result of the effort to synthesize the workplace factors connected to high levels of work motivation and job satisfaction. It was possible to map two workplace factors of focus, and six workplace factors that influence engagement. These factors are individually discussed below.

Well defined work was cited in all case studies as important for focus. In Case I, the development followed no particular development process, so it is reasonable that four participants identified the need for a better defined work process. However, the organisation in Case IV apparently followed well defined work procedures, but according to the participants of that case, lacked clarity about the customer needs in the documents. Thus, the category labelled "well defined work" refers to not only the working process, but also the content of work in terms of requirements and/or specific goals.

Cognitive Workload was cited in all cases too. The reason for workload being a relevant factor is revealed by an interviewee in Case III, which when explaining lost focus, makes a reference to the cognitive effort that software engineers must do to swap their thinking contexts between disctinct projects or concurrent demands.

Acquisition of useful knowledge appears as a factor of engagement in all four cases as well. Being updated, either to apply new technologies to work in order to be more productive (Cases I and II), or to expand one's possibility to find other job opportunities (Cases III and IV), is a relevant driver of engagement. Knowledge acquisition can occur

TABLE 14
Behavioural Descriptors for Work Motivation and Job Satisfaction (Cross-Case Tabulation)

CONSTRUCT	CASE I: BEHAV IOURAL DESCRIPTOR	CASE II: BEHAV IOURAL DESCRIPTOR	CASE III: BEHAV IOURAL DESCRIPTOR	CASE IV: BEHAV IOURAL DESCRIPTOR	EMERGING BEHAV IOURAL DESCRIPTOR
WORK MOTIVATION	*FOCUS* - *COMMITMENT* *HARD-WORK* *INTEREST*	*FOCUS* - *ENGAGEMENT* *HARD WORK* -	*FOCUS* *CARE* *ENGAGEMENT* - -	*FOCUS* *CARE* *ENGAGEMENT* *HARDWORK*	**FOCUS** **ENGAGEMENT**
JOB SATISFACTION	*MOOD* *EXCITEMENT*	*MOOD* -	*MOOD* -	*MOOD* *EXCITEMENT*	**HAPPINESS**

TABLE 15
Workplace Factors for Work Motivation and Job Satisfaction (Cross-Case Analysis)

BEHAVIOUR	BEHAV IOURAL DESCRIPTOR	CASE I: WORKPLACE FACTORS	CASE II: WORKPLACE FACTORS	CASE III: WORKPLACE FACTORS	CASE IV: WORKPLACE FACTORS	EMERGING WORKPLACE FACTORS *Definition*
WORK MOTIVA-TION	FOCUS	*WELL DEFINED WORK*	*CLEAR REQUIRE-MENTS*	*CLEAR REQUIRE-MENTS, GOAL-DRIVEN RESPONSIBILITIES*	*CLEAR PROCESS-ES, CLEAR CUSTOMER NEEDS, CLEAR GOALS*	**WELL DEFINED WORK** *Working in systematic tasks with clear goals, well defined requirements and predicable results*
		FAIR WORKLOAD	*BALANCED WORKLOAD*	*ONE PROJECT AT A TIME*	*FAIR WORK LOAD*	**COGNITIVE WORKLOAD** *how fair and balanced the cognitive workload and the responsibilities are, at work*
	ENGAGEMENT	*BEING UPDATED*	*TEAM EXPERTISE, KNOWLEDGE EXCHANGE, TECHNICAL SKILL DEVELOPMENT*	*CONTINUOUS LEARNING*	*LEARNING OPPORTUNITIES, LEARNING ABOUT THE PRODUCT MATURITY OF CO-WORKERS*	**USEFUL KNOWLEDGE** *The knowledge that the individual believes that he/she can acquire as part of, or a reward for, a task execution, and which can be useful for their life, career, performance, etc..*
		SOCIAL RELE-VANCE	*USEFUL PROD-UCTS*	*HELPING OTHERS*	*USEFUL PROD-UCTS*	**SOCIAL IMPACT** *How the individuals perceive that their products have a social impact, i.e. benefits other people's lives, is useful or significant.*
		DIFFERENT DOMAINS	*PROJECT VARIETY*	*DOMAIN VARIETY*	*PROJECT VARIETY, VARIETY OF WORK*	**WORK VARIETY** *The individuals have contact with different tasks, business domains, rules and challenges.*
		CREATIVITY, PROBLEM SOLVING	*BRAINWORK, RESEARCH*	-	*AUTHORSHIP*	**CREATIVE WORK** *The tasks involve creating new solutions for new and challenging problems*
		CONFIDENCE	-	*INTELLECTUAL CHALLENGE, TECHNICAL CONFIDENCE*	*INTELLECTUAL CHALLENGE, SELF CONFI-DENCE*	**CHALLENGING WORK** *Tasks that defies (without suppressing) the indi-vidual belief that he/she is technically able of accomplishing it.*
		ENGAGEMENT OF CO-WORKERS	*COMMITMENT OF CO-WORKERS*	*MOTIVATION OF CO-WORKERS*	*ENGAGEMENT OF CO-WORKERS*	**ENGAGEMENT OF CO-WORKERS** *How engaged the co-workers are perceived to be*
JOB SATISFAC-TION	HAPPINESS	*SUCCESS*	*WORK SUCCESS*	*PERFORMANCE*	*ACCOMPLISH-MENT*	**ACCOMPLISHMENT** *Being able to conclude the activities just as (or better than) the plans*
		RECOGNITION	*RECOGNITION*	*RECOGNITION, CUSTOMER FEEDBACK*	*PRACTICAL IMPACT RECOGNITION*	**RECOGNITION** *Compliments received from peers, supervisors and customers after the work is done.*

through training, or working with different people or different entities (technologies, projects, problem domains, etc.). According to our findings, the knowledge being offered to software engineers must be useful, i.e., can be converted to productivity or money (job opportunities), otherwise it would not be valuable for them.

