A Theory of Scrum Team Effectiveness

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Abstract—Scrum teams are the most important drivers to lead an Agile project to its success. Nevertheless, a theory, which is able to explain its dynamics is still missing. Therefore, we performed a seven-year-long investigation where we first induced a theoretical model through thirteen field studies. Based on such a model, we developed a customized and validated survey tool and collected data from almost 1.200 Scrum teams. Data have been subsequently analyzed with Covariance-Based Structural Equation Modeling. Results suggest a very good fit of the empirical data in our theoretical model ($CFI = 0.952, RMSEA = 0.041, SRMR = 0.037$). Accordingly, this research allowed us to (1) propose and validate a theory for effective Scrum teams, (2) formulate clear recommendations for how organizations can better support Scrum teams.

Index Terms—Agile software development, Scrum, Team Effectiveness, Multiple case studies, Structural Equation Modeling.

1 Introduction

SOFTWARE development teams are at the very core of Scrum [1]. One reason for this is that Scrum teams are the most important factors to improve the performance of a project's success [2]. Like any Agile development method, Scrum follows a collaborative and human-oriented approach to software development by reflecting the principles of the Agile Manifesto [3]. Among Agile methods, Scrum is the most commonly used framework [4]. According to market research led by VersionOne, in 2020, 76% of organizations reported that they use Scrum, or a hybrid version of it. Software houses routintely use it for their internal development process [5]. Scrum focuses on delivering incremental business value through the continuous interaction with stakeholders within an established framework [1]. The framework prescribes a minimal set of roles, events, and artifacts that act as a foundation to work empirically. It is up to teams to build on this foundation by adding practices for stakeholder collaboration, estimation, task breakdown, portfolio management, and so on. Thus, to be effective, Scrum assumes a high degree of autonomy for teams to perform their work [6]. The 2020 Scrum Guide highlights the importance of Scrum teams over the individual roles that make it up. [7]. By shifting control from middle management to autonomous Scrum teams, the role of management has become less relevant. Therefore, the contemporary understanding of Scrum is to support teams to deliver and deploy software as frequently as is helpful.

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In the last twenty years, researchers performed several empirical investigations into Scrum, mostly field studies [8]. So far, research typically focused on process improvement factors (such as security [9]), transformation processes [10], methodological and tailoring practices [11], or artifacts [12]. Some scholars also explored teaming aspects, like autonomy [13]. However, Scrum teams and their internal dynamics are rarely at the center of the investigations, with very few exceptions [13]. Additionally, most works performed so far are not generalizable because they are field studies or use a research strategy not properly aimed to generalize results [14]. Thus, we do not know if the accumulated knowledge about Scrum teams is specific to a few contexts or if it is generalizable to every context in the computer science domain. A sample study [14], using adequate statistical techniques to test research hypotheses [15], would bridge this gap. Accordingly, we formulate our Research Questions (RQ):

- RQ_1: *Which are the key factors of effective Scrum teams and how do they relate to each other?*
- RQ_2: *Is our theory robust and generalizable?*

The typical problem with sample studies is that they rely on pre-existing theoretical evidence [16]. Since a theory about Scrum teams did not exist, we had to induce a working theory first to address RQ_1. To do so, we performed 13 case studies from 2014 to 2019, involving informants from over 45 Scrum teams. Using the multiple cases study approach by Eisenhardt [17], we inferred prior evidence with our qualitative findings to draw our theoretical model. To answer RQ_2, we ran a large-scale cross-sectional study by collecting data from 2.939 software professionals of 1.193 Scrum teams, resulting in one of the largest sample study performed in software engineering. Data have then been analyzed through Covariance Based Structural Equation Modeling (CB-SEM or SEM in short) to test whether the empirical data fit our theoretical model and reflected the day-to-day reality of Scrum teams. Our findings suggest that the most effective teams are those that can release frequently *and* have a clear understanding of what their stakeholders need, but not one or the other.

In the remainder of this paper, we describe the related work in Section 2. Afterward, we introduce our Mixed-Methods research design in Section 3 and induce our theoretical model from 13 multiple exploratory case studies in Section 4. Subsequently, in Section 5, we validate our model through a large-scale cross-sectional study using Covariance Based Structural Equation Modeling. Eventually, we discuss the implications for research and practice along with the study limitations in Section 6 and draw our conclusion by outlying future research directions in Section 7.

2 Related work

Agile software development in general, and Scrum in particular, are widely studied in software engineering research [8]. Previous scholars discussed about a variety of topics, such as Agile transformation processes from plan-driven to Agile software development [10], requirements engineering [18], or even legal concerns [19]. Recently, the Agile Success Model provided a general understanding of the dynamics within an Agile project to lead to its success [2]. All those contributions analyzed generic or non-team related aspects of Agile projects.

Since this investigation is seeking relevance instead of completeness, we explicitly address only studies that focus on Scrum teams to identify our research gap. Indeed, software development teams have been at the core of Scrum since the first guide was issued in 2010 by Jeff Sutherland and Ken Schwaber[1]. Consequently, software engineering literature investigated several aspects of Scrum teams over the last decade. We searched for peer-reviewed publications in Scopus to find previous work, where we found 18 relevant papers.

Although Scrum teams are mentioned several times by scholars, team dynamics have rarely been the focus of an investigation. Rather than within the team, the research looked into the relationship between the team and the stakeholders, such as the Product Owner [20], and across teams [21].

Especially earlier studies examine the different positive and negative aspects of plan-driven vs. Agile practices. In a systematic literature review, Lopez et al. argue that while changing from a Waterfall process to Scrum, typically, Scrum teams lack knowledge of the method [22]. On the other hand, Van Waardenburg et al. think that Agile practices can coexist with plan-driven development if management takes proper actions to mitigate challenges and confusion that might arise in Scrum teams [23]. However, the management of uncertainties is seen as problematic by some scholars. For example, Agile practices provide little knowledge about onboarding processes, so teams have to figure out themselves how to deal with it [24].

So far, researchers put their attention to understand how teams are working in specific Scrum settings, such as in LESS, where Paasivara et al. investigated inter-team coordination [25] or in regulated environments, where the goal was to ensure a high level of system security and reliability [26]. Another case is global asynchronous teams. For example, Hidayati et al. identified hard and soft skills for remote Scrum development teams [27].

Eventually, there have also been some social psychology studies investigating personality aspects. Effective Scrum team members typically show traits of altruism, compliance, tender-mindedness, dutifulness, and openness to values [28]. Gren et al. suggest that group developmental aspects of Scrum teams are key success factors during the transition from a plan-driven to an Agile development fashion. Besides, wider use of psychological factors might improve the understanding of Scrum teams [29].

1. www.scrumguides.org/revisions.html

3 Research Design

In order to answer our research questions, we deployed a Mixed Method approach [30]. In the first inductive stage, to answer our RQ_1, we run a multiple case study to develop a testable and relevant theory, followed by a quantitative survey study to statistically assess the resulting theory (the objective of RQ_2). Mixed Methods approaches are increasingly used in the social sciences, humanities [31], and also in software engineering [32], [33] to increase the fidelity of theories and findings over purely quantitative or qualitative inquiries [34].

3.1 Preparatory Phase: Identification of Key Factors for Effective Scrum Teams

To put boundaries around our research area and focus the investigative efforts in our case studies, we first identified a framework for the most relevant factors for Scrum teams through a Delphi-like approach. With the help of one domain expert who worked for over a dozen years as Scrum Master, consultant, and professional trainer, five key factors have been iteratively identified.

