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Motivation and Satisfaction of Software Engineers

César França, Fabio Q. B. da Silva, Helen Sharp

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 organisa-

tions 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 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

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1
2 adequate use of well-established theories to underpin
3 their research designs [4]. And, empirical studies in this
4 area are still concentrated in developed countries, so as-
5 pects such as international cultural differences challenge
6 the transferability of their results to other countries.

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

13 The aim of this research is to generate a sensible and
14 contemporaneous understanding of how the work motiva-
15 tion and job satisfaction of software engineers are influ-
16 enced by workplace factors, and how these phenomena
17 influence their work-related behaviour. For that purpose,
18 we followed a process of building theory from case study
19 research, suggested by Eisenhardt [14][15]. A multi-case
20 study was carried out in four software engineering set-
21 tings, in Recife, Brazil. For 11 months, rich data was inde-
22 pendently collected in those organisations, by means of
23 semi-structured interviews, diary studies, and document
24 analyses. Then, a cross-case comparison was carried out,
25 leading to the theory of work motivation and job satis-
26 faction of software engineers (TMS-SE). Finally, the emerg-
27 ing theory was compared against similar and conflicting
28 evidence from studies available in the literature.

29 The theory presented in this article builds on the
30 understanding from Locke [16] that work motivation and
31 job satisfaction are distinguishable phenomena, with dis-
32 tinct antecedents and outcomes. Job satisfaction refers to
33 pleasurable emotions in reaction to the job, signalled
34 mainly by the individuals' happiness at work, and influ-
35 ences attitudes towards the organisation (intention to stay,
36 attendance, and others). Work motivation, in contrast,
37 refers to the desire to work, is signalled by individuals'
38 attitudes toward the work (engagement and focus), and
39 directly influences individual work performance.

40 This theory contributes to the state of art in three
41 complementary ways. First, it advances the knowledge on
42 this topic by providing a solid framework through which
43 the available knowledge in this field is integrated and
44 evaluated. Second, it enlightens the management of soft-
45 ware engineers by clarifying what aspects of the work and
46 the workplace are relevant to work motivation and job
47 satisfaction of this specific type of professional, as well as
48 by pointing out practical challenges attached to the soft-
49 ware development practices. Third, it suggests areas wor-
50 thy of further investigation, serving as a basis for future
51 research in this area.

52 The rest of this article is organised as follow: Section 2
53 reviews the concepts of work motivation and job satisfac-
54 tion as represented in the most frequently cited theories of
55 motivation. Then, in Section 3, a historical view of the re-
56 search on motivation and satisfaction in software engi-

neering 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 re-
marks, 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 motiva-
tion, they would have a common characteristic: "They are
all principally concerned with factors or events that ener-
gize, channel, and sustain human behaviour over time."
Job satisfaction, in contrast, has been defined as "complex
emotional reactions to the job" [16]. Although the phe-
nomena are connected, two critical characteristics make
work motivation different from job satisfaction. First, moti-
vation 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 individu-
als' 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 lim-
ited to the work itself.

The definitions of work motivation and job satisfac-
tion have stimulated researchers from several fields, result-
ing in different competing and complementary theories
[18]. Table 1 shows an overview of the most relevant theo-
ries 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 defi-
nition was presented in 1969, it has become a consensus
between academics from the organisational behaviour
field [19] Locke suggests that job satisfaction and dissatis-
faction 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 val-
ues.

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].

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

1
2 guide the rational choice of a determined behaviour, while
3 other theories are interested in describing what aspects of
4 the workplace may make people more or less "turned on"
5 to work. All these theories are equally constrained by the
6 approach they choose to take when looking at the motiva-
7 tion phenomenon.

8 In this research, we are specifically interested in soft-
9 ware engineers' activity. Given that individuals motivated
10 to work will perform at their best possible, we set out to
11 investigate what elements of a software engineering
12 workplace motivate these individuals to work.

13 One of the long-lasting approaches of work motiva-
14 tion refers to the motivating characteristics or potential of
15 work related tasks, based on the ideas of Hackman and
16 colleagues. According to Hackman's definition, work moti-
17 vation refers to being turned on to one's work because of
18 the positive internal feelings that are generated by per-
19 forming well [20]. It is the individuals' willingness to work
20 hard and well [12]. Hackman found three psychological
21 states that are critical in determining if a person is internal-
22 ly motivated [20]:

- 23 • *Experienced Meaningfulness*. The degree to which
24 the employee experiences the work as inherently
25 meaningful, as something that counts in his/her
26 own system of values [21].
- 27 • *Experienced Responsibility*. The degree to which the
28 individual feels personally accountable and respon-
29 sible for the results of the work he/she performs.
- 30 • *Knowledge of Results*. The degree to which the in-
31 dividual has confident knowledge about how well
32 he/she is performing.

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

42 Experienced Meaningfulness is shaped by three job
43 characteristics:

- 44 i. *Skill Variety* is the degree to which the job re-
45 quires a number of different activities in carrying
46 out the work, which involve the use of a number
47 of different skills and talents of the individual.
48 Work that stretches one's skills and abilities invari-
49 ably is experienced as more meaningful than work
50 that is simple and routine.
- 51 ii. *Task Identity* is the degree to which the job re-
52 quires completion of a whole and identifiable
53 piece of work, doing a job from beginning to end
54 with a visible outcome. Putting together an entire
55 product or providing a complete unit of service is
56 inherently more meaningful than being responsi-
57 ble for only a small part of the work.
- 58 iii. *Task Significance* is the degree to which the work
59 has a substantial impact on the lives of other
60 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 mean-
ingful 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 substan-
tial freedom, independence, and discretion in
scheduling the work and in determining the pro-
cedures 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 effective-
ness of his/her performance. When someone re-
ceives information about his/her performance
from the work itself (e.g., when a salesperson
closes a deal and receives payment from a cus-
tomer), that feedback is direct and immediate
and, therefore, contributes substantially to his/her
overall knowledge of results about work out-
comes.

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 ac-
cording 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 theo-
retically relevant, mediating variable"* [22, p. 280]. Howev-
er, 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 con-
tinued 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 engi-
neering [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 ac-

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, PS095, 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

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 satis-

1
2 faction, referring to other studies or to general knowledge,
3 without clear evidence. Theoretical papers (Table 2 –
4 Group D) generally argue about the importance of creat-
5 ing strategies to cope with the motivation of software
6 engineers, present argumentation structures aiming to
7 defend individual opinions of the authors, or propose
8 improvements on existing models and theories without
9 any empirical support.

10 It is even possible to notice a paradox in those stud-
11 ies based on the idea that software engineers are different
12 from other professionals: they rely mainly on theories
13 developed in other fields to underpin their recommenda-
14 tions about how to deal with software engineers' motiva-
15 tion. Often, theoretical studies call for clarifications about
16 the antecedents of work motivation of software engineers.

17 Moreover, a significant part of the SLR studies
18 (40/140) do not explicitly mention any theory of motiva-
19 tion or satisfaction. It does not mean that the remaining
20 portion of studies have properly used a theory. Only seven
21 papers effectively used the theory to either test or discuss
22 the empirical findings. Notice, for example, that there are
23 only three papers focusing on the antecedents of work
24 motivation for software engineers (Type C1), two of which
25 ([38][39]) are not underpinned by any classical theory of
26 motivation. Thus, as Hall et al. [4, p.10:25] concluded:
27 *"studies of motivation in software engineering (...) should
28 be more rigorously based on existing theory."*

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

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

43 Work motivation and job satisfaction of software
44 engineers in the context of agile methods, and more re-
45 cently in the context of distributed software development
46 (DSD) practice, are two common focal problems. Šteinber-
47 ga [43] and Šteinberga and Šmite [44] are mainly con-
48 cerned with employee turnover resulting from lack of job
49 satisfaction of software engineers in the context of off-
50 shore projects, because of the additional complexity that
51 globally distributed projects bring to managers. El Khatib
52 et al. [45], in contrast, focus on the subjective characteris-
53 tics of DSD practice that influence work motivation and, as
54 a consequence, performance.