Social impact was also found to be a strong facilitator of engagement. Although in public organizations the social significance of their activity is clearer, engineers from all cases pointed out that the utility and social impact of the product on which they are working causes work motivation. Developing information systems that are used by a social group of which they are themselves a member is a compelling reason to be engaged in their work.

Work variety is a complex characteristic of the work. The data shows that it is important for software engineers to have contact with different tasks (Cases II and IV), business domains, rules and challenges (Cases I and III). However, this variation of projects and tasks must be managed in a way to avoid distractions and workload problems. Working on simultaneous projects, for example, may not be an effective way to achieve work variety, because shifting the context between completely different projects may increase cognitive workload, as previously discussed.

Software engineers are likely to be engaged in creative work. It is not only the brainwork characteristic of the work (as in Case II) that is motivating, but more challengingintellectual tasks, involving problem solving (Case I), research (Case II) and creation (Case IV). Even though writing software is knowledge-intensive work, not all tasks in a development process are considered challenging and creative. Besides, the meaning of "challenge" varies with different people. Among our participants, there are a few examples of participants saying that testing is boring, while others refer to testing as a challenging and creative activity. The same conflict of opinions happens in other activities such as requirements elicitation, documentation, and programming. Thus, other subjective variables, not identifiable in our data, may influence the individuals' perception of challenge andcreativity in different tasks. Challenging work, which appears in three of the four cases, is a way of looking at the relative difficulty of the tasks. Challenging work or goals may only be of some engaging effect when the engineers perceive, beforehand, that they have the right conditions and are able to accomplish it. Otherwise they think it is a waste of effort. This reflects the idea of technical confidence, quoted by some of the interviewees.

Finally, engagement of their co-workers, in all cases, refers to how the behaviour of colleagues affects software engineers' motivation, for better (Cases I and III) or for worse (Cases II and IV).

Five participants from Case I, six (all) in Case II, seven in Case III, and eight in Case IV provided data that suggests

TABLE 16
Effects of High and Low Levels of Work Motivation and Job Satisfaction (Cross-Case Analysis)

COSNTRUCT	CASE I: OUTCOMES	CASE II: OUTCOMES	CASE III: OUTCOMES	CASE IV: OUTCOMES	EMERGING OUTCOMES
High levels of WORK MOTIVATION	*PROACTIVITY, COMMUNICATION, PRODUCTIVITY, - -*	*PROACTIVITY, COMMUNICATION, PRODUCTIVITY, TEAM INTEGRATION, HELP OTHERS*	*PROACTIVITY, INTERACTIVITY, PRODUCTIVITY, - HELP OTHERS*	*PROACTIVITY, INTERACTIVITY, PRODUCTIVITY, - MUTUAL HELP,*	**PERFORMANCE** *The best possible expression of the competencies (knowledge, abilities and attitudes) of the individual at work.*
Low levels of WORK MOTIVATION	*LAZINESS, ISOLATION - - -*	*LAZINESS, QUIET/RESERVED, PASSIVITY - -*	*LAZINESS, ISOLATION, PASSIVITY, LOW PRODUCTIVITY -*	*LAZINESS, SOCIAL ISOLATION, PASSIVITY, LACK OF PRODUCTIV-ITY, HELPLESS*	
High levels of JOB SATISFACTION	*PUNCTUALITY*	-	*COMMITMENT, CALM,*	*RESPONSIBILITY, CALM*	**PROFESSIONALISM** *A set of practices that sustain reliability and integrity of the person.*
Low levels of JOB SATISFACTION	*ABSENCE, TROUBLEMAKING*	*LACK OF COMMIT-MENT*	*ABSENCE*	*ABSENTEEISM, PESSIMISM, IRRESPONSIBILITY*	

conditions for job satisfaction. The categories generated from the cross-case analysis are shown in Table 15.

Accomplishment was identified among almost all participants. Participants achieve satisfaction when they are able to produce results as good as, or better than, those planned. This observation evidences how important the planning activity is for the satisfaction of engineers, showing that the plans are the primary source for the establishment of the individuals' expectations, which are in turn responsible for their value judgment about their own performance.

Our case studies indicate that there may be other individual characteristics that moderate the strength of some conditions of work motivation and job satisfaction, but this is outside the scope of this study. There also may be other implicit characteristics that influence perceptions. For example, an individual's values and perceptions of the feedback source, and any preference they had to the medium used to send the feedback, affect the impact of the feedback [76]. These aspects should be investigated in future studies.

RQ3 - What are the outcomes of work motivation and job satisfaction of software engineers?

Finally, when considering the effects of work motivation and job satisfaction over the data from the four cases, the outcomes were semantically combined in two main categories: performance and professionalism. Work motivation influences mainly the individual and collective performance of the software engineers, while job satisfaction influences mainly their professionalism. This combination followed the same process of interpretation and discussions between peers previously described. Table 16 shows the synthesis of the effects of high and low levels of work motivation and job satisfaction from the four cases' data. Performance was defined as the best possible expression of the competencies (knowledge, abilities and attitudes) of the individual at work. Professionalism was defined as a set of practices that sustain reliability and integrity of the person at the workplace.

5.3 A New Theory of Work Motivation and Job Satisfaction of Software Engineers (TMS-SE)

The findings presented in the previous sections served as the basis to generate a new theory of motivation and satisfaction for software engineers (hereafter referred to as TMS-SE). Our theoretical background proposes that job satisfaction and work motivation refer to distinct phenomena (see França, Sharp and Da Silva [53] for a more detailed discussion). Job satisfaction is the pleasurable emotional state resulting from the appraisal of one's job as attaining, or allowing the attainment of, one's important job values, while work motivation refers to the desire to work. Motivation happens before the action, while satisfaction happens afterwards, in a given work episode. A work episode is defined henceforth as an event in which latent performance becomes actual performance at the workplace. Latent performance here refers to the maximum level of performance possible in the given conditions.

