Impact of Work from Home on Agile Software Project Execution – the Empirical Study

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Abstract

Background: The outbreak of a Covid-19 pandemic changed the working patterns of software projects delivery.
Aim: The study examines how the work from home (WFH) impacted the software project execution for emergence of differentiating patterns.
Method: The data on project execution in two country locations was examined. The population is 3711 projects across 52 months (26 pre- and 26 post-pandemic) is analyzed. The paper identifies the changed patterns of execution.
Results: WFH resulted in a more frequent reporting of the project status, significantly higher granularity of reporting, small changes in the statuses reported and significant changes in the duration of a project in a given status.
Conclusion: The study concludes that the WFH have had overall positive impact on the software project execution, but notices that it was achieved with increase in reporting frequency and granularity.
Keywords:software engineering, project management, empirical study, data-driven software engineering.

1. Introduction

The Covid-19 pandemic disrupted the world in general, but knowledge workers in an unprecedented way in the most sectors. No different was software development and software projects delivery, except that it might have been slightly better positioned for this kind of work, practicing it beforehand [2] in a limited scope. Software organizations immediately changed their modus operandi, taking advantage of their technology, digital skills of their employees, and the fact that remote work was already a common practice in this international industry [21]. Work from home (WFH) became predominant way of delivering software projects.

This study examines how the project delivery changed after this move. The research objectives are:

RO1: Understand how the characteristics of project execution in the pandemic or WFH period is different from the pre-pandemic period.

RO2: Identify the factors that are correlated with those changes.

2. Related work

The literature review was carried out in the Google Scholar and Scopus databases.

In Scopus, the search for expression TITLE-ABS-KEY (("work" AND "home") or “WFH”) AND ("software" AND "projects") produced 467 results. Because the study was intended to cover the Covid-19 impact, only the papers published in 2020 or later were selected. This produced 127 documents. All those documents were reviewed by the title and journal / conference for applicability to a) software projects and b) work from home. That narrow-down produced 37 relevant papers.

Additional search was carried out using Google Scholar, bringing 42 documents, out of

which 29 were overlapping with the those selected in the Scopus search. All the remaining were reviewed with the same applicability criteria. That included additional 9 documents, yielding the list of 46. All the documents from the list were analyzed for further references. After the analysis of those 46 documents further 3 were added based on their bibliographies.

The outcomes show significant coverage, but not without gaps. As the Covid pandemic broke and software work shifted from office to home, the researchers started analyzing the impact of this change on software projects. Two primary research approaches were present: 1) Analysis of the publicly available data, and 2) surveys; some papers were combining both. In early studies ([6], [12], [14], [19] and [17]), the researchers examined well-being, ergonomics, fear, productivity and disparities among genders and social impact. Although the studies were carried out on different groups (e.g. [14] on Indonesian, [13] Japanese, [15] German and [17] and Brazilian programmers), they produced mixed results and conclusions.

Studies based on programming activities were carried out, examining publicly available data about programming activities. The activity trends on GitHub – the public repository of open-source code – measured by number of so-called pushes (code changes), pulls (code imports) and comments, were analyzed. In the early days of pandemic (June 2020), the author of [7] concluded that the activity patterns remained largely unchanged, except longer working days, In the later, extensive study of 100 Java projects [5], the results were confirmed. The publication [20] states "observations suggest that COVID-19 does not present a challenge for GitHub developers", while [11] observes some geographical differences and – in particular – variation between males and females, and more weekend work. [10] and [4] examine the working standards and attitudes, focusing on the social aspect of WFH.

Many studies have empirical character and examine the changes in the groups related to a single group of developers, specified by nationality [14], [19] and [17], city [8] or company [3], [9], [1]. Those studies were also based on surveys and concentrated on well-being and subjective attitudes.

The meta study [18] of the literature from years 2020-2022 discussed coordination, collaboration and communication, agile practices, agility, emotions and feelings, leadership, productivity, and quality aspects and concluded that WFH was perceived positively in the delivery teams.

