Productivity of Agile Teams:
An Empirical Evaluation of Factors
and Monitoring Processes

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1. Introduction

Software productivity is an important concept discussed in projects and organizations. At the beginning, the debate was centered on how much efficient and scalable a team could be when developing systems. The information age, however, has introduced complexity issues back into the software development practice, in a market eager to highly customized products and services. Being productive is not only being efficient, but innovative, fast learning, and adaptive. Software productivity has been changing ever since, but research studies and even industry are still tied to that old productivity concepts.

This thesis aims at exploring software productivity in an up-to-date view of software development, that includes a productivity concept review, an examination of the importance of productivity for companies, an exploration of factors influencing productivity of adaptive teams, and an investigation of approaches to identify threats to productivity in agile teams.

2. Problem outline

Lower cost and shorter time-to-market expectations are the major drivers of software productivity improvements [Trendowicz and Münch 2009]. To manage productivity effectively, it is important to identify the most relevant difficulties and develop strategies to cope with them. Agile methods, including Extreme Programming [Beck and Andres 2004] and Scrum [Schwaber and Beedle 2001], have evolved as approaches to simplify the software development process, potentially leading to better productivity. They aim to shorten development time and handle the inevitable changes resulting from market dynamics [Pikkarainen et al. 2008].

Although the industry has extensively adopted agile methods, little research has empirically examined the software development agility construct regarding its dimensions, determinants, and effects on software development performance [Lee and Xia 2010, Sudhakar et al. 2011]. Understanding the factors that affect productivity could help determine where to concentrate management efforts (and related financial resources) from a practical standpoint and where to focus research efforts from an academic perspective.

Considerable research has been directed at identifying factors that have a significant impact on software development productivity [Trendowicz and Münch 2009]. In general, the studied productivity factors were related to product (specific characterization of software), personnel (team member capabilities, experience, and motivation), project (management aspects, resource constraints), or process issues (software methods and tools). Continuously evaluating productivity factors is important, as factors may change under new software engineering practices. However, to the best of our knowledge, no study in the literature has investigated the major factors influencing *agile team* productivity.

In addition, empirical evidence points out the lack of studies on agile productivity and team producitivy measurements [Dybå and Dingsoyr 2008]. However, at the same time, there is an increasing interest on agile performance measurement systems, both in academia and industry [Highsmith 2006].

3. Research questions

The goal of this research is to explore productivity definitions, factors, and monitoring in agile teams and to improve the practice based on the evidence and gained knowledge. The overall problem addressed by this thesis is: **How to evaluate productivity in teams adopting agile software development?**

This problem can be better investigated through the following research questions:

- **RQ1. How important is productivity for companies adopting agile methods and how do they define productivity?**
- **RQ2: What factors impact agile team productivity and how is this impact from the team point of view? Which agile practices are perceived to impact on a given team's productivity?**
- **RQ3: How to monitor productivity factors, considering agility and adaptability? How do agile metrics support productivity monitoring?**

4. Research context

The research in this thesis uses quantitative and qualitative data from four companies using agile methods for at least two years. The companies are: A) large Brazilian financial corporation with over 500 IT employees; B) e-commerce and infrastructure services organization with over 120 developers; C) important player in Internet content and access provision in Brazil, and D) multinational company working with cutting-edge software technologies and processes. The four companies are detailed in Chapter 1.

We also performed a national survey involving many companies over the country, varying in size, domain, region etc. Our sample covers better the Southeast and Midwest regions (see Chapter 3). Therefore, this research is being carried out under an intensive partnership with Brazilian IT industry.

5. Research design

Empirical studies may apply different research methods. This research is a result of the combination of qualitative and quantitative methods, specifically case studies, survey, and