Although work motivation and job satisfaction are distinct, they are closely connected in a feedback loop (Fig. 2), through the self-regulation process [70] that connects past experiences to future behaviours. In the following subsections, we describe the TMS-SE in five basic propositions.

Proposition 1. ***Job satisfaction*** *is expressed in terms of happiness, while* ***work motivation*** *is a combination of* ***engagement*** *and* ***focus****.*

From the data explored in the previous section, it is possible to learn that Job satisfaction is signalled mainly by happiness of the individuals at work, but the external signs of a motivated behaviour remain unclear. From our study data, we came to the conclusion that engagement and focus are the traits that best describe the motivated behaviour of software engineers. Both engagement and focus comprise behaviours perceivable before and during a work episode. Engaged individuals differ from non-engaged individuals in their levels of involvement with the work, effort applied, concern with the results, and proactivity. Focused individuals differ from non-focused individuals in their levels of attention and care for the work.

Identifying engagement and focus as behavioural traits for motivation is consistent with other available theories of motivation. As Steers et al. [5, p. 379] pointed out, the theories of human motivation are generally concerned with factors or events that energize, sustain (engagement) and channel (focus) human behaviour over time. Goal Setting Theory [71] suggests three mechanisms through which the goal-setting practice affects performance (goal mechanisms), namely: (i) direction, which refers to the individual's attention; (ii) effort, which refers to the amount of effort mobilized in proportion

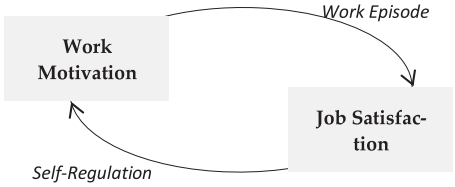

Fig. 2. Relationship between work motivation and job satisfaction.

to the perceived requirements of the goal or task; and (iii) persistence, which refers to directed effort extended over time. These three goal mechanisms are directly comparable to components of engagement (effort and persistence) and focus (direction).

While motivated engineers are both engaged and focused, if either of these is lost, i.e., if engineers are not engaged or are distracted, then motivation is likely to suffer. Looking at the possible combinations of engagement and focus reveals two other situations, illustrated in Fig. 3: "Not-engaged but focused" or Homeostasis [40], a state of balance that results in no action; and "engaged but unfocused" or Frenetic, a state in which the individuals express high levels of interest but they are not able to concentrate their effort towards a specific task.

Proposition 2. ***Motivation*** *moderates the relationship between an individual's* ***latent performance*** *and* ***actual performance*** *within a* ***work episode.***

According to the analysis of our case studies, Performance is the main outcome of work motivation. However, several other aspects of the work, such as technical knowledge, work experience, processes and tools, can influence an individual's latent performance, as documented for example by Rash and Tosi [72] and Prasad et al. [73]. In addition, Morgeson and Humphrey [78] draw attention to the fact that the working context (i.e., ergonomics, equipment use, etc.) can dissipate latent performance.

Therefore, given a working context, an individual has a latent performance against any task, and the actual performance is moderated by motivation, i.e., a motivated engineer is more likely to realize all their latent performance in a given task.

Accordingly, it is not safe to infer motivation based on the actual performance of an engineer, just as it is not reasonable to infer that an engineer is more or less motivated than others based on their comparative performance. Motivation is not the only predictor of actual performance. It is not possible to affirm that a motivated engineer will perform better than another engineer (motivated or not), because their latent performances are affected by other factors, such as individual competence.

Motivation of engineers can only be inferred from the assessment of engagement and focus behaviours, combined. Through a combination of engagement and focus, work

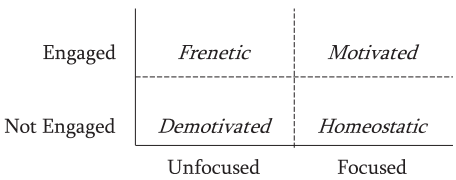

Fig. 3. Combination of engagement and focus.

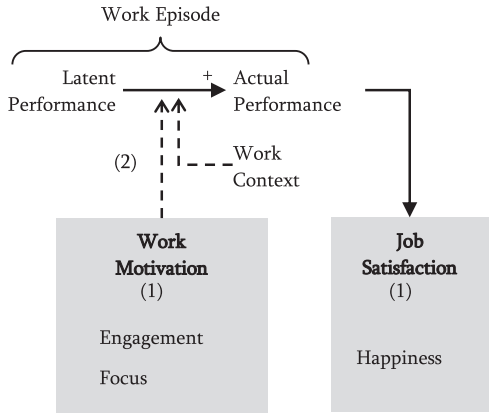

Fig. 4. The relationship between work motivation, work episode and job satisfaction.

motivation acts as a moderator in the transformation process of latent performance into actual performance, i.e., motivated software engineers are likely to perform better than they would without engagement or focus. Fig. 4 depicts the proposed relationships between work motivation, work context, work episode, and job satisfaction.

Proposition 3. ***Creativity***, ***Work Variety***, ***Work Challenge***, ***Useful Knowledge*** *and* ***Social Impact*** *are conditions for* ***engagement*** *for software engineers, moderated by* ***individual characteristics*** *and perceived* ***engagement of co-workers****.*

Proposition 4. ***Well defined work*** *and balanced* ***cognitive workload*** *are the conditions for* ***focus*** *for software engineers, moderated by* ***individual characteristics.***

The natural sequence of the investigation led us to question what factors affect the engagement and focus of software engineers. Our case studies pointed out six workplace factors that affect engagement and two workplace factors that affect focus of software engineers. The conditions for engagement and focus are those identified in the last column of Table 15.