In the first stage, we identified a list of 89 observations about what would make a Scrum team effective or not. The experience of the domain experts and literature guided the process. This resulted in items such as "No customers, users or other stakeholders attend the Sprint Review", "The resolution of impediments is considered to be the responsibility of the Scrum Master", and "The composition of Scrum teams is decided entirely by management".

In the second stage, we independently categorized the observations into six initial factors: (1) Value focus, (2) Craftsmanship, (3) Shared goals, (4) Release Frequently, (5) Continuous Improvement, and (6) Autonomy. Since we did not reach consensus on the categorization, we performed a second iteration. Accordingly, eight items which were judged to be too subjective were removed. Thus, we reduced the key factors to four: (1) Concern for Stakeholder Needs, (2) Responsiveness, (3) Continuous Improvement, and (4) Team Autonomy on which we reached full consensus. The four factors were used to guide the initial coding of the data from the field studies.

3.2 Phase I: Multiple Exploratory Case Study

This study aims to understand which factors contribute to the effectiveness of Scrum teams. To develop a working theory grounded in empirical reality, we ran multiple field studies to understand the day-to-day patterns of Scrum teams.

Thus, we performed 13 case studies between 2014 and 2019 focusing on the dynamics of Scrum teams (see table 1). Considering the exploratory nature of this first phase, we did not use *a priori* criteria to guide our sample selection. Instead, we aimed to maximize the case variability to improve our theoretical understanding [35]. In particular, we looked for a variation in size of organizations, commercial or non-commercial nature of the organizations, industry, and age of establishment.

Data were collected from multiple sources. Most of the data originated from observations and unstructured interviews that occurred during various Scrum events, team workshops, and day-to-day work. In total, we collected 155 pages of journal notes. For some cases, we also had access to internal documents (Product Backlogs, Sprint Backlogs), correspondence, and developed artifacts.

For the analyses, we initially coded the data on the four *a priori* codes that we identified in section 3.1 and then used an editing approach [36] to expand with additional codes as they emerged from our analysis. For example, we revised the code "Stakeholder Concern" into four sub-codes: (1) Shared Understanding of Value, (2) Stakeholder Collaboration, (3) Sprint Review Quality, and (4) Shared Goals. The coding was performed by the first author to maintain consistency of meaning and use of codes.

3.3 Phase II: Theoretical Model for Scrum Team Effectiveness

After developing a working theory from our multiple case studies, we validate the induced theoretical model with a large sample of Scrum teams ($N = 1.193$) using a customized online survey[2].

The survey data has been analyzed through Covariance-Based Structural Equation Modeling (SEM) (using the AMOS software package [37]) to evaluate the statistical fit and significance of the empirical data into the theoretical model. Structural Equation Modeling is commonly used to test hypothesized relationships between unobserved (latent) constructs and observed indicator variables[3] [38], [39]. The hypothesized relationships in the model are specified into a series of structural (regression) equations used to predict the variance-covariance matrix that should be observed between variables in the data if the model fits perfectly. A second variance-covariance matrix is calculated from sample data and compared with the first matrix based. The smaller the discrepancy between the matrices, as indicated by statistical goodness of fit indices [40], the better the theoretical model "fits" the observed data. A strength of Structural Equation Modeling is that it is an inherently confirmatory, hypothesis-driven approach to model testing [39]. Because the entire model is tested simultaneously, researchers can perform factor analysis and regression analysis in a single model. Finally, Structural Equation Modeling allows researchers to assess and adjust for measurement error by explicitly estimating it as part of the model, which is not possible in traditional multivariate approaches. This allows researchers to arrive at more accurate estimates, especially when there is a substantial error in the measurements, such as in sample studies [39].

Based on our theoretical model, we created a full latent variable model that contained both the measurement model and the structural model. The measurement model defines relationships between indicator variables (survey items) and underlying first-order latent factors and effectively acts as a CFA-model [38]. The structural model defines the hypothesized relations between latent variables and is effectively a regression model. This approach makes the results less prone to convergence issues because of low indicator reliability and offers more degrees of freedom to the analysis compared to a non-latent model [41].

Following the approach outlined in literature [16], [39], [42], we entered all items from our survey as endogenous indicator variables into the model, with each indicator variable loading on a single first-order latent factor that represented the associated (scale) construct and first-order latent factors loading on the four proposed second-order factors. Then, we used AMOS to calculate factor scores and errors for each latent factor based on their indicators.

As recommended by the literature, we first evaluated and fitted the measurement model and then introduced the structural part of the model [38], [39]. We evaluated goodness of fit using indices recommended by recent literature [38], [39], [40], [42]. We did not perform Chi-Square tests because they are highly susceptible to type I errors in large samples ($N > 400$, [40]). We also inspected local fit based on the standardized residual covariances between observed variables, with 2.58 as a cut-off value for poor local fit ([39]).

We present more details about the quantitative results and the results in Section 5. But first, we share the results of the case studies.

4 Findings from the Multiple Case Study

In the following sections, we report the findings from the multiple case studies as described in section 3.2. To analyze our data, we followed the framework described in Section 3.1. Thus, the numbers following each observation refer to the case studies in Table 1.

4.1 Stakeholder Concern

We found that Scrum teams varied in the degree to which the needs of stakeholders were considered in their decision-making. We define *"stakeholders"* as the individuals and groups outside the Scrum team that have a substantial stake in the outcomes of a team, like customers, key users, and investors. The differences manifested primarily in four areas.

4.1.1 Value focus

Not all Scrum teams focused equally on the value their work delivered to stakeholders. The Product Owners played an important role here. Some Product Owners (#1, #3, #5, #9, #12) frequently discussed with their team how the work fit in the overarching strategy. Three Product Owners also shared how the work returned on investments and how it impacted stakeholders (#1, #3, #12). Other Product Owners mostly passed requirements on without elaboration (#6, #7). We also observed that teams differed in how work was described on the Product Backlog. Some teams (#3, #6) captured work in technical terms without connecting it to the needs of stakeholders (e.g. "Update connector API to expose module composition."). Others, on the other hand, explicitly clarified how items on their Product Backlog connected to the needs of stakeholders (e.g. "Administrators can sort submissions by entry-date so they can address the most recent ones first.")

2. The survey has been designed in a way that Scrum teams can self-assess their development process. A customized report is automatically generated, allowing teams to take concrete actions for improvements. It is available at the following URL: www.scrumteamsurvey.org.

3. For an overview on Structural Equation Modeling and its terminology cf. Russo & Stol, 2021.

TABLE 1
Description of the cases used in this study for observations and interviews

Case	Year	Domain	Org size	Nr. of teams	Roles involved in observations
1	2014-2016	Transportation	4.000-5.000	5	2x Scrum Master, 1x Product Owner, 30+ Developers, 1x Program Manager
2	2014-2017	Software development	10-20	2	2x Scrum Masters, 1x Product Owner, 8x Developers, 1x CxO
3	2014-2018	Software development	10-20	1	2x Scrum Masters, 1x Product Owner, 1x CEO
4	2014-2016	Software development	10-20	1	1x Scrum Master, 1x Product Owner, 12x Developers, 1x CxO
5	2015-2017	Retail	50-100	2-5	5x Scrum Masters, 2x Product Owners, 25x Developers, 2x CxO
6	2016-2017	Information Technology	100-200	5	5x Scrum Masters, 4x Product Owners, 25x Developers, 2x CxO
7	2016-2017	Non-Profit	10-50	1	1x Scrum Master, 1x Product Owner, 6x Developers
8	2016-2017	Healthcare	50-100	2	1x Scrum Master, 1x Product Owner, 8x Developers
9	2017-2018	Utilities	500	1	1x Scrum Master, 1x Product Owner, 6x Developers
10	2018-2019	Tourism industry	4.000-5.000	5	12x Scrum Masters
11	2018-2019	Recruitment	50-100	1	1x Scrum Master, 1x Product Owner, 5x Developers, 1x CxO
12	2019	Retailer	$>$ 10.000	12	15x Scrum Masters, 4x Product Owners, 3x Agile Coaches
13	2019	Research & education	1.000-2.000	5	4x Scrum Masters, 2x Product Owners, 38x Developers, 1x CxO