action research. These three research methods are appropriate to answer research questions focused on "how". The dominant philosophical position taken in this thesis is *interpretivism*, which recognizes that scientific knowledge cannot be separated from its human context. We also adopt *pragmatism*, in which knowledge is judged by how useful it is for solving practical problems. The research questions guide the research design towards *exploratory* and *explanatory* inquiry strategies. Figure 1 summarizes the research phases, the methods used and their purposes.
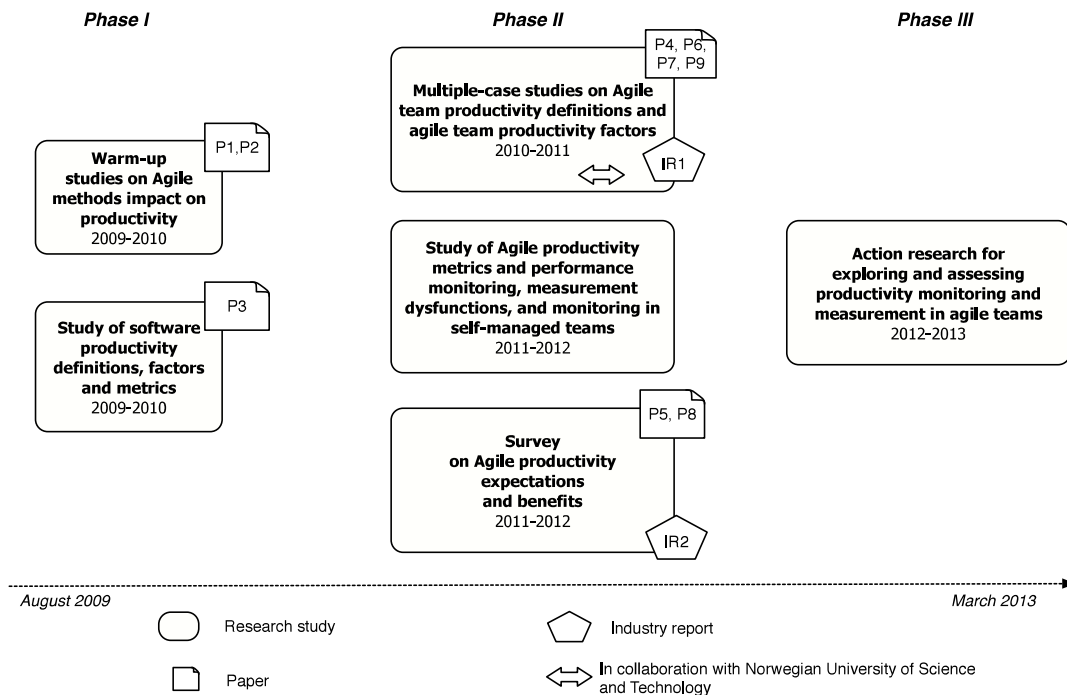
Figure 1. Research phases

Phase I is a combination of literature review of software productivity and warm-up studies. I was working already with data from Company A and performed a preliminary analysis of the effects of agile methods on their software productivity. However, traditional software productivity analysis, such as recommended by ISO/IEC 15393[1] can generate misleading analyses. In parallel, we conducted a literature review based on primary and secondary studies on software productivity definitions, factors, and metrics, both in traditional and agile approaches.

Phase II comprises two types of studies: case studies and surveys. We designed multiple case studies to explore productivity definitions and factors in agile teams. The survey was developed to generate evidence on the importance of productivity for agile teams. After that, we collected qualitative data on how some companies are evaluating agile teams productivity, and if they are using metrics for that. Results were integrated in three aspects: agile productivity definitions, productivity importance and expectations in agile teams, and factors impacting agile team productivity. Our findings answer RQ1 and RQ2.

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[1]ISO/IEC 15939: Software Engineering Software Measurement Process, Int'l Organization for Standardization, 2001

Finally, Phase III involves carrying out an agile team productivity monitoring process, and the evaluation of its usefulness. Since agile companies (and teams) are still trying to find good ways to monitor their productivity, we designed an action research study. The main goal is not to develop new metrics for measuring productivity of agile teams, but to iteratively adopt some proposed agile metrics and evaluate them in a real setting. Our findings answer RQ3.

6. Papers, Industry reports, and Book Chapters

We generated a number of research papers (P), industry reports (IR), and book chapters (CH) based on this research. Complete contributions are listed in the thesis text.

P1 MELO, C. O.; FERREIRA, G. R. M. Adopting Agile in a Large Government Institution: a case study (in Portuguese). In: Workshop Brasileiro de Métodos Ágeis (WBMA), Conferência Brasileira sobre Métodos Ágeis de Desenvolvimento de Software (Agile Brazil 2010). Porto Alegre. p. 104-117.

P2 MELO, C. O.; SANTOS Jr., C. D. ; FERREIRA, G. R. M. ; KON, F. An exploratory study of factors associated with learning in agile teams on industry (in Portuguese). In: VII Experimental Software Engineering Latin American Workshop, 2010, Goiânia. **Qualis Capes B4.**

P3 MELO, C. O.; KON, F. Empirical evaluation of agile practices impact on team productivity. In: 12th International Conference on Agile Software Development (XP), Doctoral Symposium, Madrid, 2011, pp. 322-323. **Qualis Capes B4.**

P4 MELO, C. O.; CRUZES, D. S. ; KON, F. ; CONRADI, R. Agile Team Perceptions of Productivity Factors. In: Proceedings of the Agile Development Conference (AGILE), Salt Lake City, USA, 2011, pp. 57-66. **Qualis Capes B1.**

P5 CORBUCCI, H.; GOLDMAN, A. ; KATAYAMA, E. ; KON, F. ; MELO, C. O. ; SANTOS, V. S.. Genesis and Evolution of the Agile Movement in Brazil: a perspective from the Academia and the Industry. In: Proceedings of 25th Brazilian Symposium on Software Engineering (SBES), 2011, pp. 98-107. **Qualis Capes B2.**

P6 MELO, C. O.; KON, F. Productivity of agile teams (in Portuguese). Software Engineering Magazine, Brazil, v. 43, p. 1 - 9, 05 dez. 2011. **Qualis Capes B5.**

P7 MELO, C. O.; CRUZES, D. S. ; KON, F. ; CONRADI, R. Interpretative Case Studies on Agile Team Productivity and Management. *Information & Software Technology* 55(2): 412-427 (2013). **Qualis Capes A2.**