However, those studies did not cover quantitative analysis of project management aspects in software deliveries. The study [16] examined 297 respondents around the world through survey and concluded that WFH has significant impact on the motivation, ability to innovate, collaboration and motivation. It did not examine project execution patterns, though. The paper [10] performed a meta-analysis of published articles, books and online sources and formulated number of recommendations on using tools and project practices to maintain and improve productivity of work from home during pandemic times.

There is no clear sign of a quantitative study performed on a sample of real-world projects spanning a large number of them, long period of time and using objective data obtained from the project control system. This paper is filling in that research gap.

3. Methods

A. Background

The research was based on the data available from a major software services company. The condition of data access was that the name of the company was not going to be disclosed and therefore it will be referred as "the Company".

The Company is based in United States and specializes in information technology, delivering solutions, expertise and services to global clients. Its stock is in public circulation at New York Stock Exchange. It employs ca. 65 000 specialists and runs ca. 3 000 projects in parallel. It

has a varied portfolio of services and technologies, including cloud, data, artificial intelligence, mobile technologies, intelligent automation; it works in various sectors, including financial, healthcare, retail, industry and logistics. It has regional offices in over 40 countries.

The projects that were made available for this research span two countries: Poland and Spain. The request for countries was broader, only those two have been approved by the management. It is important to mention that both locations have been rapidly growing by the number of employees and number of executed projects during the period of research. The exact data on that increase in the time of the study is not known. However, it can be clearly seen by increase in number of projects and updates that such a growth was happening during the period of the study.

B. Data collection

The project was included in the pool if it had at least one member from any of the countries under investigation, i.e. Poland or Spain. The projects were setup with number of attributes, including project symbol, business domain (e.g. finance or logistics), delivery model (e.g. time & material, outcome based, etc.), dates for start and end, scope of work, delivery approach and main technology group (e.g. cloud, data, web, etc.).

In the Company virtually all projects were run as agile during the period of the study. The delivery portal was used to track all the projects. Each project manager was responsible for updating the status of the project regularly, indicating projects without issues (green or G), with issues but under control (amber or A) and with significant issues impacting the delivery success (red or R). Apart from setting the general health of a project ('Overall'), a project manager was expected to cover additional dimensions. Those were: business continuity, work-from-home status, team retention, team performance, staffing, data-driven delivery, scope, schedule, quality, productivity, finances, contracts, alignment with the client. This gave one main and 13 accompanying discrete variables, each of them with three levels: G, A or R.

Some of the statuses were auto-generated by other systems. For example, staffing status is auto-generated from the tool that was used for staffing projects. If there were positions open and not staffed with actual specialists for a given period of time, the staffing status auto-changed to A or R.

Any change in the status was registered in the project status log. One record in the log contained the date of the change, the changed attribute and the new value. Overall, the table with all status updates contained 1 222 883 status updates for 3 711 projects. The exact structure of the dataset in the form of SQL table is attached to this paper in the form of CREATE DATABASE statement.

C. Periods of time

The data available was divided to two periods of time. The pre-pandemic period was defined as January 2018 till February 2020.

The post-pandemic period was defined as April 2020 till June 2022. March 2020 was omitted (the WFH standard was introduced in the middle of the month) and in June 2022 the Company enabled voluntary return to the office. From that date it is hard to determine whether the data is gathered from office work of WFH.

In this way, both periods have exactly the same duration – 26 months.

4. Analysis

A. Approach

The analysis was made about the most significant changes after the date of pandemic. The research questions were the following, applying to both pre-pandemic and post-pandemic changes.

RQ1: What was the impact of the WFH on the frequency of status reporting?

RQ2: What was the impact of the WFH on the granularity of status reporting?

RQ3: What was the impact of the WFH on statuses reported (G, A, R)?

RQ4: What was the impact of the WFH on duration of projects in each status (G, A, R)?

B. Data cleaning and enhancement

In order to answer these questions, the data was loaded from the CSV file into the SQL Server database and the queries were executed, extracting the data.