While in the Job Characteristics Theory, Hackman and his colleagues use the terms Job Characteristics and Task Characteristics as interchangeable concepts, in the TMS-SE, we find it useful to distinguish three different dimensions of the workplace: *Task* refers to a specific thing to do, e.g., write code, test a system, etc; *Work* refers to the set of tasks that are part of a individual's responsibilities at work; and *Job* refers to the social and contractual relationships existing between an individual and an organisation.

However, notice that creativity, work variety, work challenge, useful knowledge, social impact, well defined work, and cognitive workload refer clearly to characteristics of the work, while engagement of co-workers is a workplace factor that pertains to a more social dimension. Scrutinizing our data, it is possible to evidence that the engagement of co-workers moderates how the work characteristics influence the engagement of software engineers. Fig. 5 protrays Propositions 3 and 4.

In our study, some individual characteristics seemed to interfere in the strength to which the workplace factors are perceived or valued, such as work experience and technical

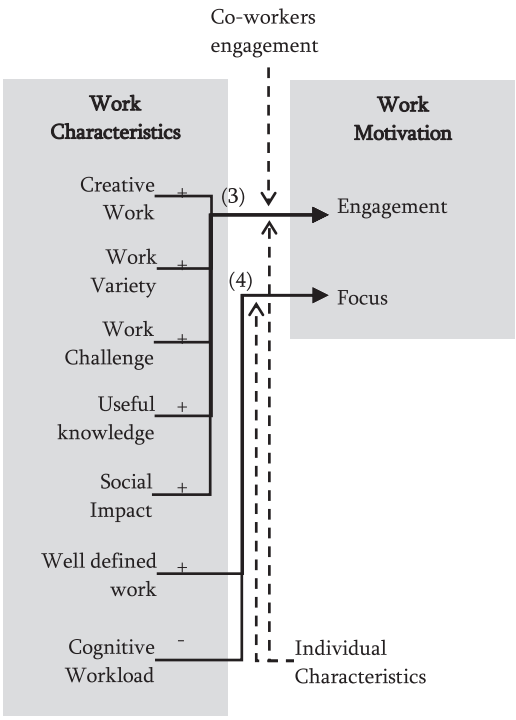

Fig. 5. Antecedents of engagement and focus.

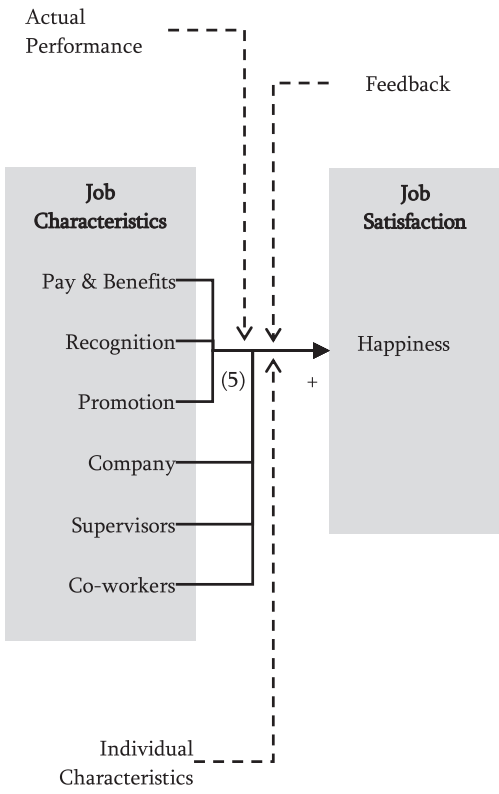

Fig. 6. Antecedents of happiness.

orientation. However, these aspects were not investigated, and must be explored in future work.

Proposition 5. ***Actual performance*** *in a determined* ***work episode****, influences the software engineer's appraisal of the workplace factors, and this relationship is moderated by available* ***feedback*** *and* ***individual characteristics.***

Recognition and accomplishment emerged from our study as antecedents of job satisfaction. Both are forms of feedback that help to build an individual's self-perception of actual performance, within a single work episode. This is consistent with other recent research developments, such as Sach [76], which shows that positive and negative feelings are the most representative outcome of feedback instances in a software engineering context. Feedback then is interpreted as trustworthy information that individuals get about the results and about the impacts of their work.

Besides feedback, we found no further conditions for job satisfaction beyond those job characteristics already documented in Locke [77]. Locke lists 'the work itself', which refers to the intrinsic interest that the individuals have for the work, as one of the conditions for job satisfaction, together with Pay, Benefits, Recognition, Promotion, Working Conditions, Company, Supervisors and Co-workers. In the TMS-SE, the notion of "the work itself" is embedded in the appraisal of actual performance, as perceived based on the available feedback and individual characteristics. Therefore, unlike Locke's simplification, actual performance models the expectations of the engineers regarding the other antecedents of job satisfaction, as explained in [79]. Fig. 6 depicts this proposition.

Finally, we produced a full model of work motivation and job satisfaction of software engineers, pictured in Fig. 7, which integrates all the concepts, propositions and relations in the TMS-SE, described in this section.

6 Discussion

6.1 The TMS-SE and the Job Characteristics Theory

The main distinction between the TMS-SE and the JCT is the clear separation between the conditions for work motivation and those for job satisfaction made in the TMS-SE, which is not clear in Hackman's original work. In addition, the JCT refers to internal motivation as a non-observable set of internal emotions. In the TMS-SE, this internal state was mapped onto a combination of engagement and focus, as observable behavioural proxies for individual work motivation.

The set of factors found in our study confirms that the job characteristics described in the Hackman's Job Characteristics Theory (JCT) are not enough to explain the nuances of this particular type of work. The relationships between the elements of TMS-SE and the original five factors of the JCT are discussed below.