4.1.2 Stakeholder collaboration

There was a substantial difference between Scrum teams in how they involved stakeholders. Some teams frequently invited stakeholders to their Sprint Reviews (#1, #2, #3, #9). The Product Owner often took the initiative here. Nevertheless, we also observed many teams where developers interacted directly with stakeholders (#1, #3, #4, #7, #9, #14). Developers visited stakeholders on-site or contacted them by e-mail or telephone for clarification. In some cases, developers trained stakeholders to use their product (#1, #2, #3). In some teams, only the Product Owner interacted with stakeholders (#2, #5, #6, #8, #11, #12). The purpose of stakeholder collaboration was mostly described in terms of gathering feedback:

> "It allows us to involve key users in development to get early feedback." [PO - 7]

> "Prioritize work together with all internal stakeholders." [PO - 1]

4.1.3 Sprint Review Quality

The Sprint Review is a formal event in Scrum where feedback is gathered from stakeholders and adjustments are identified [7]. Not all teams used the Sprint Review for this purpose. Some teams never invited stakeholders (#4, #6, #7). In the teams that did, the way feedback was gathered differed. Some teams offered a formal presentation (#1, #6, #8, #11). Other teams offered stakeholders opportunities to "take the wheel" and try new features on the spot (#3, #5, #8, #9, #13). This interactive approach tended to draw out more constructive feedback than formal presentations. Only in a few cases did teams use Sprint Reviews to reflect on the larger objective and inform the following steps (#1, #9).

4.1.4 Shared goals

Shared goals are used in the Scrum framework to encourage collaboration and clarify how individual tasks connect to larger business goals [43]. In practice, the use of shared goals varied greatly. In some cases, Product Owners began Sprint Planning by stating a business objective that then guided the ordering and selection of work for that Sprint (#1, #2, #7, #8, #9, #12, #13). Other teams selected the top items, even when they were unrelated (#3, #4, #5, #6, #10). Teams that did not use shared goals often acknowledged that it would bolster team spirit, customer orientation, and collaboration if they would (#1, #4, #7).

4.2 Team Autonomy

The observed teams varied in their freedom to make decisions about how to perform their work. This broadly concerned two types of constraints to their autonomy. The first type was imposed from outside the team (self-management). The other type emerged from skill-based constraints within the team (cross-functionality).

4.2.1 Self-Management

The ability of the observed Scrum teams to self-manage their work varied by case. For example, the use of the work method was often suggested by management and co-opted by teams after exploratory workshops (#1, #2, #5, #6, #8, #9, #10, #11, #12, #15). During these workshops, the participants distributed roles, scheduled the formal Scrum events, and clarified collective ambitions. Scrum teams controlled their composition in some cases (#1, #3, #6, #14). One department manager initially proposed a composition for five teams, and then decided against this during a collective kickoff workshop with everyone present:

> "I discovered today that I should not make decisions for others. So I will leave the composition of the teams to you instead." [DM - 15]

In another case, a department manager proposed an initial composition for several teams and encouraged them to switch members when they discovered better compositions (#6). While all teams in our study were able to distribute work internally as they saw fit, their control over incoming work and when to perform it varied greatly. In one case, a Scrum Master observed:

> "Our Product Owners have no autonomy. They are told what to do, when to do it, and often how to do it, and they pass that on to the team" [SM - #10]

Similarly, contractual agreements about the scope and delivery dates were sometimes controlled by external departments or steering committees and not by Scrum teams and their Product Owners (e.g., #1, #2, #4, #7). Finally, only a few teams were directly responsible for their contractual agreements with stakeholders (#3, #14).

4.2.2 Cross-functionality

Another type of constraint emerged from the skills present in teams. Some of the Scrum teams covered a diverse range of skills from testing, business analysis, and design to coding (#1, #3, #5, #6, #9). The range of skills was much narrower in other teams, often only coding (#2 and #7). We observed two consequences of low versus high functional diversity. First, when a team lacked a certain skill and was not available in the environment, they would forego tasks altogether (e.g., testing, user interface improvements, security hardening). This impacted the quality and usability of their product (#6 and #7). Second, when a team lacked the skill and it was available in their environment, this effectively introduced a dependency on people outside the team who possessed that skill. These dependencies increased development time as teams had to wait for dependencies to complete the task (#1, #2, #5, #6, #10). For example, teams in case #1 frequently waited for a vendor to deploy new versions to one of a dozen environments. This delayed internal testing and caused confusion as to which version was running on which environments at a given moment in time. Another striking example from case #1 was how the initial composition of Scrum teams included skills for coding, design, and testing, but not requirements analysis. This was initially done by a separate team and created a recurring dependency as Scrum teams ran into questions about the requirements on the one hand and delivered work that did not meet the requirements on the other. This resulted in frequent rework and bugs. When the requirement analysts later joined the Scrum teams, the department manager concluded:

> "this greatly improved quality now that testing is part of the development cycle." [DM - 6]

4.3 Continuous Improvement

The teams we studied also varied in the degree to which they engaged in continuous improvement. This manifested primarily in five areas:

4.3.1 Sprint-Retrospective Quality

In the Scrum framework, the Sprint Retrospective is a recurring opportunity for teams to "plan ways to increase quality and effectiveness" [43]. The majority of the Scrum teams we observed organized a Sprint Retrospective every Sprint (#1, #3, #5, #6, #7, #8, #9, #12, #13). However, other teams did so less frequently (#2, #4, #10, #11). In terms of what was discussed during Sprint Retrospectives, we observed that some teams used different formats to address different themes (e.g., the Definition of Done, customer satisfaction, or code quality) (#1, #2, #3, #4, #5, #6, #9, #12). Though, a small number of Scrum teams generally repeated the same format, usually variations of a "plus delta"[4] to discuss general improvements (#7, #10). Compared with the repeated use of the same format, We observed that a more diverse range of formats and themes tended to generate more improvements in a broader range of areas.

4.3.2 Quality Concern

The Scrum teams we observed also varied in their concern for quality standards. This was most evident in their Definition of Done, which is used in the Scrum framework to clarify the "quality standards required for the product" [43]. While some teams frequently challenged their Definition of Done to reformulate or add criteria (#1, #3, #5, #8, #9, #12, #12), others never or rarely did (#2, #6, #10). One Scrum team did not have an explicit Definition of Done (#11). The concern for quality was also apparent in how new practices and technologies were explored to improve quality. While some teams frequently did so (#1, #3, #5), others rarely did (#2, #6, #7, #10).