55 In terms of practical effects of motivation and satis-
56 faction over performance, Graziotin et al. [46] reported a
57 quasi-experiment containing evidence that happy software
58 developers performed better at solving problems than
59 non-happy developers; but found no difference between
60 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 Mo-
tivation-Hygiene Theory. The use of these theories is dis-
couraged in the organisational behaviour field, partly be-
cause 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 our methodological approach, de-
signed 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 indi-
vidual software engineers experience work motivation and
job satisfaction, and why certain combinations of work-
place factors lead to more or less motivated behaviour
and job satisfaction. The following research question guid-
ed the investigation: **How do workplace factors influence
the work motivation and job satisfaction of software en-
gineers?**

Workplace factors here refer not only to job charac-
teristics 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 guid-
ance 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 Grae-
bner [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

Table 3 - What is known about Job Satisfaction factors in software engineering

Factors	What the literature says*
The work itself	Seven studies [P005, P016, P102, P105, P116, P120, P134] 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 [P102, P116], the relationship between task identity and job satisfaction was not supported in two [P005, P065]. P065 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 [P016, P134] and a good variable remuneration [P102] 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 [P102] 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 [P102] that supports it.
Company	One study [P016] finds a positive relationship between job security and job satisfaction, while another study [P102] 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, P065, 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 [P120], while working with other people in a team appear related to job satisfaction in two other [P102, P134].
The self	<i>None</i>

*see the list of the SLR primary studies (PS) on Appendix B

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.

1
2 *Getting started.* The research design in the present
3 work established two a priori constructs of interest: job
4 satisfaction and work motivation. In the beginning, we
5 were interested in understanding how workplace factors
6 affected the motivation of software engineers, and what
7 the perceived outcomes of motivation were. In [51], we
8 reported a meta-ethnographical synthesis [52] of two case
9 studies. In that work, motivation and satisfaction were
10 considered as a single construct as perceived by the study
11 participants, which has been a common practice in previ-
12 ous research on motivation in the software engineering
13 field (see Section 3).

14 However, the more sophisticated understanding of
15 work motivation and job satisfaction that we acquired
16 from that experience, led us to question whether partici-
17 pants from different cases had a consistent understanding
18 of the terms "motivation" and "satisfaction" or were they
19 in fact expressing their opinions and experiences about sev-
20 eral other distinct phenomena (see [53] for more details).

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

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

40 **RQ1. Which behavioural descriptors characterise**
41 **the work motivation and job satisfaction of soft-**
42 **ware engineers?**

43 **RQ2. Which workplace factors influence the be-**
44 **havioural descriptors of work motivation and job**
45 **satisfaction of software engineers?**

46 **RQ3. What are the outcomes of work motivation**
47 **and job satisfaction of software engineers?**

48 This approach addressed any potential inconsisten-
49 cies in the participants' understanding because we could
50 use the answer for RQ1 to establish an empirical basis to
51 enable the investigation of RQ2 and RQ3.

52 *Selecting Cases.* In the first level of sampling, cases to
53 be investigated were selected. The rationale for choosing
54 cases based on Yin's [54] replication logic was used here.
55 In the cases level, we sought variation in sizes of organisa-
56 tions (large and small, having respectively more and fewer
57 than 50 workers), and in their business nature (private/public).
58 In Brazil, the contractual rules are different
59 between private and public organisations and we wanted
60 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, back-
ground, education, years of employment in the organisa-
tion, 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 rele-
vant 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 em-
ployee-organisation relationships to verify and corrobo-
rate evidence raised in interviews and diary studies about
organisational characteristics and policies. The instruments
for collecting data in the interviews and in the diary stud-
ies 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 information acted as an aide memoire for events to enter in the online form.

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?

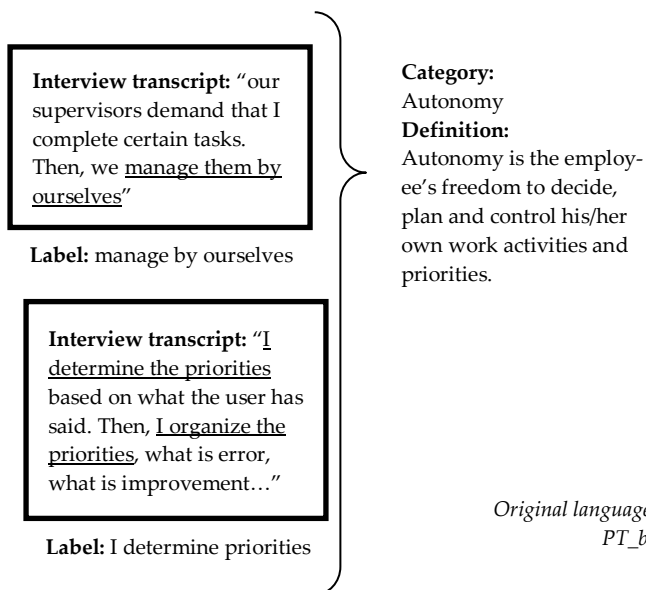
Entering the field. Over a period of one year between 2010 and 2011, four Masters' students carried out the data collection, each one in a distinct organisation, under the supervision of the authors of this article. Potential participants were initially contacted by e-mail, and invited to participate; 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 8¹ 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].

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



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

¹ <http://www.qsrinternational.com/>

1
2 the answers to our research questions.

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

9 *Enfolding literature.* Finally, the emerging theory was
10 compared to already existing concepts from scientific litera-
11 ture. After that, the resulting theory was compared to
12 previous studies with purposes similar to the present re-
13 search: Couger and Zawacki [6] and Sharp et. al [37], and
14 other relevant papers selected from the references of the
15 systematic literature studies [7][8].

16 *Reaching closure.* It was not possible to achieve theo-
17 retical saturation in this study, which is properly discussed,
18 together with other threats to validity and reliability of this
19 method, in the next section.

20 4.2 Threats to validity and reliability

21 According to Merriam [50], three issues are common-
22 ly pointed out in qualitative research: how to provide evi-
23 dence that the findings are credible? Are the findings con-
24 sistent with the data collected? And what is the possibility
25 of someone else transferring the results to other similar
26 contexts?

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

34 To increase consistency (also referred to as Reliabil-
35 ity), we also kept research diaries and process logs that
36 were constantly used as audit trails. In addition, two strat-
37 egies were employed to enhance transferability (External
38 Validity): first, detailed descriptions of the research meth-
39 od, context in which the research was performed, and the
40 results themselves are provided here; second, cases and
41 participants were sampled to achieve maximum variation
42 since this helps to provide richer data and a more robust
43 resulting theory.

44 Dey [65], advocates that instead of theoretical satura-
45 tion, it is better to guarantee that categories are consist-
46 ently built from the data, i.e., to look for theoretical suffi-
47 ciency instead of saturation. This also agrees with the un-
48 derstanding of Charmaz [66]. In this research, at both
49 levels of individual cases and cross-case, all the analyses
50 were performed by at least two researchers, an audit trail
51 was generated, and multiple sources of data were collect-
52 ed and used. According to Merriam [50], these procedures
53 are enough to assure confidence, consistency and, thus,
54 the theoretical sufficiency for our findings. Therefore, al-
55 though theoretical saturation was not tested, we are confi-
56 dent that theoretical sufficiency has been achieved and
57 that enough evidence is provided for the reader to decide
58 the extent to which the findings can be applied to other
59 situations.
60

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, 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^o. 6.123/68).

At the time the research was conducted, the organi- sation was structured in 14 offices distributed in different locations throughout the State. Its employees, including software engineers, were distributed in the main man- agement units and in over 60 other public administration buildings. At the time this research 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 satisfac- tion are also listed in Table 6 (RQ2). Our analysis identified the perceived outcomes of work motivation and job satis- faction listed in Table 7 (RQ3).

Table 5 – Participants and amount of data

CASE I: Government organisation	CASE II: Private not-for-profit organisation
<p>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.</p> <p>Profile of the participants: <i>System analysts:</i> 3 males, 1 female; Ages: 27, 29, 32 and 39 years. <i>Developers:</i> 2 males; Ages: 29 and 32 years.</p>	<p>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.</p> <p>Profile of the participants: <i>System analysts:</i> 2 males; Ages: 36 and 32 years. <i>Developers:</i> 3 males; Ages: 25, 29 and 28 years. <i>Tester:</i> 1 male; Age: 25 years.</p>
CASE III: Small software development company	CASE IV: IT department of a University
<p>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.</p> <p>Profile of the participants: <i>Developers:</i> 7 males; Ages: 21, 23, 26, 26, 27, 28 and 29 years. <i>Tester:</i> 1 male, 1 female; Ages: 21 and 23 years. <i>Designer:</i> 1 male; Age: 22 years.</p>	<p>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.</p> <p>Profile of the participants: <i>System analysts:</i> 3 male; Ages: 27, 27, 29 years. <i>Developers:</i> 5 male, 2 female; Ages: 21, 23, 23, 25, 26, 31, 40 years.</p>

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.

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% of whom were technical and 15% 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).

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	• Success
	• Mood	• Recognition

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

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 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).