- Task significance: is defined as "the degree to which the work has a substantial impact on the lives of other people, whether in the immediate organisation or in the external environment". It is similar to the concept of Social impact in the TMS-SE. However, the TMS-SE complements the notion of significance, revealing that the task is also perceived as significant when it has an impact on the individual's own life, particularly through the acquisition of useful knowledge.
- Skill variety: defined as "the degree to which the job requires a number of different activities in carrying out the work, which involve the use of a number of different skills and talents of the individual". Morgeson and Humphrey [78] refers to Task Variety (as in job enlargement) and Skill Variety (as in job enrichment) as two distinctive dimensions of work

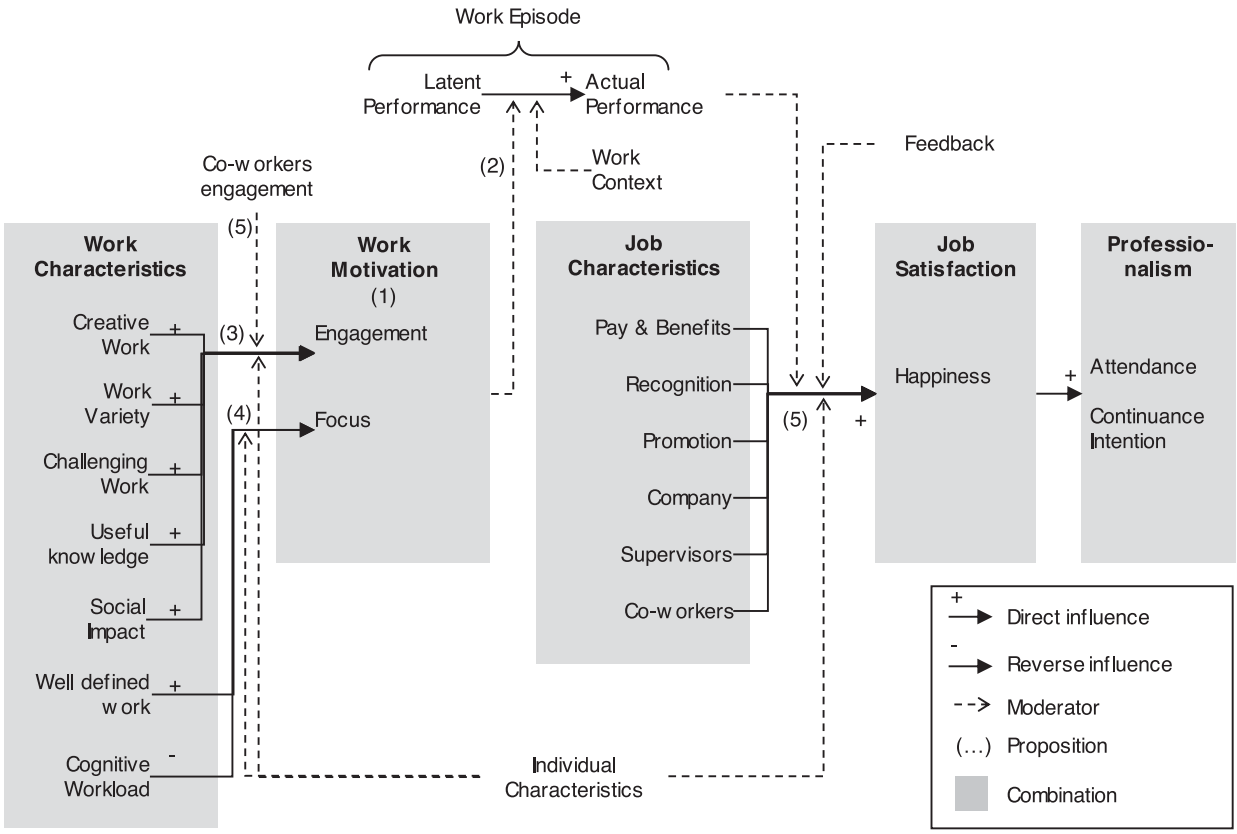

Fig. 7. Model of work motivation and job satisfaction.

variety. In TMS-SE, the concept of work variety seems to carry another new type of variation that also accounts for the software engineers' engagement: the variation of the intellectual content of the task, complementing the more limited notion of skill variety from the original JCT.

- Autonomy: is defined as the "freedom, independence, and discretion in scheduling the work and in determining the procedures to be used in carrying it out". Autonomy implies that individuals establish an emotional connection with the product on which they are working, because the workers feel personally responsible for the results of the work. That feeling of experienced responsibility is critical in determining the individual's motivation. In our case studies, this feeling of experienced responsibility is achieved through the creative work.
- Task identity: is defined as "the degree to which the job requires completion of a whole and identifiable piece of work, doing a job from beginning to end with a visible outcome". In the JCT, task identity appeared as a workplace factor that shaped the experienced meaningfulness of the work. In our research, the idea of Well defined work is partially compatible with this concept. However, instead of just referring to it as meaningful, the notion of well defined work in the TMS-SE also captures the need to enable engineers' focus.
- Feedback: In the JCT, feedback represents "the degree to which carrying out job specific work activities provide the jobholder with direct and clear information about the effectiveness of his/her performance". However, it is not clear, in their work, whether feedback is a condition for work motivation or job satisfaction. Oldham and Hackman [21] stated: "*motivated employees feel good when they perform well and feel bad when they perform poorly*". Additionally, the JCT suggested that "*the crucial condition is that feedback be present in form that is believable to the worker, so a realistic basis exists for the satisfaction*" [75]. Locke [77] also mentions that "*a person who is highly involved in his job should be more likely to feel extremely satisfied or dissatisfied with it (depending upon his degree of success)*". These quotations imply that feedback happens in the after-performance side of the work episode, so it can only influence job satisfaction. That becomes clearer in the TMS-SE. However, in the TMS-SE feedback appears as a moderator for job satisfaction.