4.3.3 Psychological Safety

We also observed that Scrum teams diverged in how they addressed internal conflicts. For example, in one team (#6), an argument built up between two members over several weeks eventually erupted when one member suddenly left the team, and another ended up at home with a burnout. The Scrum Master observed that:

> "people interrupt each other constantly and do not listen" [SM - 6]

We observed a similar pattern of interrupting and talking over each other in several other Scrum teams (#1, #4, #6, #7). However, other teams purposefully made time for their members to express personal concerns and frustrations (#3, #5, #8, #9). In one instance, the teams actively sought help from an outside coach to address growing frustrations (#1). In another instance, two team members (#3) expressed deep concern about whether or not their customers were satisfied with their ability to meet deadlines. The team scheduled a 1-hour session to talk things through. One member of this team explained the benefits of this as:

> "It is important for me to talk about what is buzzing around in my head so that I can move on" [TM - 3]

4. In this format, teams generally create two columns on a shared work-space. One column lists the things that went well (the "plus"), while another shows improvements (the "delta")

4.3.4 Shared Learning

While Scrum teams can often make substantial improvements to their own process, many improvements are bound to transcend individual teams. Nevertheless, the degree to which Scrum teams actively involved others varied greatly. Some teams rarely involved others (#2, #4, #7, #10). However, other teams shared their learning with other teams in a "marketplace," or "Scrum of Scrums" (#1, #6), invited management (#3, #8, #9), organized cross-team workshops on shared challenges (#6, #12, #13) or started Communities of Practice (#1, #10, #12, #13).

4.4 Responsiveness

The Scrum teams we observed also showed also a variety in their ability to respond quickly to emerging needs or issues. This manifested in two related areas.

4.4.1 Release Frequency

The Scrum framework requires Scrum teams to deliver at least one increment every Sprint that is either ready for release to stakeholders or already released. Every increments must conform to the quality standards of the Definition of Done [7]. In two cases, teams generally released to stakeholders at least once during the Sprint (#11, #12). However, most teams released intermediate versions to internal staging environments (#1, #2, #3, #4, #5, #8, #13) or used several Sprints before they were able to do so (#6, #9, #10). These teams (except #11 and #12) released batches to their stakeholders infrequently - once per quarter or less - except for critical bug fixes. At the same time, teams recognized the benefits of releasing more frequently. One team stated that:

> "It allows us to deliver something to our customers sooner and gives them an opportunity to suggest changes, or even stop" [TM - 3]

While another team observed that frequent releases contribute to:

> "rhythm, clarity and getting things done" [TM - 6]
>
> "increased software quality" [TM - 6]
>
> "happier customers" [SM - 3]

4.4.2 Refinement

Finally, the Scrum teams we observed varied in how they approached the clarification and decomposition of work on the Product Backlog. This is generally called "refinement" by Scrum teams. Teams engage in this activity to break down more extensive features into more minor features that can be delivered within the scope of a Sprint or less. Most teams performed refinement during weekly workshops attended by the entire team (#1, #3, #4, #5, #9). Other teams performed it mainly during Sprint Planning (#2, #7, #8).

One consistent pattern was that while most teams performed refinement, they also felt it should be more. For example, one team concluded that:

> "We lack the discipline to refine well" [TM - 1]

While another Scrum Master observed that:

> "When we do refine work, the Sprint seems to be much smoother" [SM - 9]

In addition, most Scrum teams frequently raised refinement as a topic during Sprint Retrospectives (e.g., #1, #2, #3, #13). This was usually driven by a desire to have more clarity as to what is needed, identify external dependencies earlier, or make Sprint Planning easier. One Scrum Master described the purpose of refinement as:

> "a way to identify dependencies on other teams upfront, so that we are not surprised by it during a Sprint" [SM - 1]

4.5 Management Support

The role of managers varied greatly between cases. In some cases, managers primarily took a supporting role by asking the teams what they needed from them (e.g., #1, #2, #3, #4, #5, #7, #10, #13, #14). Management remained distant from the teams in other cases (#9, #10, #11) or retained a directive style (#6, #7). In one extreme example, a top manager would occasionally leave a memo in the team room with sharp criticism about development speed (#6). A Scrum Master in this organization initially described the support of management as:

> "lip service, because they are rarely present to help us" [SM - 6]

In several cases, we observed how managers supported teams in expanding their skills. This involved training and personal development in some cases (e.g., #3 and #5), adding members with missing skills (#1, #2, #3, #4), or giving teams the freedom to change their composition as needed (#5, #6, #14). We also observed instances where managers actively managed the boundaries of the Scrum teams. For example, in one case (#3), the company owner openly renegotiated the distribution of responsibilities for particular activities (sales, salary setting, company vision) with the team. In another (#1), the program manager moved deployment engineers from an external vendor into each of the teams to remove a dependency that made it difficult for teams to deploy quickly.

4.6 Team Effectiveness

Two main variables characterized the effectiveness of Scrum teams according to the teams themselves.

4.6.1 Stakeholder satisfaction

Most Scrum teams expected that effective Scrum would make it easier to satisfy their stakeholder (#1, #2, #3, #4, #5, #7, #8, #12). Many teams reasoned that this was because Scrum allowed them to release increments sooner (#2, #3, #4) and include new ideas as they emerged (#3). The increased collaboration between teams and stakeholders was another reason. (#2, #5, #6).

4.6.2 Team Morale

The second effectiveness characteristic that Scrum teams expected was increased morale (#2, #3, #4, #5, #6, #7, #8, #9, #13). For many Scrum teams, this resulted from increased collaboration (#1, #3, #6, #8). Other reasons that were given ranged from "do work that matters" (#6), "more personal autonomy" (#2, #6) to "getting things done" (#4, #6).

4.7 Theory Development And Hypotheses

We used the findings from our case studies, together with insights from extant literature, to induce a theoretical model to explain how team-level factors contribute to the effectiveness of Scrum teams.

Our first hypothesis concerns the outcomes of effective Scrum Teams and is divided into two sub-hypotheses. The first is that we expect to see stakeholder satisfaction increase as Scrum teams expand their ability to release to those stakeholders frequently (or "responsiveness"). This notion is central to Agile methodologies and was anticipated by many Scrum teams in the case studies. Each release offers Scrum teams an opportunity to bridge the gap between what stakeholders need and what is actually delivered, thus increasing the likelihood of satisfying those needs.

Where the first sub-hypothesis concerns a positive outcome for stakeholders, our second sub-hypothesis concerns a positive outcome for Scrum teams. We expect that the responsiveness of a Scrum team positively influences team morale. As the capability of teams to release frequently increases, they gain more opportunities for constructive feedback and a stronger sense of accomplishment ("get things done"). Accordingly, we are formulating our first hypothesis:

Hypothesis 1 (H1). *The responsiveness of a team is positively associated with team morale (H1a) and stakeholder satisfaction (H1b).*

Our remaining hypotheses concern predictors of responsiveness. Following the patterns we observed in the case studies, we expect that Scrum teams are more effective when they have a shared understanding of what their stakeholders need and how those needs will be met. This can be thought of as "shared mental models" from the perspective of team cognition [44], [45]. Such models contribute to behavioral coordination on interdependent tasks, the motivational state and cohesion of its members, and their ability to meet objectives [46]. Team cognition has been shown to explain a significant amount of variance in team performance [47].

We observed that Product Owners play a vital role here, which is corroborated in literature. Product Owners can use different strategies to promote collective product ownership [20], [48], [49] The use of shared goals to clarify business objectives is one way [20]. There is extensive evidence for the positive influence of clear, shared goals on team effectiveness [50], [51], [52], cohesion [53], motivation [54] and cooperation [55].

We hypothesize, therefore, that a shared concern for the needs of stakeholders positively impacts the effectiveness of Scrum teams in two complementary ways. First, we expect that Scrum teams that are more concerned about the needs of stakeholders are also more likely to see the benefit to release more frequently to those stakeholders, and thus become more responsive:

Hypothesis 2 (H2). *Stakeholder concern is positively associated with responsiveness*

Second, we hypothesize that stakeholder concern is positively associated with stakeholder satisfaction and team morale. In the case studies, we observed that teams found it easier to satisfy the needs of stakeholders when they actually understood those needs clearly. We also expect that a strong concern for stakeholders bolsters their sense of purpose and boosts morale. This finding is well-grounded in work on positive psychology [56], [57]. The psychological experience that one's work is meaningful encourages people to engage in that work and push through even in the face of challenges [58], [59], [60], [61].