In the first step, auto-generated statuses were removed from the database. The purpose of the study (i.e. investigation of project execution patterns by delivery managers) they were irrelevant - this study examines the actions of the delivery managers, not the decisions of the system developers on introducing automatic monitoring and validation.

In the second step, additional columns were created for simplification of queries and calculations. Those were:

yearmonth - for year and month, instead of date with the day number

days_since_update - number of days since previous update, if this was the first update for this project

prev_updated - the date of the previous update, NULL if it was the first update for this project

days_to_update - number of days till next update, NULL if this was a last update for this project

next_updated - the date of the next update, NULL if it was the last update for this project

With those additional columns in the table, the actual analysis was started.

B. Results

RQ1: What was the impact of the WFH on the frequency of status reporting?

RQ2: What was the impact of the WFH on the granularity of status reporting?

The number of status updates for pre-pandemic period (N_{pre}) was 61 457 and the number of projects in that period was 1 105; on average 55,6 per project. The number of status updates for pre-pandemic period (N_{post}) was 536 461 and the number of projects in that period was 2 708; on average 198,1 per project.

Fig 1 shows the trend, indicating pre-pandemic and post-pandemic period. As one can see, there is a significant increase of the updates frequency in the pandemic period – first to almost 10 per project per month, then to 20. This, however, does not indicate that the same status is being updated more frequently, but rather more statuses to be updated. When we eliminate all granular status updates and stay with 'Overall' status (Fig 2), the increase is still visible, but smaller – from ca. 3 per project to ca. 5. Therefore the answer to the RQ1 and RQ2 is: the WFH period has increased the status reporting slightly and granularity significantly.

RQ3: What was the impact of the WFH on statuses reported (G, A, R)? Bearing in mind the differences in granularity of reporting between pre-pandemic and post-pandemic period, for the sake of comparable results, in this study only the Overall status was used.

Fig 3 presents the comparison between pre-pandemic and post-pandemic period. The numbers show the size of the sample – as one can see, the number of projects realized in those two countries grew significantly in the pandemic period, so the absolute number for post-pandemic

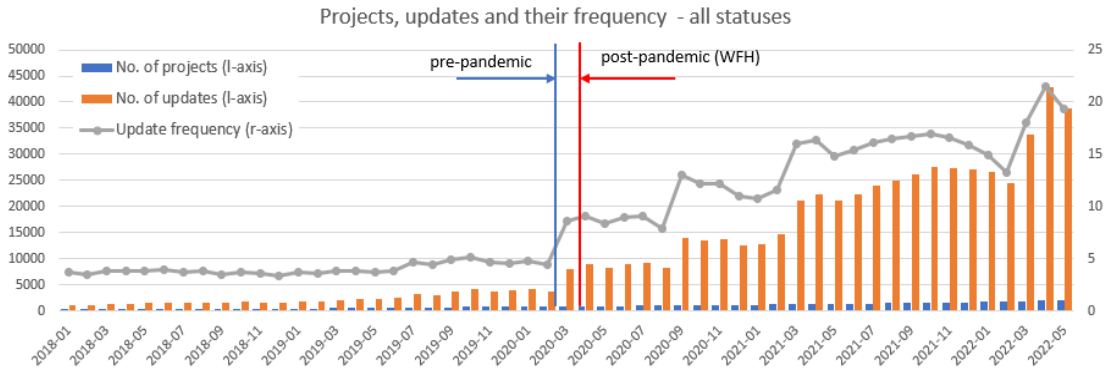

Fig. 1. Number of projects, updates and the frequency of updates for all statuses