The notion of Growth Need Strength (GNS), or "the strength of a person's need for personal accomplishment, learning, and development" in the JCT, is found throughout the TMS-SE, in a different manner. Acquisition of useful knowledge, for example, appears as a new factor. The notion of personal accomplishment is embedded in some conditions, such as in the factor challenging work, and consequences, such as the role of feedback on actual performance over the job satisfaction elements. In addition, the TMS-SE uncovered that there may be other individual characteristics that mediate the effect of workplace factors on work motivation. There are, as examples, individual characteristics that influence perception of what useful knowledge may mean, about what trustworthy feedback is, and so on.

The TMS-SE extends the boundaries of the original JCT. All case studies conducted in this work raised the issue that an individual's state of motivation influences and is influenced

by their co-worker's motivation. This phenomenon is only explained by the Inequity Theory [79], which is not explicitly a theory of motivation to work, but states that:

> *"the presence of inequity will motivate Person to achieve equity or reduce inequity (. . .) Person may increase his inputs if they are low relative to Other's inputs and to his own outcomes (. . .) [or] Person may decrease his inputs if they are high relative to Other's inputs and to his own outcomes." [79, p. 427–428]*

In this excerpt, the "other's inputs" can be seen as the engagement of co-workers of the TMS-SE. The inequity theory, in contrast to TMS-SE, does not discern work motivation from job satisfaction [22], so inequity can be manifested in terms of both emotional and behavioural signs. The Job Satisfaction Theory [77] posits equity as an antecedent of job satisfaction and, consistently, more recent research provided strong evidence of the relationship between general organisational justice and individual health [80]. Our study, on the other hand, provides complementary evidence for the effect of inequity over work motivation, rather than exclusively over job satisfaction.

Hackman's job characteristics [74] generally refer to valuable aspects pertaining either to the means or to the ends of performing a specific activity, as part of the work. Although the eventual use of the term "task characteristic" might convey the notion that such characteristics must pertain specifically to a task, they actually pertain to the experience of performing it. As pointed out in Hackman and Lawler III [75], all the workplace factors are psychological and subjective in essence i.e., it is not their objective state that affects employee's attitudes and behaviour, but rather how they are perceived by the employees. That is the same understanding of the TMS-SE.

Finally, the concept of challenging work represents a bridge that makes our theoretical framework consistent with the Social Cognitive Theory (SCT) [81], [82]. The SCT defines self-efficacy as "*the strength of people's convictions in their own effectiveness*" [82, p. 193]. The JCT and the SCT were built on the precepts of Vroom's expectancy theory [83]. However, the SCT was mainly developed around the idea that personal expectations influence one's motivation, while in the JCT this idea is not explicit. The SCT asserts that self-efficacy influences choice, as predicted in the Expectancy Theory, but also determines "*how much effort people will expend and how long they will persist in the face of obstacles and aversive experiences*." [82, p. 194], which is consistent with our assertion that challenging work (tasks that stretches one's self-efficacy) influences engagement. Nevertheless, the TMS-SE focuses on workplace factors rather than on individual characteristics. Thus, the idea of self-efficacy appears in the TMS-SE in this more work-oriented manner.

6.2 The TMS-SE and Couger and Zawacki's work

Couger and Zawacki [6] built their studies on Hackman's Job Diagnostic Survey, and discovered that (1) software engineers from all over the world exhibited similarities regarding their high growth needs (GNS); (2) they hold specific personality traits that limit their social interactions, which would be responsible for a poor level of feedback among software engineering teams; and (3) organisations should seek specific strategies for improving engineers' feedback as a means to enhance their motivation, such as the Goal Setting approach. We opted to not use the JDS questionnaire, and personality profiles of our case study participants were not assessed. Therefore, it is not possible directly to affirm that our results are fully consistent with Couger and Zawacki's basic findings.

Nevertheless, there are two main points of comparison between our work and Couger and Zawacki's. First, the software engineers' high growth needs, defined as "*the degree to which an individual values opportunities for personal growth and development at work*", is well represented in the factor useful knowledge in the TMS-SE. Second, in our four case studies, software organisations suffered from low levels of performance feedback. Notice that the low levels of feedback could be either a result of a specific personality trait common in software engineers or simply a result of how the software development processes are designed. The TMS-SE argues that feedback does not impact directly work motivation, but does influence job satisfaction.

Although Couger and Zawacki suggested that the Goal Setting approach could only serve to enhance feedback (and hence job satisfaction), the right manipulation of goal attributes can also act over the conditions for engagement and focus of software engineers (and work motivation therefore). For instance: judgements about goal difficulty are expected to have some connection with the notion of challenging work of the engineer, influencing their potential engagement; and goal clarity is supposed to influence engineers' perception about how well the work is defined, generating an impact on their focus. The recent work with creativity workers by Amabile and Kramer [84] also suggests that it is possible to ignite workers' motivation by redesigning goals to progressively build their self-efficacy.

6.3 The TMS-SE and the MOCC Model

The MOCC Model [37] represents, so far, the most relevant advance in describing motivation of software engineers. The general abstract rationale tying the elements of the MOCC together are in fact consistent with the TMS-SE: contextual factors and individual personality and preferences influence the characteristics of the software engineers; these characteristics influence the strength of motivators, which in turn influence the outcomes of motivation, mediated by elements of the context again.