However, we expect that the responsiveness of Scrum teams mediates the positive association between stakeholder concern on the one hand, and stakeholder satisfaction and team morale on the other. Even when a team has a serious concern for the needs of stakeholders, stakeholder satisfaction and team morale will remain low when teams are not actually releasing intermittent increments. This is essentially a waterfall approach where only one or a few releases happen. The effect is at its strongest when teams can release frequently *and* focus on the needs of stakeholders:

Hypothesis 3 (H3). *The positive relationship between stakeholder concern on the one hand, and team morale and stakeholder satisfaction on the other is fully mediated by responsiveness*

Our previous hypotheses highlight stakeholder concern and responsiveness as predictors of stakeholder satisfaction and team morale. From the case studies, we recognize that teams often face many challenges and constraints here. The following hypotheses explore three predictors that emerged from the case studies; team-based continuous improvement, team autonomy, and management support.

We begin with the first antecedent, continuous improvement. Every Sprint offers teams an opportunity to detect mismatches in their tools, processes, and quality standards and adjust accordingly. This process of detecting errors and correcting them is defined as "learning" [62]. We observed that Scrum teams varied in the degree to which they capitalized on these learning opportunities. This was apparent in the quality of Sprint Retrospectives, quality standards to guide improvements, and shared learning with others in the organization. These factors are reminiscent of learning organizations [63], [64], which also require a climate of openness and inquiry. In the case studies, too, we observed that teams varied in the degree to which difficult topics were openly discussed. This reflects psychological safety, or *"the shared belief that it is safe to take interpersonal risk"* [65]. Psychological safety has been demonstrated to influence learning behavior and team efficacy, also in the context of Agile teams [66], [67]. We expect that Scrum teams that engage in continuous improvement are more likely to overcome the barriers to responsiveness and stakeholder concern (over time):

Hypothesis 4 (H4). *Continuous improvement is positively associated with stakeholder concern (H4a) and responsiveness (H4b)*

The second predictor concerns team autonomy. In the case studies, we observed that autonomy varied in two areas: autonomy from external constraints (self-management) and autonomy due to fewer internal skill constraints (cross-functionality). The Scrum framework describes Scrum teams as *"self-managing, meaning they internally decide who does what, when, and how"* [43]. This follows the principle of *responsible autonomy* from sociotechnical systems (STS) [68]. In order to make teams more resilient in unpredictable environments where managers cannot constantly regulate work, the team as a whole is made responsible for its composition, task distribution, and leadership. The need for autonomy has been recognized as important for Agile teams [24]. Self-

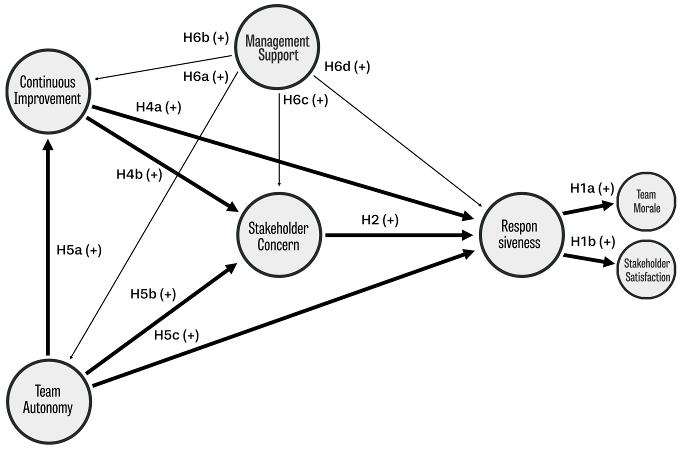

Fig. 1. Theoretical model

managing teams have been associated with a range of positive effects [54], such as increased productivity, job satisfaction, and higher commitment. Where team autonomy generally refers to reduced constraints imposed by the environment, autonomy can also be reduced by constraints within the team. This is where cross-functionality matters. Cross-functional teams are defined as consisting of members with different functional backgrounds [69], which contributes to *organizational ambidexterity* [24]. Functional diversity has been linked to shorter development time [70], increased quality and schedule performance [69] and higher performance [47], [71].

We hypothesize three positive outcomes of team autonomy. The first focuses on the facilitation of continuous improvement by giving teams ownership over their process, similar to how individual job autonomy encourages continuous improvement on the individual level [72]. We also expect a positive influence from team autonomy on stakeholder concern because teams (and in particular, Product Owners) are better able to identify and order work to address the needs of stakeholders. Furthermore, we expect that team autonomy facilitates the responsiveness of teams by removing constraints to their responsiveness, like requiring permission or dependencies on other teams and departments:

Hypothesis 5 (H5). *Team autonomy is positively associated with continuous improvement (H5a), stakeholder concern (H5b), and responsiveness (H5c)*

Finally, our case studies revealed how support from management support varied between Scrum teams. Because Scrum teams are self-managing, managers have to shift their approach from leading to "leading others to lead" [73]. In self-managing teams, the locus of control for work-related decisions shifts from external managers to the team [23], [74], [75], [76]. We expect that Scrum teams are more likely to be effective when they experience support from management:

Hypothesis 6 (H6). *Management Support is positively associated with team autonomy (H6a), continuous improvement (H6b), stakeholder concern (H6c), and responsiveness (H6d).*

Our six hypotheses, and their sub-hypotheses, are visualized in figure 1. In the following sections, we will validate these hypotheses with a large sample of Scrum teams.

5 Large-scale cross-sectional study

After the induction of the theoretical model described in Section 4, we will now evaluate it to assess its generalizability. To do so, we use Structural Equation Modeling (SEM) on quantitative data that was collected through a large-scale cross-sectional survey study.

5.1 Data collection and analysis

We performed our data collection process through a customized online survey. We operationalized the latent variables identified in the multiple case studies with sixteen established or new measurement instruments. A description of the scales, along with their reliability and attribution, can be found in the Supplementary Materials (see section 7). To improve the usability and measurement reliability or the sample study, we performed three pilots of the survey between June 2019 and June 2020. After the pilots, we employed two strategies to reduce response bias. First, we incentivized participation by offering participants a report to support their teams in their Sprint Retrospective. The report included team scores and a benchmark derived from the overall and aggregated team responses. In addition, teams received actionable improvement suggestions based on their scores drawn from a professional book [77]. Second, we sent reminders to participants who started the survey but did not complete it within two days. The survey was advertised on channels that are frequented by people interested in Scrum, ranging from industry platforms, blog posts, podcasts, and videos by industry influencers[5]. In the pilot studies, we observed that many participants first tested the survey with a quick test run with fake answers and then returned for an actual attempt. To prevent such responses from influencing our results, we added an item at the start of the survey to ask respondents if their answers were reflective of a real team or were meant to test the survey.

The use of a single method - like a survey - introduces the potential for a systematic responses bias where the method itself influences answers [78]. To control for such common method bias, the most accurate approach in current literature is the use of a marker variable that is theoretically unrelated to other factors in the model [79]. We included three items from the social responsibility scale (SDRS5) [80] and found a small but significant unevenly distributed response bias. Following recommendations in literature, we retained the marker variable "social desirability" in our causal model to control for common method bias [79].