Table 8 - Behavioural descriptors and workplace factors (Case II)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR (RQ1)	WORKPLACE FACTORS (RQ2)
WORK MOTIVATION	Focus	<ul style="list-style-type: none"> • Clear requirements • Balanced workload • Quiet environment
	Engagement	<ul style="list-style-type: none"> • Technical skill development • Project variety • Team expertise • Knowledge exchange
	Hard work	<ul style="list-style-type: none"> • Useful product • Brainwork • Research • Commitment of co-workers
JOB SATISFACTION	Mood	<ul style="list-style-type: none"> • Work success • Recognition

Table 9 - Outcomes of work motivation and job satisfaction (Case II)

CONSTRUCT	OUTCOMES (RQ3)	
	WHEN HIGH, CAUSES...	WHEN LOW, CAUSES...
WORK MOTIVATION	<ul style="list-style-type: none"> • Participation • Help others • Proactivity • Integration • Productivity 	<ul style="list-style-type: none"> • Quiet/reserved • Laziness • Passivity
JOB SATISFACTION	-	• Lack of commitment

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).

Table 10 - Behavioural descriptors and workplace factors (Case III)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR (RQ1)	WORKPLACE FACTORS (RQ2)
WORK MOTIVATION	• Focus	<ul style="list-style-type: none"> • Clear requirements • Goal-driven responsibilities • One project at a time
	• Care	• Helping others
	• Engagement	<ul style="list-style-type: none"> • Domain variety • Intellectual challenge • Motivation of co-workers • Technical confidence • Continuous learning
JOB SATISFACTION	• Mood	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Interactivity • Help others • Proactivity • Productivity 	<ul style="list-style-type: none"> • Laziness • Isolation • Passivity • Low productivity
JOB SATISFACTION	<ul style="list-style-type: none"> • Commitment • Calm 	• Absence

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.

Table 12 - Behavioural descriptors and workplace factors (Case IV)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR (RQ1)	WORKPLACE FACTORS (RQ2)
WORK MOTIVATION	• Focus	<ul style="list-style-type: none"> • Clear processes • Clear customer needs • Clear goals • Fair work load
	• Care	<ul style="list-style-type: none"> • Useful products • Authorship
	• Engagement	<ul style="list-style-type: none"> • Learning opportunities • Learning about the product • Engagement of co-workers • Project variety • Maturity of co-workers • Variety of work
	• Hardwork	<ul style="list-style-type: none"> • Intellectual challenge • Self confidence
JOB SATISFACTION	• Excitement	<ul style="list-style-type: none"> • Accomplishment • Practical impact
	• Mood	<ul style="list-style-type: none"> • Recognition

Table 13 - Outcomes of work motivation and job satisfaction (Case IV)

CONSTRUCT	OUTCOMES (RQ3)	
	WHEN HIGH, CAUSES...	WHEN LOW, CAUSES...
WORK MOTIVATION	<ul style="list-style-type: none"> • Proactivity • Interactivity • Mutual help • Productivity 	<ul style="list-style-type: none"> • Laziness • Passivity • Social isolation • Helpless • Lack of productivity
JOB SATISFACTION	<ul style="list-style-type: none"> • Responsibility • Calm 	<ul style="list-style-type: none"> • Pessimism • Absenteeism • Irresponsibility

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).

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

1
2 important for focus. In Case I, the development followed
3 no particular development process, so it is reasonable that
4 four participants identified the need for a better defined
5 work process. However, the organisation in Case IV appar-
6 ently followed well defined work procedures, but accord-
7 ing to the participants of that case, lacked clarity about the
8 customer needs in the documents. Thus, the category
9 labelled "well defined work" refers to not only the working
10 process, but also the content of work in terms of require-
11 ments and/or specific goals.

12 Cognitive Workload was cited in all cases too. The
13 reason for workload being a relevant factor is revealed by
14 an interviewee in Case III, which when explaining lost fo-
15 cus, makes a reference to the cognitive effort that software
16 engineers must do to swap their thinking contexts be-
17 tween distinct projects or concurrent demands.

18 Acquisition of useful knowledge appears as a factor
19 of engagement in all four cases as well. Being updated,
20 either to apply new technologies to work in order to be
21 more productive (Cases I and II), or to expand one's possi-
22 bility to find other job opportunities (Cases III and IV), is a
23 relevant driver of engagement. Knowledge acquisition can
24 occur through training, or working with different people or
25 different entities (technologies, projects, problem domains,
26 etc.). According to our findings, the knowledge being
27 offered to software engineers must be useful, i.e. can be
28 converted to productivity or money (job opportunities),
29 otherwise it would not be valuable for them.

30 Social impact was also found to be a strong facilitator
31 of engagement. Although in public organizations the so-
32 cial significance of their activity is clearer, engineers from
33 all cases pointed out that the utility and social impact of
34 the product on which they are working causes work moti-
35 vation. Developing information systems that are used by a
36 social group of which they are themselves a member is a
37 compelling reason to be engaged in their work.

38 Work variety is a complex characteristic of the work.
39 The data shows that it is important for software engineers
40 to have contact with different tasks (Cases II and IV), busi-
41 ness domains, rules and challenges (Cases I and III). How-
42 ever, this variation of projects and tasks must be managed
43 in a way to avoid distractions and workload problems.
44 Working on simultaneous projects, for example, may not
45 be an effective way to achieve work variety, because shift-
46 ing the context between completely different projects may
47 increase cognitive workload, as previously discussed.

48 Software engineers are likely to be engaged in crea-
49 tive work. It is not only the brainwork characteristic of the
50 work (as in Case II) that is motivating, but more challeng-
51 ing intellectual tasks, involving problem solving (Case I),
52 research (Case II) and creation (Case IV). Even though
53 writing software is knowledge-intensive work, not all tasks
54 in a development process are considered challenging and
55 creative. Besides, the meaning of "challenge" varies with
56 different people. Among our participants, there are a few
57 examples of participants saying that testing is boring,
58 while others refer to testing as a challenging and creative
59 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 and creativity 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 accom-
plish 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 sug-
gests conditions for job satisfaction. The categories gener-
ated 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 me-
dium 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 motiva-
tion and job satisfaction over the data from the four cases,
the outcomes were semantically combined in two main
categories: performance and professionalism. Work moti-
vation influences mainly the individual and collective per-
formance of the software engineers, while job satisfaction
influences mainly their professionalism. This combination
followed the same process of interpretation and discus-
sions 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 per-
son at the workplace.

Table 14 - Behavioural descriptors for work motivation and job satisfaction (cross-case tabulation)

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

Table 15 – Workplace factors for Work Motivation and Job Satisfaction (cross-case analysis)

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

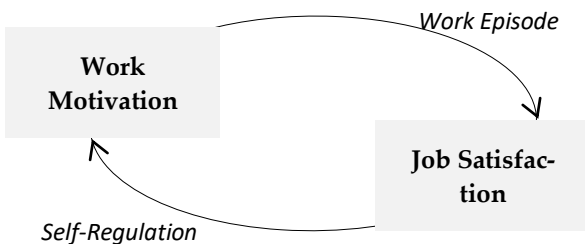
Table 16 - Effects of high and low levels of work motivation and job satisfaction (cross-case analysis)

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, -	PROACTIVITY, INTERACTIVITY, PRODUCTIVITY, -	PERFORMANCE <i>The best possible expression of the competencies (knowledge, abilities and attitudes) of the individual at work.</i>
Low levels of WORK MOTIVATION	LAZINESS, ISOLATION -	LAZINESS, QUIET/RESERVED, PASSIVITY -	LAZINESS, ISOLATION, PASSIVITY, LOW PRODUCTIVITY	LAZINESS, SOCIAL ISOLATION, PASSIVITY, LACK OF PRODUCTIVITY, HELPLESS	
High levels of JOB SATISFACTION	PUNCTUALITY	-	COMMITMENT, CALM,	RESPONSIBILITY, CALM	PROFESSIONALISM <i>A set of practices that sustain reliability and integrity of the person.</i>
Low levels of JOB SATISFACTION	ABSENCE, TROUBLEMAKING	LACK OF COMMITMENT	ABSENCE	ABSENTEEISM, PESSIMISM, IRRESPONSIBILITY	

1
2 **5.3 A new theory of work motivation and job**
3 **satisfaction of software engineers (TMS-SE)**
4

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

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



32 Although work motivation and job satisfaction are
33 distinct, they are closely connected in a feedback loop (Fig.
34 2), through the self-regulation process [70] that connects
35 past experiences to future behaviours. In the following
36 subsections, we describe the TMS-SE in five basic proposi-
37 tions.
38

39 *Proposition 1) Job satisfaction is expressed in terms of*
40 *happiness, while work motivation is a combination of en-*
41 *gagement and focus.*

42 From the data explored in the previous section, it is
43 possible to learn that Job satisfaction is signalled mainly by
44 happiness of the individuals at work, but the external signs
45 of a motivated behaviour remain unclear. From our study
46 data, we came to the conclusion that engagement and
47 focus are the traits that best describe the motivated be-
48 haviour of software engineers. Both engagement and
49 focus comprise behaviours perceivable before and during
50 a work episode. Engaged individuals differ from non-
51 engaged individuals in their levels of involvement with the
52 work, effort applied, concern with the results, and proac-
53 tivity. Focused individuals differ from non-focused individ-
54 uals in their levels of attention and care for the work.