However, some aspects of the MOCC are disputed in this research. First, the MOCC model does not distinguish work motivation from job satisfaction, so it suggests that outcomes such as retention, attendance, productivity, budget adherence, project delivery time, and project success are directly influenced by the motivation of software engineers. In contrast, the TMS-SE approaches work motivation and job satisfaction as distinguishable phenomena, with separable outcomes. Our case studies illustrated two situations in which the precepts of the MOCC do not stand for motivated engineers: (1) if they are not satisfied, they may exhibit high intention to leave anyway; and (2) in face of organisational hindrances or individual limitations of competence, they may not be productive. Second, Sharp et al. [37] classified motivators as intrinsic, which come from the pleasure of doing the work itself, and extrinsic, referring to workplace factors external to the work. In a

different direction, the TMS-SE considers that all workplace factors are subjective, i.e., they pertain to an interactive relationship between a person and reality, in which the individuals make use of their functions of cognition, evaluation and regulation to appraise the work situations.

A limitation of both the TMS-SE and the MOCC model is that they do not clarify how the factors combine to shape the work motivation and the performance outcomes. In the MOCC model, the long list of motivational factors makes the investigation of the combination of factors impractical. In the TMS-SE, however, it is clearer that each factor is singly influential over the software engineer's motivation, while none of the factors are sufficient to ensure improved performance. The TMS-SE provides support to operationalize the constructs, in order to enable future research focused on more specific behavioural traits (engagement, focus and happiness), which has been a trend in the organisational behaviour field [22].

6.4 The TMS-SE and Other Studies

Some of the previous studies found in the two above mentioned systematic reviews (Section 3) are not directly focused on work motivation or job satisfaction, but produce relevant insights into this subject. Turley and Bieman [85], Kandeel and Wahba [86], and Beecham et al. [87], for example, explore characteristics of high and low performers in software development. Engagement and focus are among the common traits that those studies point out. In the TMS-SE, it is possible to find the reasons that explain these results: highly motivated software engineers are engaged and focused, so they achieve their best.

Nevertheless, the belief that motivated employees perform better than de-motivated workers is a common misleading idea. The TMS-SE argues that motivation influences the individual performance, i.e., motivated individuals perform as best as they can, which does not ensure that they will perform better than others. Motivated software engineers are not necessarily the best performers, but they perform better than they would if they were not motivated.

As pointed out in the review of the literature described in Session 3, one of the biggest challenges for the empirical study of work motivation and job satisfaction has been the operational approach to observe or measure these phenomena. It is not always clear whether the investigated phenomenon is job satisfaction or work motivation. There are cases in which: (a) studies intended to assess work motivation use questionnaires that assess job satisfaction (e.g., [88]); (b) studies intended to assess job satisfaction, use self-designed questionnaires, for which the reliability is unknown (e.g., [89]); (c) studies intended to assess self-defined constructs, which are neither work motivation nor job satisfaction (e.g., [38]). It was out of the scope of this research to provide a ready-to-go assessment questionnaire, but it provides a practical framework that can be used in future research to delineate sensible operationalization of the work motivation and job satisfaction constructs.

6.5 Implications and Challenges for Software Engineering

Based on the TMS-SE, we suggest how software engineers could consider the following workplace factors:

- Engagement of co-workers: our case studies showed that a highly motivated engineer may positively influence others, as well as a poorly motivated engineer may contaminate others. The first challenge for software engineering team leaders is to identify the poorly motivated engineers before the contamination occurs, to avoid a generalized decrease in motivation. The second challenge is to identify the highly motivated engineers, to leverage the motivation of the other team workers. In both cases, interventions must be conducted carefully to avoid the introduction of inequity in the team. Inequity sets off a significant risk for job satisfaction.
- Challenging work: the relationship between work characteristics and work motivation is not necessarily linear. In the case of challenging work, it seems to be an inverted U-shape relationship: too little, or too much challenge may not be effective to engage, because of the self-efficacy effect. Our case studies show, for example, that a realistic and reliable estimation process can be a relevant source of leveraging challenge, while an untrustworthy estimation wipes out an engineer's belief that they can deliver timely results.
- Social impact: the four organisations studied in this work developed software systems supposed to benefit other people's lives or the efficacy of other organisations' processes, so it was not difficult to notice in the software engineers a motivated behaviour justified by the sense of responsibility for the social impact caused by their work. This may represent a challenge for software projects that are in their initial stages, with no actual users yet. In one of our case studies, we could evidence that the motivating role of the contact with users was replaced by a strong persuasion process from the company directors, because the product had not been sold yet.
- Acquisition of useful knowledge: Our case studies showed that long-term projects tend to lose their novelty appeal over time. Thus, another challenge in software engineering practice is how to cope with the engineers' need for constant learning in these types of project, without introducing technical risks related to the change of technologies. Figuring out what is useful for each engineer may already be a challenge for team leaders. Our case studies show that "useful" may be something that improves the quality of the product, the engineer's future performance, or even enhances their opportunity to find other jobs. Finally, managers could propose specific incentive strategies using useful knowledge as a reward, instead of money or other financial incentives.
- Work variety: There are at least two challenges concerning work variety. First, how to assure work variety in a single-project setting. The organisation in Case Study IV had a large product, whose maintenance consumed a significant amount of the workforce, and work variety depended on knowing the different modules of the project. In Case Study II, in contrast, the work variety depended on finishing short-term projects to start other projects in different domains of knowledge. Both examples represent practical forms

of avoiding monotonous work, but the work variety in Case IV was limited by the project boundaries while in Case II there was no limit. Another challenge is how to assure work variety without stressing the engineers in multi-project settings. Our studies show that changing the allocation of an engineer during a project with which he/she is engaged may cause the opposite effect, which is consistent with recent empirical work on job rotation in software engineering [90], [91]. Allocating engineers to simultaneous projects may also hamper their work motivation.