For our sample, we began with all individual responses from June 3, 2020, and onward ($N = 3.151$). Because our survey was public, we applied several strategies to remove careless responses from the sample and prevent them from influencing the results [81]. We first discarded 78 responses where the team's name indicated a test, e.g., "Fake" or "Test." To further reduce the impact of careless responses, we removed 144 participants that completed the survey below the 5% percentile (6.87 minutes). We identified a handful of multivariate outliers based on their Mahalanobis distance but did not remove them. These cases may represent unusual

5. Due to the opt-in nature of the survey, we not able to compute a meaningful response rate. However, we were able to establish that 42% of the participants who started the survey completed it.

cases, and their removal should be done with the utmost caution [82]. Our final sample contained 2.939 responses from individuals from 1.193 teams. We aggregated the data to the team level by calculating mean-based averages for each item in the survey. The composition of the sample is detailed in Table 2. Accordingly, we ran a post-hoc power analysis using G*Power [83] version 3.1. We determined that the size of the sample allows us to capture small effect sizes ($f = .05$) with a power of almost 100% ($1 - \beta = .999$). This means that we can accurately reject non-significant relations, also in case of almost undetectable effect sizes. In other words, we are very confident that our sample is big enough to provide a reliable outcome of our SEM analysis.

Next, we tested our data for necessary statistical assumptions to run our SEM analysis. We assessed normality by inspecting the skewness and kurtosis of individual items. The skew for all items remained well below the recommended thresholds for kurtosis (< 3) and skew (< 2) [82]. We tested linearity by entering all pairs of independent and dependent variables into a curve estimation [84] to see if the relationship was appropriately linear, which was significant in all cases ($p < 0.01$). We assessed homoscedasticity by inspecting the scatter plots for all pairs of independent and dependent variables for inconsistent patterns but found none. Finally, multicollinearity was assessed by entering all independent variables one by one into a linear regression [84]. The VIF remained below the critical threshold of 10 [42] for all measures but indicated modest multicollinearity for Psychological Safety (between 6 and 8.5) and Quality (between 5 and 5.5).

Finally, we prepared the data for imputation of missing values. Imputation avoids the list-wise deletion of otherwise meaningful cases or variables by replacing missing data with estimates based on valid values. However, data must be missing at random (MAR) or missing completely at random (MCAR) to avoid biased estimates [39], [42]. We used Little's MCAR Test ($Chi^2 = 8,425.128$, $df = 8,592$, $p = 0.899$) [42] to conclude that the data was indeed missing completely at random (MCAR). We then performed EM maximum likelihood imputation in SPSS.

5.2 Model fit evaluations

Before testing for the model fit, we assessed reliability, convergent, and discriminant validity for the resulting measurement model. The individual steps involved in the model-fitting process are included in the Supplementary Materials (see 7). Discriminant validity was assessed by analyzing the heterotrait-monotrait ratio of correlations (HTMT) with a third-party plugin in AMOS [85], and following the approach outlined in literature [42], [86]. The maximum shared variance (MSV) was indeed lower than the average extracted variance for all pairings. The square root of average extracted variance was also greater than the inter-construct correlations for all pairings, indicating good discriminant validity. We assessed convergent validity by inspecting composite reliability (CR) and average extracted variance (AVE) and found no serious issues. The AVE was above > 500 for all pairs of factors. The CR was equal to or above the threshold of .7 [42] for all scales. Consequently, the measurement model fit the data well ($Chi^2(763) = 1841.527$; $TLI = .957$; $CFI = .965$; $RMSEA = .034$; $SRMR = .0303$).

We then proceeded to test the path model for the effects we predict from our theory. Our hypothesized theoretical model fit the data well on each of the fit indices, as described in Table 3: $Chi^2(712) = 2163.290$; $TLI = .952$; $CFI = .952$; $RMSEA = .041$; $SRMR = .038$. However, the Chi-Square test (CMIN/Df) indicated a significant difference between the predicted and the observed data ($p < .001$). However, because this is almost always the case for samples with more than 400 cases [39], [40], [42], and because the other fit indices showed a good fit, this was no reason for concern. Taken together, the predictors in our model explain respectively 48.6% of the variance in stakeholder satisfaction and 34.9% of the variance in team morale. For studies in the social sciences, values above 26% are considered large [87].

TABLE 2
Composition of the sample

Variable	Category	N (%)
Respondents		2.939
Teams		1.193
Respondents per team	1 respondent	120 (10.4%)
	2-4 respondents	415 (35.8%)
	5-8 respondents	329 (28.4%)
	9+ respondents	294 (25.4%)
Product Type	Product for internal users	630 (53.6%)
	Product for external users / customers	545 (46.4%)
Scrum Team Size	1-4 members	53 (4.5%)
	5-10 members	838 (71.1%)
	11-16 members	228 (19.3%)
	>16 members	60 (5.1%)
Organization Sector	Technology And Telecommunications	440 (37.4%)
	Financial	266 (22.6%)
	Government	73 (6.2%)
	Other	414 (34.7%)
Organization Size	1-50 employees	120 (10.4%)
	51-500 employees	415 (35.8%)
	501-5.000 employees	329 (28.4%)
	>5.000 employees	294 (25.4%)
Region	Europe	822 (68.9%)
	North America	141 (11.8%)
	Asia & Oceania	99 (8.3%)
	South America	69 (5.8%)
	Africa & Middle East	24 (2%)
	Other & Global	38 (3.2%)

5.3 Hypothesis Testing and Interpretation

We reported the means, standard deviations, and (Pearson) correlations of all variables in Table 4. Following recommendations in statistical literature [38], [39], we used a bootstrapping procedure with 2.000 samples and 95% bias-corrected