55 Identifying engagement and focus as behavioural
56 traits for motivation is consistent with other available theo-
57 ries of motivation. As Steers et al. [5, p. 379] pointed out,
58 the theories of human motivation are generally concerned
59 with factors or events that energize, sustain (engagement)
60

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 to the perceived re-
quirements 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 (direc-
tion).

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 engage-
ment 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.

Fig. 3 - Combination of engagement and focus

Engaged	<i>Frenetic</i>	<i>Motivated</i>
Not Engaged	<i>Demotivated</i>	<i>Homeostatic</i>
	Unfocused	Focused

Proposition 2) Motivation moderates the relationship be-
tween an individual's latent performance and actual per-
formance within a work episode.

According to the analysis of our case studies, Perform-
ance 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 document-
ed for example by Rash and Tosi [72] and Prasad et. al
[73]. In addition, Morgeson and Humphrey [78] draw at-
tention to the fact that the working context (i.e. ergonom-
ics, equipment use, etc.) can dissipate latent performance.

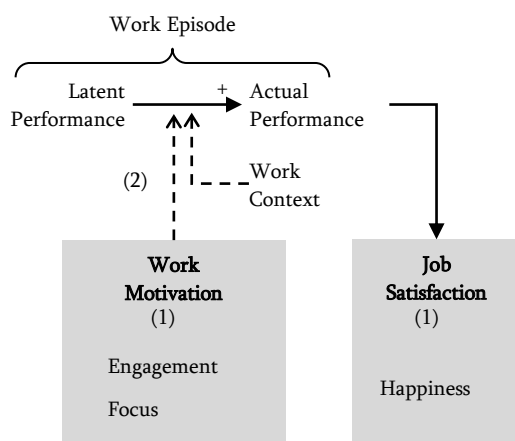
Therefore, given a working context, an individual has
a latent performance against any task, and the actual per-
formance is moderated by motivation, i.e. a motivated
engineer is more likely to realize all their latent perfor-
mance in a given task.

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 moti-
vated than others based on their comparative perfor-
mance. Motivation is not the only predictor of actual per-
formance. It is not possible to affirm that a motivated
engineer will perform better than another engineer (moti-
vated or not), because their latent performances are af-
fected 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 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.

Fig. 4 – The relationship between work motivation, 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.

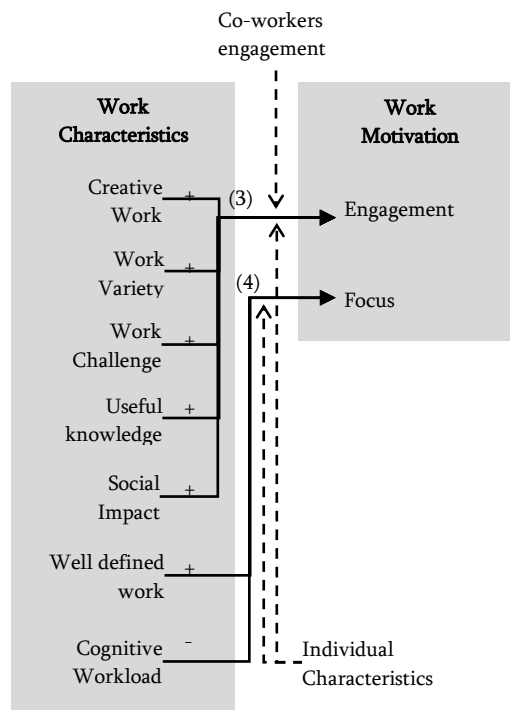
While in the Job Characteristics Theory, Hackman and his colleagues use the terms Job Characteristics and Task Characteristics as interchangeable concepts, in the TMS-SE, we find it useful to distinguish three different dimensions of the workplace: *Task* refers to a specific thing to do, e.g. write 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 char-

acteristics influence the engagement of software engineers. Fig. 5 portrays 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 orientation. However, these aspects were not investigated, and must be explored in future work.

Fig. 5 – Antecedents of engagement and focus



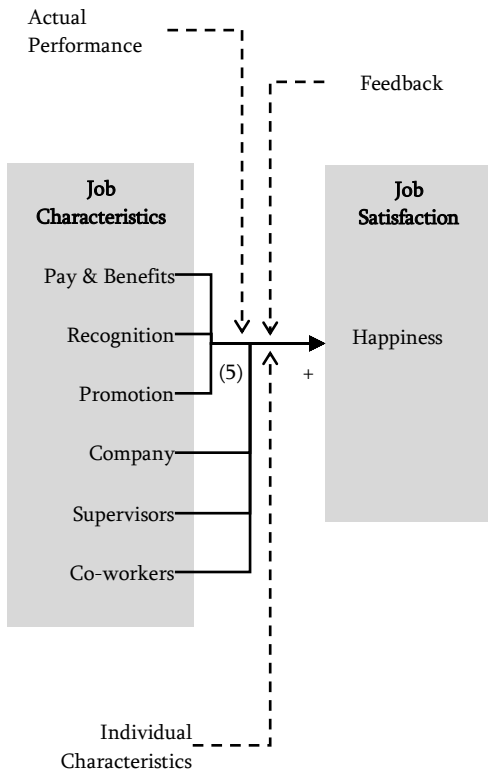
Proposition 5) Actual performance in a determined work episode, influences the software engineer's appraisal of the workplace factors, and this relationship is moderated by available feedback and individual characteristics.

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 per-

ceived 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.

Fig. 6 – Antecedents of happiness



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.

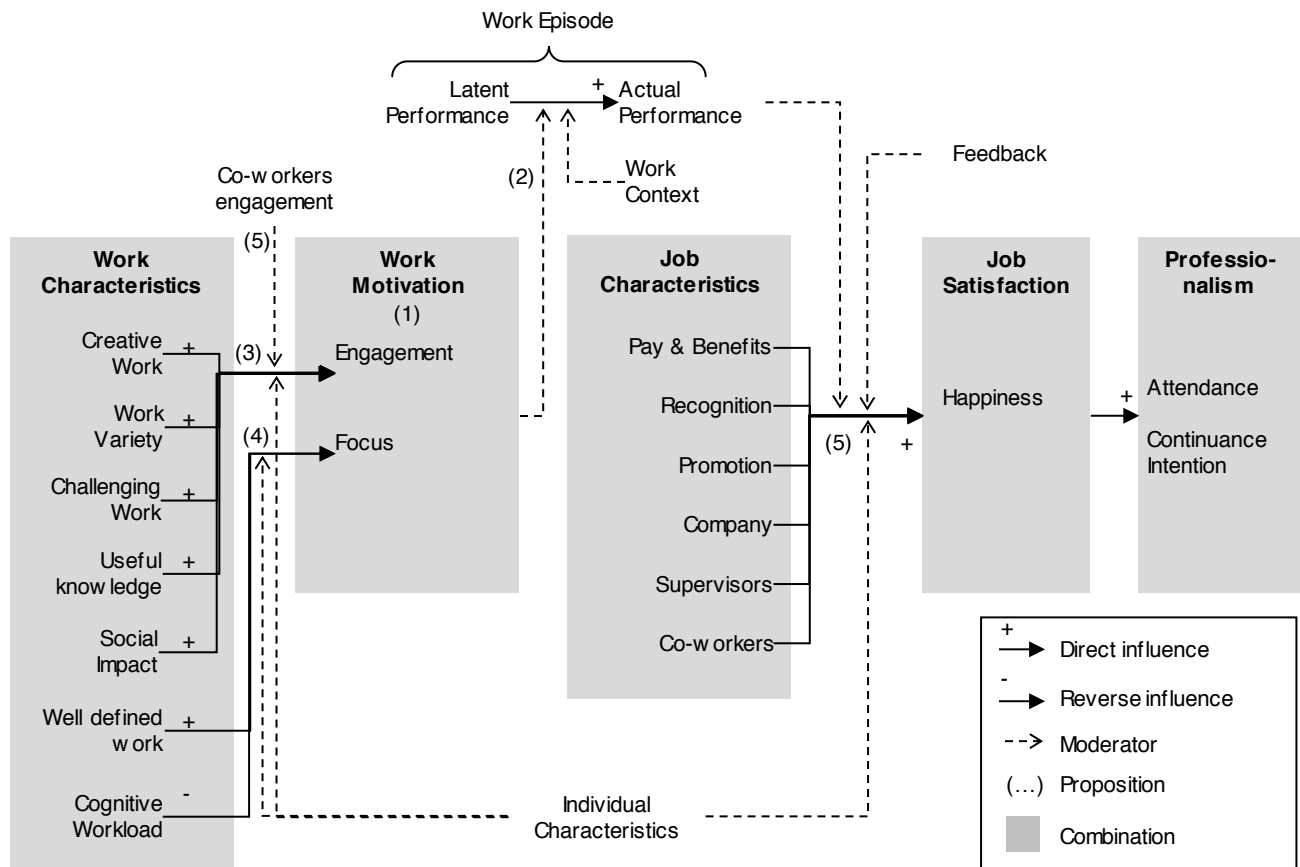
The set of factors found in our study confirms that the job characteristics described in the Hackman’s Job Characteristics Theory (JCT) are not enough to explain the nuances of this particular type of work. The relationships between the elements of TMS-SE and the original five factors of the JCT are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