- Creativity: It was possible to notice that the participants of our case studies tended to focus on the creative part of a task when referring to their favourite tasks, and tended to focus on the non-creative part when talking about the tasks that they dislike. However, all the tasks seemed to have both creative and non-creative steps. The challenge for software engineers is how to maintain high levels of work motivation during the phases in which they are executing the non-creative parts of their work.
- Well defined work: challenges regarding this factor concern several problems common in software engineering project settings, such as how well the requirements are elicited and documented [92], how well transitory artefacts are understood [93], how well the productive process is defined [94], etc. It is needless to reinforce how challenging it is to define software engineering work well, because these problems comprise large areas of research in the software engineering field.
- Communication, participation and Collaboration: Our case studies show that software engineers tend to exhibit more collaborative behaviour when they are highly motivated to work. However, this influence is mediated by the degree of communication and participation in the team. Previous research has suggested that participation is an antecedent of work motivation [37] but, in fact, the available evidence in software engineering literature only testifies weak connections between participation and job satisfaction. The challenge for the practice implied in the TMS-SE is that improving communication channels and participation procedures will not assure higher levels of collaboration, unless the engineers are motivated to work.
- Feedback: Recent work on feedback in software engineering [76] uncovered several informational properties that determine the effect of feedback on an individual's job satisfaction, such as the content, the source and the medium of the information. Thus, managers should also figure out how to deal with all these variables in order to administer beneficial feedback for their engineers.

7 Concluding Remarks

Issues related to work motivation and job satisfaction have, for a long time, attracted the curiosity of researchers from all over the world, due not only to the complexity of the study of human behaviour, but also to the practical business benefits that the enhancement of individuals' performance could represent.

In this article, a theory of work motivation and job satisfaction of software engineers (TMS-SE) is proposed, based initially on the Job Satisfaction and Job Characteristics theory, enhanced and adapted for the software development context. The theory presented in this article emerged from a cross-case analysis of four software engineering organisations, and it focuses on the work motivation and job satisfaction of software engineers. Conflicting aspects within the theory and outside its boundaries have been thoroughly discussed and reviewed in the text, which has consolidated its explanatory and predictive power.

This research is not the first attempt to address the motivation of software engineers at a theoretical level, nor the first empirical study, nor the first qualitative case study, nor the first to suggest a model of motivation for software engineers. However, to the best of our knowledge, it is the first research to weave all of these elements together. The present work contributes to the current state of art mainly by providing a solid theoretical framework, adapted to cover the software engineering specificities. While there is no consensus about the possibility that software engineers hold individual characteristics that distinguishes them from the overall population, our work shows that the nature of software engineering tasks creates specific conditions that alter the motivational structure of these professionals.

According to Ven [95], a good theory must be capable of (i) advancing knowledge in a scientific discipline, (ii) guiding research toward crucial questions, and (iii) enlightening the profession of management.

This work reinforces the importance of treating work motivation and job satisfaction as two distinguishable phenomena, with different antecedents, behavioural signs, and outcomes. This is an innovative theoretical approach for the software engineering field, which helps us to understand better which workplace factors effectively contribute to an engineer's happiness and retention, as well as which workplace factors influence engineers' individual performance through work motivation. These aspects are not clear in previous available models such as the MOCC model.

The TMS-SE theory leaves many open questions and opportunities for future research, such as the development of measurement and assessment tools; the design of intervention strategies; quantification of the impact of work motivation on individual performance; and the investigation of which and how individual characteristics influence the whole model.

The case studies presented in this article were conducted in 2010 and 2011, as part of the PhD work of the first author. It took a long time to synthesize all the data, as predicted in Merriam [50]. Merriam also describes three types of case studies: (1) *Particularistic*, which means that the study is focused on a particular situation; (2) *Descriptive*, which aims to produce a rich description of the subject being studied; and (3) *Heuristic*, which brings about the discovery of meaning and enhances the understanding of the phenomenon under study [50, p. 29]. The first two types are very sensitive to time, simply because particular situations may change. However, the third type results in mid-level theories which abstract the particular characteristics of the cases into a more stable conceptual level, a process which Eisenhardt [14] refers to as "building theory from case studies". This is

precisely the case of the present study. In addition, the presented data continues to be representative of the field, because many of the factors in practice still pertain and the data is much more recent than other studies on motivation in software engineering.

However, it would be sensible for practitioners to evaluate the compatibility of the characteristics of other contexts before transferring the TMS-SE to their practice. In previous work [106] we have shown how a theory can underpin the design of specific strategies to deal with motivation and satisfaction of software engineers. Furthermore, the strength of the theory can be enhanced by using it as a lens to look at data from other case studies in the future.

A limitation of the TMS-SE is that it does not make explicit how the workplace factors combine to shape the work motivation and the performance outcomes. Some factors may be more or less influent according to extraneous contextual variables, or internal individual characteristics. Further, there may be interactions among the factors. The approach followed in [96] may be useful to help design research aimed at looking for a combination or a scale of importance among these workplace factors.

Teamwork in software engineering is also an area that increasingly attracts academic and industrial attention. Team motivation has been defined as "*the collective system by which team members coordinate the direction, intensity, and persistence of their efforts*." [97, p. 233]. According to Chen and Kanfer [97], team motivation cannot be understood without having a clear understanding of the work motivation of the members of a team. The TMS-SE can be used to guide investigation in this area. Still in the context of teamwork, several studies recall the importance that leaders have on determining the effectiveness of motivational strategies. Concepts of transformational and transactional leadership from Burns [98], for example, communicate two types of leaders that adopt different strategies to intervene in the team members' work motivation. The TMS-SE can offer a theoretical framework to interpret and predict how the attitudes and decisions of leaders will influence the work motivation of software engineers.

Finally, this work serves as a practical and detailed worked example of theory building based on interpretive multi-case studies, for which we believe there are not many examples available in the software engineering literature. The software engineering scientific discipline is also starting to care about a more systematic development of theories. Thus, this work also contributes to future research from a methodological perspective, adding to the general body of knowledge of Empirical Software Engineering.

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