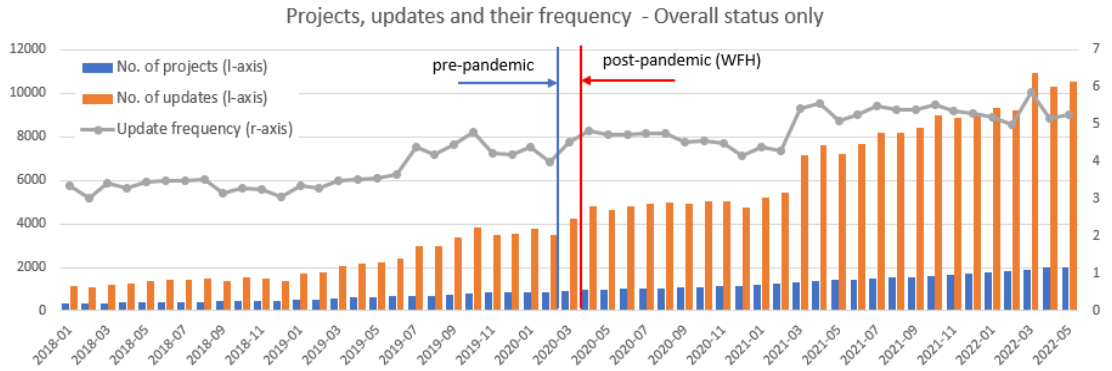

Fig. 2. Number of projects, updates and the frequency of updates for status "Overall" only

(WFH) period is higher in absolute numbers. However, the difference is not big in percentage. The fraction of G statuses is slightly smaller in the WFH; the percentage or R is almost the same. A difference is in A status – it's bigger in the WFH period. The growth from 18,4% to 22,2%, or by over 20%, can be considered as significant.

RQ4: What was the impact of the WFH on duration of projects in each status (G, A, R)?

Apart from frequency of status updated to G, A or R, the duration of the project in a given status was calculated. The average and standard deviation was used for measuring the characteristics of pre-pandemic and post-pandemic (WFH) period. Fig 4 presents both results.

The average time of duration for R was the lowest among all statuses. It is presumed that if the project status turned red, the actions must have been were taken to come back to A or G. Consequently, the largest mean was G; almost the same as A. In the WFH period all the means decreased, the most significant decrease was for G – from 11,8 days to 10,0 days on average. However, the most interesting part is the standard deviation. Here we can see in that the pre-pandemic period it was 11,3 days for R, 15,1 days for A and 22,8 days for G. After the pandemic, during the WFH period, those deviations were significantly smaller: 10,3 days (9% less for R), 11,0 days (27% less) for A and 15,0 (34% less) for G. Clearly that indicates much tighter control during WFH period.

5. Discussion

The above data show, above all, that the WFH period was characterized by a significantly higher level of control than pre-pandemic period. It is a bit of a paradox that – when the Company lost control over daily work of it projects through the presence of the project teams in the office, it