P8 MELO, C. O.; KATAYAMA, E.; SILVA, V. S.; CORBUCCI, H.; PRIKLADNICKI, R. GOLDMAN, A.;KON, F. The evolution of agile software development in Brazil. *Journal of Brazilian Computer Society* 19(4):523-552 (2013). **Qualis Capes B2.**

P9 MELO, C. O.; SANTANA, C.; KON, F. Developers motivation in agile teams. 38th Euromicro Conference on Software Engineering and Advanced Applications (SEAA), Çesme, Izmir, 2012, p. 376-383. **Qualis Capes B1.**

P10 MELO, C. O.; KON, F. Agile team productivity monitoring: it is all about learning. *In preparation* for the *Information and Software Technology.*

IR1 MELO, C. O.; KON, F. Productivity Factors in Agile teams - an exploratory study in Brazilian Companies (in Portuguese). March, 2012.

IR2 MELO, C. O.; SANTOS, V. A.; CORBUCCI, H.; KATAYAMA, E.; GOLDMAN, A.; KON, F. Agile methods in Brazil: state of the practice in teams and organizations (in Portuguese). Technical Report MAC-2012-03. Department of Computer Science. IME-USP. May, 2012. Available at: http://agilcoop.org.br/MetodosAgeisBrasil2011, *with over 5200 visits* (April, 2014).

CH1 GOLDMAN, A; MELO, C. O. ; KON, F.; CORBUCCI, H.; SANTOS, V. The History of Agile Methods in Brazil (in Portuguese, to appear), In: *Maré de Agilidade*. Bookman, 2014.

CH2 MELO, C. O. Productivity and adaptability of agile teams: leveraging the paradox towards innovation (in Portuguese, to appear), In: *Antologia ThoughtWorks Brazil*. Casa do Código. 2014.

7. Claimed Contributions

The goal of this thesis is to investigate productivity definitions, factors, and monitoring in agile teams. Based on this objective, we claim that this thesis contains five main novel contributions to theory and practice, which are:

C1. Empirical verification of the importance of productivity for companies adopting agile and the perceived benefits Agile methods are being widely adopted by companies worldwide, increased productivity is one of the claimed reasons. Our empirical results verify this assumption in the Brazilian IT industry, in which 481 practitioners responded to our survey. Companies not only adopt agile expecting productivity increasing, but also perceive productivity as one of the most important benefits. There is no previous literature on productivity expectations in Brazilian agile teams. Productivity is, therefore, an important issue when deploying, analyzing, and improving agile methods in companies. Despite the result is limited to the Brazilian scenario, we argue that our country study enable comparisons among countries, enhancing the knowledge on productivity in a particular way.

C2. Rationale on productivity definition in the agile methods context. There are several concepts involved in the productivity definition, such as effectiveness, efficiency, and performance. To date, there is no discussion around this definition in agile software development teams. In fact, we found that productivity is often a diffuse term for agile team members. One may argue that productivity is not the focus of agile teams. Indeed, there is a paradoxical relationship between flexibility and efficiency in the context of agility and productivity. We thus provide a rational in which both flexibility and efficiency are important for long-term productivity in agile teams. We also argue that agile team productivity should be evaluated in a holistic way.

C3. Empirical verification of agile team productivity factors. The findings shed light on under-researched questions pertaining to the productivity factors of agile teams. Our contribution to research in this area has been to synthesize an I-P-O (input-process-output) conceptual framework on factors impacting agile team productivity and to present a thematic map exploring productivity factors impacting agile teams, whereas the main factor was *team management*. Our study sheds light on staff turnover, team design choices, and inter-team coordination factors that, through processes mediators, generated variations on the observed productivity outcomes.

    C3.1. As a minor contribution, we analyzed motivational factors in agile teams impacting on productivity.

C4. A framework of agile team productivity factors and their impact, to be tested. To interpret data in the case studies, we adapted three IPO frameworks of teamwork effectiveness aiming to describe a more coherent conceptual framework of

agile team productivity. Based on these proposed frameworks, we selected inputs, processes, and outcomes related to the agile values and principles. After the study (corresponding to papers P4 and P7), We revised the conceptual IPO framework by referring back to the findings on team management. The updated framework (with agile productivity factors, mediators, and their impact) is prepared for testing through confirmatory studies.

C5. A team productivity monitoring process considering agility and an evaluation of the usefulness of agile team productivity metrics. We are developing, in collaboration with Company D a team productivity monitoring process for agile teams. The team discusses their goals and define main productivity areas they want to monitor. We assess the environment and the team, supporting the metrics choice. The team implement the metrics in the work environment, while we observe their use. In the retrospectives and project meetings, we discuss the metrics usefulness, the actual context and goals, and decide if the team will keep the same metrics or not. The main contribution here is to provide an agile productivity monitoring model that can be further tested by other agile teams. Finally, we aim at understanding how agile productivity metrics support productivity monitoring, and whether they provide a tool for diagnosis or not.

Chapter 1 summarizes the preliminary contributions, and their relationship with the posed research questions and papers.

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