Fig. 7 - Model of work motivation and job satisfaction



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

1
2 experience of performing it. As pointed out in Hackman
3 and Lawler III [75], all the workplace factors are psycholog-
4 ical and subjective in essence i.e., it is not their objective
5 state that affects employee's attitudes and behaviour, but
6 rather how they are perceived by the employees. That is
7 the same understanding of the TMS-SE.

8 Finally, the concept of challenging work represents a
9 bridge that makes our theoretical framework consistent
10 with the Social Cognitive Theory (SCT) [81][82]. The SCT
11 defines self-efficacy as "*the strength of people's convictions*
12 *in their own effectiveness*" [82, p. 193]. The JCT and
13 the SCT were built on the precepts of Vroom's expectancy
14 theory [83]. However, the SCT was mainly developed
15 around the idea that personal expectations influence one's
16 motivation, while in the JCT this idea is not explicit. The
17 SCT asserts that self-efficacy influences choice, as predicted
18 in the Expectancy Theory, but also determines "*how much*
19 *effort people will expend and how long they will*
20 *persist in the face of obstacles and aversive experiences.*"
21 [82, p. 194], which is consistent with our assertion that
22 challenging work (tasks that stretches one's self-efficacy)
23 influences engagement. Nevertheless, the TMS-SE focuses
24 on workplace factors rather than on individual characteristics.
25 Thus, the idea of self-efficacy appears in the TMS-SE in
26 this more work-oriented manner.

27 **6.2 The TMS-SE and Couger and Zawacki's work**

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

42 Nevertheless, there are two main points of compar-
43 ison between our work and Couger and Zawacki's. First,
44 the software engineers' high growth needs, defined as "*the*
45 *degree to which an individual values opportunities for*
46 *personal growth and development at work*", is well repre-
47 sented in the factor useful knowledge in the TMS-SE. Sec-
48 ond, in our four case studies, software organisations suf-
49 fered from low levels of performance feedback. Notice
50 that the low levels of feedback could be either a result of a
51 specific personality trait common in software engineers or
52 simply a result of how the software development process-
53 es are designed. The TMS-SE argues that feedback does
54 not impact directly work motivation, but does influence
55 job satisfaction.

56 Although Couger and Zawacki suggested that the
57 Goal Setting approach could only serve to enhance feed-
58 back (and hence job satisfaction), the right manipulation of
59 goal attributes can also act over the conditions for en-
60 gagement 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' mo-
tivation 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 ele-
ments of the MOCC together are in fact consistent with
the TMS-SE: contextual factors and individual personality
and preferences influence the characteristics of the soft-
ware 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 suc-
cess are directly influenced by the motivation of software
engineers. In contrast, the TMS-SE approaches work moti-
vation 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, evalu-
ation 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 out-
comes. 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 en-
gineer'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 en-
able 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

1
2 focused on work motivation or job satisfaction, but pro-
3 duce relevant insights into this subject. Turley and Bieman
4 [85], Kandeel and Wahba [86], and Beecham et. al [87], for
5 example, explore characteristics of high and low perform-
6 ers in software development. Engagement and focus are
7 among the common traits that those studies point out. In
8 the TMS-SE, it is possible to find the reasons that explain
9 these results: highly motivated software engineers are
10 engaged and focused, so they achieve their best.

11 Nevertheless, the belief that motivated employees
12 perform better than de-motivated workers is a common
13 misleading idea. The TMS-SE argues that motivation influ-
14 ences the individual performance, i.e. motivated individu-
15 als perform as best as they can, which does not ensure
16 that they will perform better than others. Motivated soft-
17 ware engineers are not necessarily the best performers,
18 but they perform better than they would if they were not
19 motivated.

20 As pointed out in the review of the literature de-
21 scribed in Session 3, one of the biggest challenges for the
22 empirical study of work motivation and job satisfaction has
23 been the operational approach to observe or measure
24 these phenomena. It is not always clear whether the inves-
25 tigated phenomenon is job satisfaction or work motiva-
26 tion. There are cases in which: (a) studies intended to as-
27 sess work motivation use questionnaires that assess job
28 satisfaction (e.g. [88]); (b) studies intended to assess job
29 satisfaction, use self-designed questionnaires, for which
30 the reliability is unknown (e.g. [89]); (c) studies intended to
31 assess self-defined constructs, which are neither work
32 motivation nor job satisfaction (e.g. [38]). It was out of the
33 scope of this research to provide a ready-to-go assess-
34 ment questionnaire, but it provides a practical framework
35 that can be used in future research to delineate sensible
36 operationalization of the work motivation and job satisfac-
37 tion constructs.

38 **6.5 Implications and challenges for software** 39 **engineering**

40 Based on the TMS-SE, we suggest how software en-
41 gineers could consider the following workplace factors:

- 42 • Engagement of co-workers: our case studies
43 showed that a highly motivated engineer may posi-
44 tively influence others, as well as a poorly motivated
45 engineer may contaminate others. The first chal-
46 lenge for software engineering team leaders is to
47 identify the poorly motivated engineers before the
48 contamination occurs, to avoid a generalized de-
49 crease in motivation. The second challenge is to
50 identify the highly motivated engineers, to leverage
51 the motivation of the other team workers. In both
52 cases, interventions must be conducted carefully to
53 avoid the introduction of inequity in the team. In-
54 equity sets off a significant risk for job satisfaction.
- 55 • Challenging work: the relationship between work
56 characteristics and work motivation is not neces-
57 sarily linear. In the case of challenging work, it
58 seems to be an inverted U-shape relationship: too
59 little, or too much challenge may not be effective to
60 engage, because of the self-efficacy effect. Our case

studies show, for example, that a realistic and reli-
able estimation process can be a relevant source of
leveraging challenge, while an untrustworthy esti-
mation 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 be-
haviour 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 mo-
tivating 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 per-
formance, 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 in-
centives.
- Work variety: There are at least two challenges con-
cerning work variety. First, how to assure work vari-
ety in a single-project setting. The organisation in
Case Study IV had a large product, whose mainte-
nance consumed a significant amount of the work-
force, 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 differ-
ent domains of knowledge. Both examples repre-
sent 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 vari-
ety without stressing the engineers in multi-project
settings. Our studies show that changing the alloca-
tion 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]. Allo-
cating engineers to simultaneous projects may also
hamper their work motivation.
- Creativity: It was possible to notice that the partici-
pants of our case studies tended to focus on the
creative part of a task when referring to their fa-

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avourite 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.

42 7 CONCLUDING REMARKS

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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.