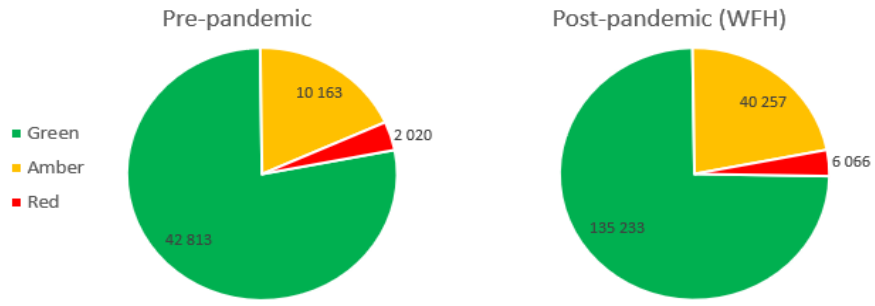

Fig. 3. Pre- and post-pandemic status update volume by color

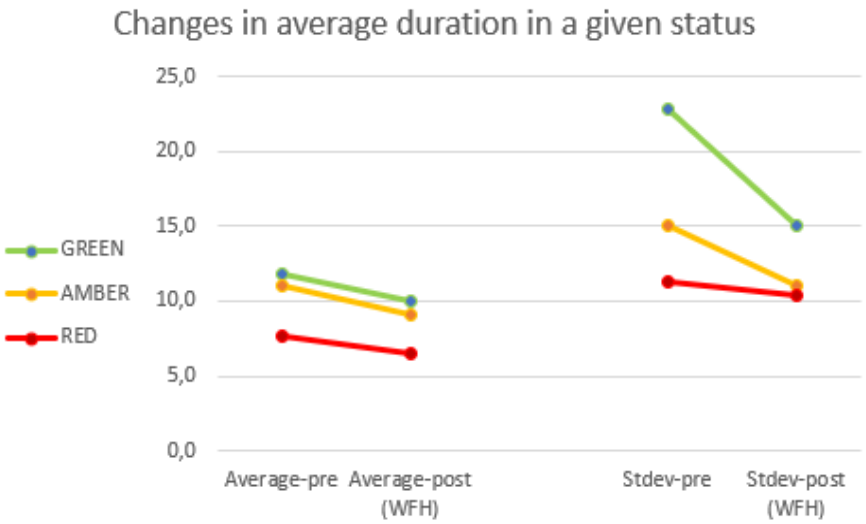

Fig. 4. Pre- and post-pandemic status duration, by color, in days (average and standard deviation)

actually got better in keeping projects under control.

A part of that can be attributed to increased granularity of the project status reporting. At the break of a pandemic period, the Company had ca. 4 update per project per month; at the end of this period, it had over 20. Also, this result could be aligned to the subjective feeling on well-being increased with WFH - following conclusions of [18].

The study did not show the significant change of project status distribution between G, A and R during the WFH versus pre-pandemic period. The results are consistent with [7] and [20] and not confirming the observations of [16].

For software companies like the Company, it is an optimistic observation about the results that can be achieved when the personnel is working from home. Provided that they have sufficient tools, control and reporting granularity, the projects can execute without significant drawbacks or even with benefits.

In fact, the difference observed in the better regularity and granularity of WFH project execution illustrated in Fig 4 suggest that it is the supervision and attention paid to project, not the location of employees that matter.

There is a number of limitations why the researchers should be cautious about applying the results of this research broadly.

Sample source – although that research is based a large population, it is composed by the data of a single company and from two countries only.

Parallel factors – this population draws conclusions about work from home, but the result of work from home cannot be isolated from other factors and changes that the Company was undergoing – e.g. changes in technology and project portfolio in the duration of 4 years and 4 months.

Introduced process changes – the Company did not disclose the exact list and dates of actions taken in the project management standard and project management tools. It is possible that some of the ups and downs (especially in Fig 1 and Fig 2) can be explained by the introduction

Arbitrary choice pre-pandemic period start – While the other remarkable dates (i.e. pandemic period start, pandemic period end) can be clearly identified with accuracy of weeks, the start of pre-pandemic period (January 2018) is arbitrary; dictated by the consistency of duration and overall understanding that the stability in technology and project execution environments and standards is measured in months and quarters rather than many years.

6. Conclusions

A. Observations

The study observed that WFH period introduced by the Company after April 2020 resulted in a slightly more frequent reporting of the project status, significantly higher granularity of reporting, small changes on the statuses reported and significant changes in the duration of a project in a given status until next update. The last phenomenon was particularly observed in reduction in variation of the duration (measured by standard deviation) much more than (still present) reduction in the average.

Looking from the business perspective, the Company proactively addressed challenges brought by the emerge of a pandemic threat and the change of working mode to home work. It increased the granularity of reporting, bringing a better, up-to-date information. Although the study did not span that, it is presumed that it led to the better business overall results in projects execution.

B. Further research

A rich data set acquired from the Company will be used for further research. The planned research span in-depth analysis of project delivery patterns in the subgroups defined by technology, industry, size of a team. The research group is already conducting a research on early warning signs of issues with project execution. The submission of the paper on that topic is planned for late 2024.

The upcoming research will be monitoring the same parameters during stabilized post-pandemic period (2023 and after) to compare if the changes in WFH patterns persisted after the work shifted to the hybrid mode. The submission of the paper is planned for 2025.

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