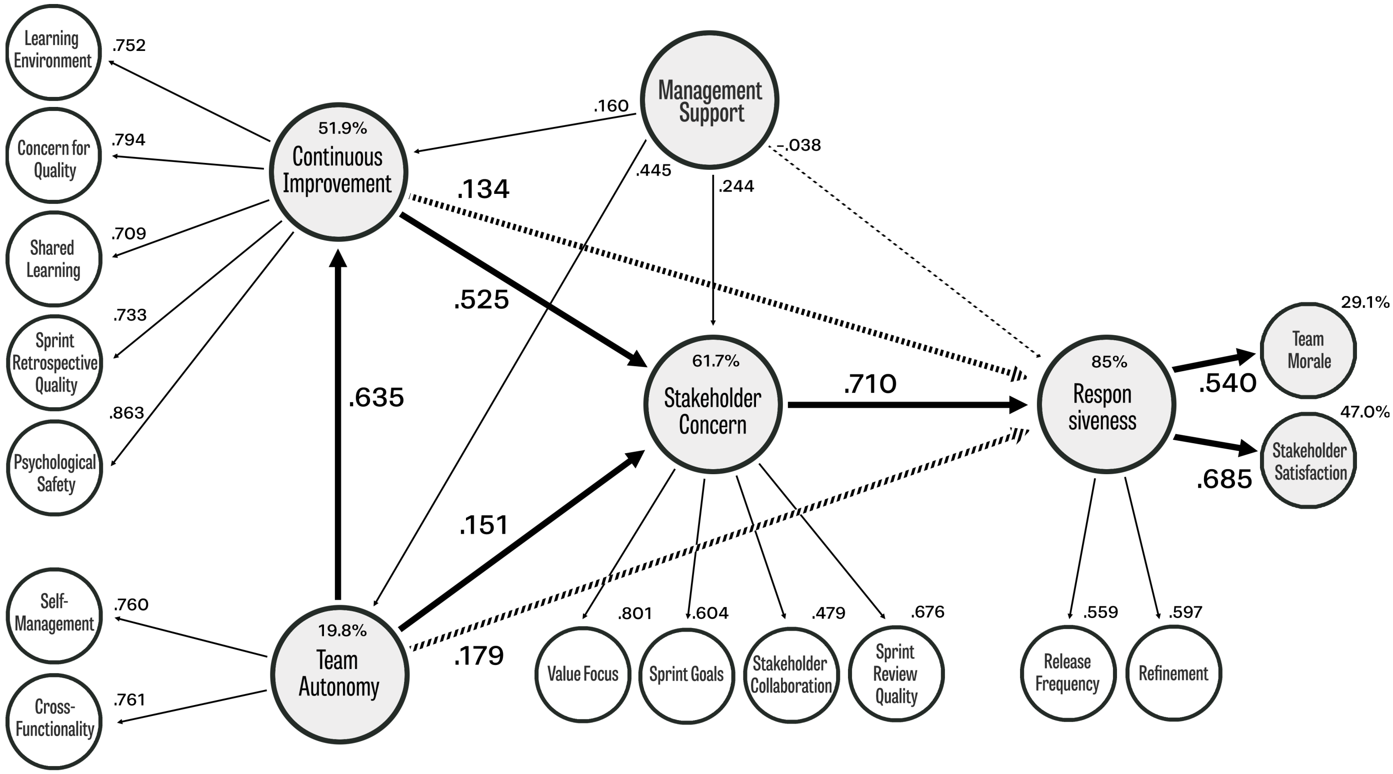

Fig. 2. Standardized factor loadings and standardized path coefficients for the research model. All paths, except dotted lines, are significant at $p < 0.01$. The model shows first- and second-order latent factors. Control variables and indicators are excluded from the model for the sake of clarity. Squared Multiple Correlation is reported inside all endogenous variables

TABLE 3
Model Fit Indices

Model fit index	**Value**	**Interpretation**
Chi-Square	2.163,290	n/a
Degrees of freedom (df)	712	n/a
CMIN/df	3.038	A value below 5 indicates an acceptable model fit [88], below 3 a good fit [89]
Root Mean Square Error of Approximation	0.041	Values $\leq .05$ indicates good model fit
RMSEA 90% CI	0.039-0.043	
p of Close Fit (PCLOSE)	1.000	Probability that RMSEA ≤ 0.05, where higher is better
Comparative Fit Index (CFI)	0.952	Values $\geq .95$ indicates good model fit [42]
Tucker Lewis Index (TLI)	0.945	Values $\geq .92$ indicates good model fit [42]
Standardized Root Mean Square Residual (SRMR)	0.038	Values $\leq .05$ indicates good model fit
Stakeholder satisfaction: Variance explained by predictors (R^2)	47.0%	Values $\geq 26\%$ indicates large effect [87]
Team morale: variance explained by predictors (R^2)	29.1%	Values $\geq 26\%$ indicates large effect [87]

confidence intervals to more accurately estimate parameters and their p-values for direct effects, factor loadings, and the hypothesized indirect effects. The parameter estimates for our hypotheses are reported in Table 4, with additional estimates and factor loadings available in the supplementary materials.

The results allowed us to confirm twelve out of fourteen hypotheses. We found a significant and positive association between the responsiveness of teams and team morale (H1a, $\beta = .540, p < .001$) and stakeholder satisfaction (H1b, $\beta = .685, p < .001$). A positive association was also found between stakeholder concern and responsiveness (H2, $\beta = .710, p = .001$). This indicates that a strong concern for the stakeholders either drives teams to be more responsive or vice-versa. We also hypothesized that a strong concern for stakeholders is likely to result in more satisfied stakeholders and higher morale but that this effect is mediated by the ability of teams to release their work to those stakeholders frequently. We tested for mediation by looking for significant indirect effects with bootstrap testing. This strategy is recommended in recent statistical literature [90], [91] in favor of the overly conservative test by Baron and Kenny [92]. A significant and substantial indirect effect was indeed found from stakeholder concern to team morale mediated through responsiveness (H3a, $\beta = .383, p < .001$), and from Stakeholder Concern to stakeholder satisfaction mediated through responsiveness (H3b, $\beta = .486, p < .001$). From these results, it seems that stakeholder concern indeed has a positive influence on the dependent variables, but only indirectly through the capability of teams to respond quickly

TABLE 4
Parameter Estimates, Confidence Intervals, Standard Errors, and Standardized Coefficients for Direct Effects and Indirect effects for hypotheses (statistically significant hypotheses at $p < 0.05$ are set in boldface)

Parameter	Unstandardized	95% CI	SE	*p*	Standardized
		Direct Effects			
H1a: Responsiveness → Team Morale	**.572**	**(.476, .683)**	**.048**	**.001**	**.540**
H1b: Responsiveness → Stakeholder Happiness	**.725**	**(.631, .834)**	**.054**	**.001**	**.685**
H2: Stakeholder Concern → Responsiveness	**.604**	**(.478, .752)**	**.074**	**.001**	**.710**
H4a: Continuous Improvement → Stakeholder Concern	**.625**	**(.483, .782)**	**.076**	**.001**	**.525**
H4b: Continuous Improvement → Responsiveness	.136	(-.037, .295)	.073	.191	.134
H5a: Team Autonomy → Continuous Improvement	**.701**	**(.575, .875)**	**.070**	**.000**	**.635**
H5b: Team Autonomy → Stakeholder Concern	**.199**	**(.051, .387)**	**.083**	**.027**	**.151**
H5c: Team Autonomy → Responsiveness	.201	(.032, .392)	.076	.055	.179
H6a: Management Support → Team Autonomy	**.263**	**(.215, .321)**	**.026**	**.001**	**.445**
H6b: Management Support → Continuous Improvement	**.105**	**(.050, .161)**	**.027**	**.002**	**.160**
H6c: Management Support → Stakeholder Concern	**.191**	**(.133, .252)**	**.030**	**.001**	**.244**
H6d: Management Support → Responsiveness	-.025	(-.082, .029)	.028	.444	-.038
		Indirect Effects			
h3a: Stakeholder Concern → Responsiveness → Team Morale	**.345**	**(.271, .443)**	**.051**	**.001**	**.383**
h3b: Stakeholder Concern → Responsiveness → Stakeholder Satisfaction	**.438**	**(.347, .557)**	**.062**	**.001**	**.486**

to changing needs.

Our model proposes that stakeholder concern and responsiveness are positively impacted by the degree to which teams operate in environments where continuous improvement is encouraged. Our results allowed us to confirm a positive effect from continuous improvement on stakeholder concern (H4a, $\beta = .525, p < .001$). However, this was not the case for responsiveness (H4b, $\beta = .134, p = .191$). In a similar vein, we found support for the positive influence of team autonomy. A positive effect was found on continuous improvement (H5a, $\beta = .635, p < .001$) and on stakeholder concern (H5b, $\beta = .151, p < .050$), but not on responsiveness (H5b, $\beta = .179, p = .055$). Again, although we cannot infer the causal sequence from our data, it does support the notion that more autonomous teams are more likely to improve continuously and are more capable of focusing on the needs of stakeholders.

Finally, we hypothesized that (perceived) support from management is an important enabler for the other factors in our model. And while we found a positive effect from management support on team autonomy (H5a, $\beta = .445, p < .001$), continuous improvement (H5b, $\beta = .160, p = .002$) and stakeholder concern (H5c, $\beta = .244, p < .001$), management support was not significantly associated with responsiveness (H5d, $\beta = -.038, p = .444$).