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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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Motivation and Satisfaction of Software Engineers

César França, Fabio Q. B. da Silva, Helen Sharp

APPENDIX A – INTERVIEW EXCERPTS

Case I

Table A 1 - Behavioural descriptors for work motivation and job satisfaction (Case I – RQ1)

CONSTRUCT	POSITIVE ADJ. {Participants} "example of the adjective as in the data"	NEGATIVE ADJ. {Participants} "example of the adjective as in the data"	EMERGING BEHAVIOURAL DESCRIPTOR
WORK MOTIVATION	FOCUSED {P1.1, P1.4, P1.5, P1.6} — "Totally dedicated, persistent, <u>focused</u> in his objectives" (P1.6)	UNFOCUSED {P1.1, P1.2, P1.4} — "It would be a person that every moment small things steal their attention, the person is <u>distracted</u> " (P1.4)	FOCUS
	COMMITTED {P1.2, P1.4, P1.5, P1.6} — "His involvement with the project, his commitment" (P1.4)	UNINVOLVED {P1.2} — "What happens is that this person arrived here late, and is there... (...) and <u>spends three hours reading unimportant emails</u> " (P1.2)	COMMITMENT
	HARD-WORKING {P1.6} — "Totally dedicated, <u>persistent</u> , focused in his objectives" (P1.6)	-	HARD WORK
	INTERESTED {P1.4, P1.5} — "the person is <u>interested</u> in seeing the work results later" (P1.4)	INDIFFERENT {P1.1, P1.4} — "She <u>does not value</u> the work. She does not do the work the way she is supposed to" (P1.1)	INTEREST
JOB SATISFACTION	EXCITED {P1.4} — "[he/she] is <u>excited</u> with the achievements" (P1.4)	RESENTED {P1.3, P1.6} — "I only consider it when the person keeps <u>complaining</u> about the work" (P1.3)	EXCITEMENT
	GOOD MOOD {P1.1} — " <u>Smiling</u> " (P1.1)	BAD MOOD {P1.1} — "she comes in a <u>bad mood</u> " (P1.1)	MOOD

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

Table A 2 – Work motivation and job satisfaction factors (Case I – RQ2))

CONSTRUCT	BEHAVIOURAL DESCRIPTOR	WORKPLACE FACTOR {Participants} "examples as in the actual data"
WORK MOTIVATION	FOCUS	WELL DEFINED WORK {P1.1, P1.4, P1.5, P1.6} — "dealing with a finite number of activities that will get to a <u>result</u> " (P1.4, in: answer to Q13) FAIR WORKLOAD {P1.2, P1.3, P1.4} — "if there is <u>too much</u> , nobody likes it... if there is <u>too little</u> , the person gets lost" (P1.3, in: answer to Q11)
	COMMITMENT	BEING UPDATED {P1.2, P1.5, P1.6} — "the possibility of <u>participating</u> [in an academic event] <u>motivates</u> , because it enriches and <u>brings new and useful experiences</u> for our day-to-day work." (P1.5, in: diary data 03/03/2011) DIFFERENT DOMAINS {P1.4} — "this idea of <u>knowing a little more about different business domains</u> , and to present IT solutions for them, has <u>always been attractive</u> " (P1.4, in: answer to Q2)
	HARD-WORK	ENGAGEMENT OF CO-WORKERS {P1.1, P1.2, P1.5} — "when you* see other people working and showing results (...) you become stimulated to follow their behaviour" (P1.1, in: answer to Q27) SOCIAL RELEVANCE {P1.1, P1.2, P1.4, P1.5} — "I think that the <u>role of the organization is also important</u> , it stimulates me." (P1.1, in: answer to Q6) CONFIDENCE {P1.1, P1.3} — "to do the things that I am good at" (P1.3, in: answer to Q13)
	INTEREST	CREATIVITY {P1.1, P1.2, P1.3, P1.6} — "precisely, in the development process, I <u>like to take part in creation</u> ." (P1.1, in: answer to Q3) PROBLEM SOLVING {P1.1, P1.4}

		— “I like (...) to <u>discuss the solutions</u> , to discuss about the architecture” (P1.1, in: answer to Q3)
JOB SATISFAC-TION	EXCITEMENT	SUCCESS {P1.1, P1.2, P1.4, P1.5, P1.6} — “all the improvement demands would be released without any problems (...) By the end of the day, <u>every-thing worked</u> ” (P1.2, in: answer to Q11)
	MOOD	RECOGNITION {P1.5} — “People <u>saying thank you for things that you have done</u> (...) <u>It makes me happy</u> ” (P1.5, in: answer to Q11)

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

* in slang Brazilian Portuguese, it is fairly common to see the use of the pronoun "you" or to refer to "people", when a person describes his/her own attitudes and behaviours with the intention of generalizing it to others.

Table A 3 – Outcomes of work motivation and job satisfaction (Case I – RQ3)

CONSTRUCT	WHEN HIGH, CAUSES... {Participants} “example as in the actual data”	WHEN LOW, CAUSES... {Participants} “example as in the actual data”
WORK MOTI-VATION	PRODUCTIVITY {P1.3, P1.4} — “he is with a <u>high productivity</u> ” (P1.3) COMMUNICATION {P1.4, P1.5} — “the person is there, <u>speaking</u> about possible solutions, <u>showing things to you</u> ” (P1.4) PROACTIVITY {P1.1, P1.2} — “You <u>go after</u> solutions to fix the things, you <u>don't wait</u> ” (P1.1)	LAZINESS {P1.1} — “[the person] <u>doesn't finish</u> the activities, or leaves them to the last day of the deadline... <u>procrastinating</u> ” (P1.1) ISOLATION {P1.2} — “The person is there, in a bad mood, <u>does not want to talk to anybody</u> , stays in a place, quiet” (P1.2)
JOB SATISFAC-TION	PUNCTUALITY {P1.1} — “Starts by <u>arriving early</u> ” (P1.1)	ABSENCE {P1.1, P1.2, P1.5} — “ <u>arrives late</u> ” (P1.1) TROUBLEMAKING {P1.1, P1.3, P1.5} — “ <u>complains a lot</u> , about everything. Everything is wrong, even the taste of the water” (P1.5)

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

Case II

Table A 4 - Behavioural descriptors for work motivation and job satisfaction (Case II – RQ1)

CONSTRUCT	POSITIVE ADJ. {Participants} “example of the adjective as in the actual data”	NEGATIVE ADJ. {Participants} “example of the adjective as in the actual data”	EMERGING BEHAVIOURAL DESCRIPTOR
WORK MOTI-VATION	FOCUSED {P2.3} — “shows that he is <u>focused</u> on his tasks” (P2.3)	CARELESS {P2.1, P2.2, P2.4} — “release their piece of work with some <u>malfunc-tions</u> , which impacts all the team” (P2.1)	FOCUS
	ENGAGED {P2.1, P2.2, P2.6} — “ <u>embraces the cause</u> , carries the load together” (P2.2)	UNINVOLVED {P2.2, P2.3, P2.4} — “sometimes, you can see that <u>lacks heart</u> , be-cause the code was not written in the best way, ” (P2.4)	ENGAGEMENT
	HARD-WORKING {P2.2, P2.3} — “Stays until <u>late hours at work</u> , on a day or another, to finish things” (P2.3)	INDIFFERENT {P2.3} — “the person is not able to finish the activities in the expected time, and just <u>don't care</u> for that” (P2.3)	HARD WORK
JOB SATISFAC-TION	GOOD MOOD {P2.3} — “a person that is <u>not upset</u> ” (P2.3)	BAD MOOD {P2.4} — “sometimes, the <u>bad mood</u> , I don't know, it is possible to see” (P2.4)	MOOD

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

Table A 5 - Work motivation and job satisfaction factors (Case II – RQ2)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR	WORKPLACE FACTOR {Participants} “examples as in the actual data”
WORK MOTI-VATION	FOCUS	CLEAR REQUIREMENTS {P2.1} — “our cliente actively participated at the definition of the working method of the team, which made <u>very clear the understanding</u> for both parts” (P2.1, in diary data, 15/02/2011) BALANCED WORKLOAD {P2.3} — “if someone in the team does not properly do their work, you must always <u>work more</u> , to assure quality in that project” (P2.3, in? Answer to Q7) QUIET ENVIRONMENT {P2.2, P2.3} — “it was a very complicated thing to do, but everyone <u>kept interrupting me</u> to ask ‘what should I do, now?’” (P2.3, in: answer to Q20)
	ENGAGEMENT	TECHNICAL SKILL DEVELOPMENT {P2.3, P2.5, P2.6}

	<p>— “So, <u>to learn new things</u>, to make changes in the system, I think that this dynamics (...) has always attracted me.” (P2.5, in: answer to Q3) PROJECT VARIETY {P2.3, P2.4, P2.6} — “at the end of the two years of the project, you would be allocated in <u>another project</u>. Other business rules, other things to learn, other challenges” (P2.3, in: answer to Q3) TEAM EXPERTISE {P2.1} — “the <u>know how of people in the team</u> is good (...) In a way or another, you end up by <u>making profits of this expertise</u>” (P2.1, in: answer to Q22) KNOWLEDGE EXCHANGE {P2.5} — “the <u>information change</u> is very, very interesting. We can take large steps.” (P2.5, in: answer to Q22)</p>
HARDWORK	<p>USEFUL PRODUCT { P2.2, P2.3, P2.5, P2.6} — “you want to see the thing going public, <u>being used by actual clients</u>, see the feedback, and there was not much of it in there” (P2.5, in: answer to Q5) BRAINWORK {P2.2, P2.3, P2.4, P2.5, P2.6} — “I don’t like when the <u>things get very mechanic</u>. (...) just clicking, I... I am very restless” (P2.4, in: answer to Q16) RESEARCH {P2.5, P2.6} — “when an activity requires <u>research effort</u>” (P2.5, in: answer to Q12) COMMITMENT OF CO-WORKERS {P2.1, P2.2, P2.3} — “what <u>lowers my motivation</u> is the <u>lack of commitment of other people in the team</u>” (P2.2, in: answer to Q16)</p>
JOB SATISFACTION	<p>MOOD</p> <p>WORK SUCCESS {P2.1, P2.2, P2.3, P2.4, P2.5, P2.6} — “when <u>everything goes right</u>, and I finish everything, everything that was expected to do in that day, making it on the right time and leave work at the right hour” (P2.2, in: answer to Q11) RECOGNITION {P2.2} — “just after the release moment, because soon comes the compliment for that (...) then I <u>feel satisfied</u>” (P2.2, in: answer to Q12)</p>

‘P’ – refers to participants. ‘Q’ – refers to interview script’s questions (Appendix A)

Table A 6 - Outcomes of work motivation and job satisfaction (Case II – RQ3)

CONSTRUCT	WHEN HIGH, CAUSES... {Participants} “example as in the actual data”	WHEN LOW, CAUSES... {Participants} “example as in the actual data”
WORK MOTIVATION	<p>PARTICIPATION {P2.6} — “His participation in the project, like, in helping other, <u>in asking questions</u>” (P2.6) HELP OTHERS {P2.1} — “<u>tries to help his colleagues</u>” (P2.1) PROACTIVITY {P2.4, P2.6} — “he is always looking for more things... when finishes something, goes for the next thing” (P2.4) INTEGRATION {P2.2, P2.4, P2.5, P2.6} — “I felt free to say ‘I don’t know how to do this’ or ‘I like to do that’. So, I felt the team very open in this aspect” (P2.6, in: answer to Q21) PRODUCTIVITY {P2.1} — “carries the planned activities within the defined expectations” (P2.1)</p>	<p>QUIET/RESERVED {P2.4, P2.6} — “barely talks to anybody, for example, when leaving, just don’t talk” (P2.4) LAZINESS {P2.1, P2.2, P2.3, P2.4} — “when the guys decide to stay after office hours, and communicate everybody, some people just leave earlier” (P2.2) PASSIVE {P2.4} — “You can see that the person kept postponing” (P2.4)</p>
JOB SATISFACTION	-	<p>LACK OF COMMITMENT {P2.1} — “loses the commitment to the deadlines, and to the quality of what’s being done” (P2.1)</p>

‘P’ – refers to participants. ‘Q’ – refers to interview script’s questions (Appendix A)

Case III

Table A 7 - Behavioural descriptors for work motivation and job satisfaction (Case III – RQ1)

CONSTRUCT	POSITIVE ADJ. {Participants} “example of the adjective as in the actual data”	NEGATIVE ADJ. {Participants} “example of the adjective as in the actual data”	EMERGING BEHAVIOURAL DESCRIPTOR
WORK MOTIVATION	<p>FOCUSED { P3.2, P3.7, P3.9} — “he is focused on what he is doing, he doesn’t get distracted” (P3.9)</p>	<p>DISTRACTED {P3.5, P3.6, P3.8, P3.9, P3.10} — “he is distracted, like, not focused in the activity, keeps doing other things” (P3.9)</p>	FOCUS
	<p>CAREFUL {P3.7} — “cares to do the best ways” (P3.7)</p>	<p>CARELESS {P3.1, P3.2, P3.3, P3.5} — “doesn’t care with the final results, just make it work” (P3.1)</p>	CARE
	<p>ENGAGED {P3.2, P3.5, P3.7} — “He doesn’t count how many hours are left to</p>	<p>UNINVOLVED {P3.1, P3.5, P3.6} — “people avoided the things that would compro-</p>	ENGAGEMENT

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	<i>leave work, he is just doing that, he's got a goal"</i> (P3.2)	<i>mise their time"</i> (P3.5)	
JOB SATISFACTION	GOOD MOOD {P3.10} — <i>"he is a smiling person, who (...) works in a natural way, without apparent stress"</i> (P3.10)	BORED {P3.2, P3.7} — <i>"he has no spirit"</i> (P3.2)	MOOD

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

Table A 8 - Work motivation and job satisfaction factors (Case III – RQ2)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR	WORKPLACE FACTOR {Participants} "examples as in the actual data"
WORK MOTIVATION	FOCUS	CLEAR REQUIREMENTS {P3.4, P3.7, P3.9} — <i>"what demotivates me the most are requirements that come out from nowhere and new projects that come out from nowhere, without any reasonable specification"</i> (P3.9, in: answer to Q38) GOAL-DRIVEN RESPONSIBILITIES {P3.2} — <i>"you know that you have responsibilities and deadlines, usually short deadlines, but the guys don't pressure"</i> (P3.2, in: answer to Q36) ONE PROJECT AT A TIME {P3.4, P3.9} — <i>"I stop working in a Project and then I start in other, and this other is completely different, then I have to change all my thinking context, change the way I think"</i> (P3.9, in: answer to Q16)
	CARE	HELPING OTHERS {P3.7} — <i>"The issue is that we deal with technology, and it is always changing and updating, and the fact that we are using it to a greater good, to help the general population"</i> (P3.7, in: answer to Q2)
	ENGAGEMENT	DOMAIN VARIETY {P3.4, P3.6} — <i>"when a project finishes and another starts, everything is new from there onwards, I mean, none of the problems are very routine ones"</i> (P3.6, in: answer to Q3) INTELLECTUAL CHALLENGE {P3.3, P3.5, P3.6, P3.8, P3.9, P3.10} — <i>"I like challenges, I like things that make people think and discuss about it, it stimulates me and makes me eager to solve the problem"</i> (P3.3, in: answer to Q13) MOTIVATION OF CO-WORKERS {P3.5, P3.6} — <i>"the people here is very animated, I think that it is cool and it motivates me a lot"</i> (P3.5, in: answer to Q36) TECHNICAL CONFIDENCE {P3.1, P3.4, P3.6, P3.7, P3.9} — <i>"Activities that I had already experienced at work, that I already knew the way to follow, or possible errors that may happen, already knowing more or less where I am and what to do"</i> (P3.7, in: answer to Q11) CONTINUOUS LEARNING {P3.5, P3.6, P3.7, P3.8, P3.10} — <i>"to learn with others, in a daily basis, that is what stimulates me the most"</i> (P28, in: answer to Q13)
JOB SATISFACTION	MOOD	PERFORMANCE {P3.10, P3.2, P3.3, P3.4, P3.9} — <i>"when I am able to make several things in a day, that's very important"</i> (P3.3, in: answer to Q11) RECOGNITION {P3.2, P3.8, P3.9} — <i>"acknowledge when you do something well-done"</i> (P3.2, in: answer to Q40) CUSTOMER FEEDBACK {P3.4, P3.6} — <i>"so, it is more like having a sight of the people using the features, thinking that this thing is new, or is interesting maybe"</i> (P3.4, in: answer to Q13)

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

Table A 9 - Outcomes of work motivation and job satisfaction (Case III – RQ3)

CONSTRUCT	WHEN HIGH, CAUSES... {Participants} "example as in the actual data"	WHEN LOW, CAUSES... {Participants} "example as in the actual data"
WORK MOTIVATION	INTERACTIVITY {P3.5, P3.10} — <i>"talk and work easy"</i> (P3.10) HELP OTHERS {P3.8} — <i>"he is answering questions, helping others too"</i> (P3.8) PROACTIVITY {P3.1, P3.2, P3.4, P3.5, P3.8} — <i>"He is a pearson looking for the work"</i> (P3.1) PRODUCTIVITY {P3.2} — <i>"demonstrates through his production time"</i> (P3.2)	LAZINESS {P3.2, P3.5, P3.10} — <i>"he sees no reason to release things before the deadline, if something is expected to Friday, he fools around at work until Friday, and release it then"</i> (P3.2) ISOLATION {P3.4, P3.5, P3.10} — <i>"with low interaction with other people"</i> (P3.4) PASSIVITY {P3.2} — <i>"do what they do just for an obligation"</i> (P3.2) LOW PRODUCTIVITY {P3.3} — <i>"working slow, with low productivity"</i> (P3.3)
JOB SATISFACTION	COMMITMENT {P3.6} — <i>"showing some commitment with the team, with the deadlines, and with the releases"</i> (P3.6) CALM {P3.7, P3.9} — <i>"do not lose temper when facing some challenges"</i> (P3.7)	ABSENCE {P3.1} — <i>"arrives late (...) does not want to be there"</i> (P3.1)

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

Case IV

Table A 10 - Behavioural descriptors for work motivation and job satisfaction (Case IV – RQ1)

CONSTRUCT	POSITIVE ADJ. {Participants} "example of the adjective as in the actual data"	NEGATIVE ADJ. {Participants} "example of the adjective as in the actual data"	EMERGING BEHAVIOURAL DESCRIPTOR
WORK MOTIVATION	FOCUSED {P4.10} — "does not waste time with unimportant things (...) he is <u>focused on that</u> " (P4.10)	UNFOCUSED {P4.2, P4.3} — "always <u>deviates from what needs to be done</u> " (P4.3)	FOCUS
	CAREFUL {P4.1, P4.4, P4.6, P4.7} — "used to be more <u>careful than needed</u> " (P4.1)	-	CARE
	ENGAGED {P4.2, P4.4, P4.5, P4.8, P4.9, P4.10} — "the person comes, and does what must be done, with <u>engagement</u> " (P4.4)	INDIFFERENT {P4.6, P4.7} — "He finds <u>any other thing to do</u> , except to do his work activities" (P4.7)	ENGAGEMENT
	HARD-WORKING {P4.2, P4.9} — "sometimes, he stays a little <u>after the working hours</u> , because he <u>wants to finish something</u> " (P4.2)	-	HARDWORK
JOB SATISFACTION	EXCITED {P4.1, P4.2, P4.9} — "get <u>excited</u> when talking about the work" (P4.9)	BORED {P4.1, P4.2, P4.3, P4.8, P4.9, P4.10} — "the person is not enthusiastic with those tasks" (P4.2)	EXCITEMENT
	GOOD MOOD {P4.1} — "talks always in a <u>good mood</u> " (P4.1)	BAD MOOD {P4.1, P4.7} — "does not say a good morning for his work friends, <u>lowers his head</u> " (P4.7)	MOOD

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

Table A 11 - Work motivation and job satisfaction factors (Case IV – RQ2)

CONSTRUCT	BEHAVIOURAL DESCRIPTOR	WORKPLACE FACTOR {Participants} "examples as in the actual data"
WORK MOTIVATION	FOCUS	CLEAR PROCESSES {P4.3} — "these <u>processes are very poorly defined</u> , we do not know who is supposed to do the things (...) Then we do not know how to act right in this messy environment" (P4.3, in: answer to Q38) CLEAR CUSTOMER NEEDS {P4.4, P4.7, P4.8} — "When you get in touch with the client, you are able to <u>perceive precisely what he wants</u> " (P4.8, in: answer to Q14) CLEAR GOALS {P4.3} — "before accepting [a task / a goal] (...) I would <u>try to clarify why the things should be that way</u> " (P4.3, in: answer to Q35) FAIR WORK LOAD {P4.2, P4.3} — "Priorities are not managed correctly, so it becomes a snowball of tasks that are not finished, problems that are not solved, then we face <u>stress that could be avoided</u> " (P4.3, in: answer to Q28)
	CARE	USEFUL PRODUCTS {P4.1, P4.2, P4.5, P4.8} — "a thing that you are contributing to make someone else's work easier. I think that it is what makes me happy, what <u>stimulates any person</u> that is doing the work. You are working for somebody, and you want it to be <u>useful to that person</u> ." (P4.8, in: answer to Q13) AUTHORSHIP {P4.1, P4.3, P4.6} — "to create a solution for a problem, if not 100%, at least 80% originated from your work, from own effort" (P4.1, in: answer to Q13)
	ENGAGEMENT	LEARNING OPPORTUNITIES {P4.2, P4.3, P4.4, P4.6, P4.8, P4.9, P4.10} — "what stimulates me is <u>always having something new</u> , however small, I talk, I learn, I discover because I heard someone else talking, I look for deeper information." (P4.3, in: answer to Q6) LEARNING ABOUT THE PRODUCT {P4.5, P4.7} — "it is to discover <u>new things about the product</u> , so that in face of any problem or user question, I can figure out how to solve it quickly" (P4.5, in: answer to Q12) ENGAGEMENT OF CO-WORKERS {P4.7, P4.4, P4.6} — "As all teams, there is always someone that is demotivated a little more than needed, and he ends up <u>infecting the others with this low motivation</u> " (P4.6, in: answer to Q28) PROJECT VARIETY {P4.1, P4.5} — "the business is too wide, and we have the opportunity to learn, slowly, more about it, in <u>different projects</u> , learning a bit of each part of the whole business, and that is motivating" (P4.4, in: answer to Q36) MATURITY OF CO-WORKERS {P4.2, P4.10} — "we do not have very <u>mature people</u> in some areas, with whom we could learn a lot" (P4.2, in: answer to Q7) VARIETY OF WORK {P4.1, P4.4, P4.5, P4.6, P4.7, P4.9}

		— “if you get a documentation task, and gets <u>always the same documentation task</u> (...) It is going to demotivate me, because <u>gets monotonous</u> ” (P4.5, in: answer to Q35)
	HARDWORK	INTELLECTUAL CHALLENGE {P4.1, P4.2, P4.4, P4.6, P4.7, P4.8, P4.9, P4.10} — “having a question, and then you have to <u>figure out what to do</u> to get to the solution” (P4.10, in: answer to Q13)- SELF CONFIDENCE {P4.1, P4.2, P4.4, P4.5, P4.8} — “it is very challenging. But, like, what is going to happen is that bug will come up, or problems, or conflicts, and I will take hours and hours and hours to figure out the solution. And, <u>probably, I will not find it.</u> ” (P4.2, in: answer to Q18)
JOB SATISFACTION	EXCITEMENT	ACCOMPLISHMENT {P4.1, P4.3, P4.4, P4.5, P4.8, P4.9, P4.10} — “take some activity that has, maybe, some challenge, something new, but which is possible to do. <u>If you finish it, that will be a nice day</u> ” (P4.4, in: answer to Q11) PRACTICAL IMPACT {P4.1, P4.5, P4.7, P4.10} — “You have spent, I think, a long time implementing several things, (...) and you do not see the thing working, <u>nobody using it, that is terrible.</u> ” (P4.10, in: answer to Q39)
	MOOD	RECOGNITION {P4.5} — “when the <u>client starts to interact and provide positive feedback</u> about your work, that motivates too” (P4.5, in: answer to Q36)

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

Table A 12 - Outcomes of work motivation and job satisfaction (Case IV – RQ3)

CONSTRUCT	WHEN HIGH, IT CAUSES... {Participants} “example as in the actual data”	WHEN LOW, IT CAUSES... {Participants} “example as in the actual data”
WORK MOTIVATION	PROACTIVITY {P4.6, P4.8, P4.10} — “Does not wait until you find she has got a problem. She <u>finds the problem</u> , and tells you that <u>she is going to solve that already</u> ” (P4.6) INTERACTIVITY {P4.2, P4.5, P4.8, P4.9} — “she is <u>interacting</u> with the people (...) she wants to participate in the activities” (P4.5) MUTUAL HELP {P4.5} — “she is really <u>helping</u> , bringing doubts, raising questions to other people” (P4.5) PRODUCTIVITY {P4.4, P4.6, P4.7} — “usually <u>more productive</u> ” (P4.4)	LAZINESS {P4.2, P4.6, P4.8, P4.9} — “I think he <u>goes several times to the coffee room, leaves the desk frequently</u> ” (P4.9) PASSIVITY {P4.6, P4.8} — “ <u>lacks proactivity</u> ” (P4.6) SOCIAL ISOLATION {P4.5, P4.7, P4.9} — “ <u>do not interact with the others</u> ” (P4.5) HELPLESS {P4.5} — “ <u>does not want to help, does not like to help anybody</u> ” (P4.5) LACK OF PRODUCTIVITY {P4.2, P4.4} — “ <u>productivity decreases a lot</u> ” (P4.4)
JOB SATISFACTION	RESPONSIBILITY {P4.3, P4.5} — “I think that they feel good with the received <u>responsibilities</u> ” (P4.3) CALM {P4.3} — “I think that they <u>do not hesitate under pressure</u> ” (P4.3)	PESSIMISM {P4.6} — “the person <u>finds barriers for everything</u> ” (P4.6) ABSENTEEISM {P4.5} — “he <u>does not meet the schedules</u> ” (P4.5) IRRESPONSIBILITY {P4.5, P4.8} — “he is <u>not able to achieve what was planned</u> ” (P4.5)

'P' – refers to participants. 'Q' – refers to interview script's questions (Appendix A)

Motivation and Satisfaction of Software Engineers

César França, Fabio Q. B. da Silva, Helen Sharp

APPENDIX B – LIST OF THE SLR PRIMARY STUDIES

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