6 Discussion

This study set out to identify which team-level factors contribute to the effectiveness of Scrum teams. Although the Agile Success Model provided a general theoretical framework to understand the dynamics within an Agile project, specific recommendations at a team level are still missing [2]. Thus, in the absence of an existing team-based model, we induced a five-factor model from 13 case studies and tested it with Covariance-Based Structural Equation Modeling and a large, representative sample of Scrum teams. The model demonstrated a good fit based on recommended fit indices. The five factors explained a substantial amount of variance in our measures for team effectiveness: stakeholder satisfaction ($R^2 = 47.0\%$) and team morale ($R^2 = 29.1\%$). Although Scrum teams are permanently embedded in larger systems, this highlights that much of what makes Scrum teams effective can be designed and assessed at the level of individual teams. We discuss findings and their implications below and summarized them in Table 5.

First, Scrum teams that can release to stakeholders more often are more likely to see higher stakeholder satisfaction and higher team morale (H1). We defined this more broadly as "responsiveness", and it includes release frequency as well as supporting skills to create this capability. This finding reflects the core notion of Agile methodologies that it is easier to satisfy stakeholders by discovering requirements and emergent needs through frequent releases [3]. Furthermore, this finding stresses the motivational effect of frequent releases. This ties in well with goal-setting theory [93] when we consider each release as a tangible and ambitious short-term goal to be achieved by the team.

Our second finding emphasizes that responsiveness alone is not enough. Scrum teams with a strong concern for stakeholders are more likely to satisfy those stakeholders (H2). They also experience higher team morale. However, this effect is indirect and fully mediated through responsiveness (H3). The positive effect of stakeholder concern on stakeholder satisfaction diminishes when teams are unable to release frequently to stakeholders. However, the inverse is also true; teams that are highly focused on stakeholder needs , *and* release frequently are most likely to satisfy their stakeholders and experience high morale.

Although we treated responsiveness as a mediator for stakeholder concern, the interaction is more reciprocal in practice. Teams that are highly concerned with the needs of stakeholders are probably also more inclined to increase their responsiveness to those needs. In any case, our findings suggest that Scrum teams should be designed, assessed, and supported in both stakeholder concern and responsiveness instead of one or the other. In support of existing literature, Product Owners are instrumental in shaping stakeholder concern [48], [94]. Product Owners can support Scrum teams by providing a vision and strategy to address stakeholder needs, use formal gatherings to gather feedback from stakeholders, and encourage collaboration between the team and stakeholders.

Our remaining hypotheses concerned three team-level predictors of stakeholder concern and responsiveness and their indirect effects on team effectiveness. The first is that Scrum teams that engage in continuous improvement are more likely to show greater concern for the needs of stakeholders (H4b). Second, we did not find an expected positive effect of continuous improvement on responsiveness (H4a). While this affirms that continuous improvement enhances team processes, it does so only for the ability of teams to build what stakeholders need. We expected that teams that strongly engage in continuous improvement would also acquire the skills and strategies to release more frequently. However, this is apparently not the case. We suspect that challenges to responsiveness are arguably more technical and skill-based in nature than a stakeholder concern. Because our measures for continuous improvement did not include items about skills and technologies, we may have missed the part of the improvements that are relevant to responsiveness. It is also possible that teams indeed rarely focus their improvements on responsiveness, either because they do not know how or because they experience less control over this due to external constraints. Whatever the case, more research is needed to understand better how continuous improvement interacts with responsiveness.

Additionally, we also found that team autonomy significantly contributes to the degree of continuous improvement and the concern of teams for stakeholders (H5a & H5b). If team autonomy is understood as a reduction in external and internal constraints a team has to navigate, the results illustrate different types of constraints. For stakeholder concern, the mandate of a team to make decisions about their product may be one such constraint. The case studies highlighted that some Product Owners control scope and delivery dates, whereas others have to follow provided plans or contracts. The larger this mandate, the more Product Owners can capitalize on stakeholder needs that are discovered as work progresses. Furthermore, team autonomy also increases continuous improvement. When teams experience fewer constraints in how to organize their work, they are also more inclined to take ownership of the improvements to how that work is done. We did not find support for the hypothesized positive effect of team autonomy on responsiveness (H5c). We expected that autonomous teams would be more responsive due to fewer dependencies on people outside the team (e.g., need for approval, work to be done by other teams). In hindsight, our measures only assessed experienced autonomy and not dependencies specifically. So this finding may be a consequence of our operationalization. Future studies can explore how and if a decrease in external dependencies improves responsiveness directly. In any case, a practical implication of these findings is that organizations that seek to improve the effectiveness of Scrum teams do well to invest in their autonomy. This is also apparent from extant literature [24]

We also found that management support positively influences team autonomy, continuous improvement, and stakeholder concern (H6a, H5b & H6c). The results did not support the hypothesized positive effect on responsiveness (H6d). This also seems to be a result of different types of constraints. Where stakeholder concern, continuous improvement, and team autonomy are more susceptible to team-level constraints, responsiveness may be more constrained by individual skills and technologies in use. A practical implication of these results is that support from management is most relevant where it involves the removal of constraints in the environment of Scrum teams, particularly where it concerns the autonomy of Scrum teams and the quality and mandate of Product Owners. This is an excellent example of "boundary control"; one of the strategies that managers can use to support autonomous work groups [95].

6.1 Limitations

This is a Mixed Methods study. Following the recommendations of Russo et al. [33], we discuss both qualitative and quantitative limitations. In particular, we combined the threats to credibility transferability, dependability, and confirmability [96] of our multiple field studies, with internal, construct, external, and conclusion validity from our sample study [97].

Credibility & Internal. The factors that we identified in the qualitative phase were derived from thirteen cases that took place over five years. Triangulation was achieved through multiple cases. For the quantitative part of our study, we employed several strategies to safeguard internal validity. One threat to public surveys is that samples are based on voluntary (non-probabilistic) response and may be biased due to self-selection or non-completion. Therefore, we advertised the survey on industry platforms that are frequented by the target population. We also incentivized participation by offering teams a detailed score profile upon completion. Although we can not calculate the non-response rate without knowing how many people visited the survey, we did establish that 42% of the participants that started the survey also completed it.

The cross-sectional nature of the data also does not allow conclusions about the causality of effects.

Transferability & External. A key strength of the Eisenhardt approach is that it grounds theories in the substantive area of use [17], and thus increases the likelihood of valid and relevant theories [98]. Although we used a non-random sample for the case studies, it included Scrum teams that varied in size, sector, scale, and product. More importantly, the second phase of our study provided support for our theory with one of the largest sample studies ever performed in our community, surveying almost 3.000 professionals of 1.200 Scrum teams from a range of industries, organizations,

TABLE 5
Summary of Findings and Implications

	Findings	Implications
Five Factors Team Theory	From 13 case studies, we developed a theoretical model for Scrum teams from thirteen lower-order indicators grouped into five latent factors. This model fit the data from a large and representative sample of Scrum teams well ($Chi^2(712) = 2163.290$; $TLI = .952$; $CFI = .952$; $RMSEA = .041$; $SRMR = .038$). The five factors explain a substantial amount of variance in stakeholder satisfaction (47.0%) and team morale (29.1%).	Design and assess Scrum teams with five team-level factors in mind: responsiveness, stakeholder concern, continuous improvement, team autonomy, and management support. Design the environment of Scrum teams to minimize constraints to these factors on the one hand, and train and support them in the skills they need for each factor.
Responsiveness	Responsiveness is positively associated with team morale ($\beta = .540, p < .001$) and stakeholder satisfaction ($\beta = .685, p < .001$).	Support Scrum teams in their ability to be responsive. Implement technical tooling, increase automation, and train necessary skills (particularly *refinement*). Invest in team autonomy, stakeholder concern, and management support to make the need for Responsiveness more relevant to teams.
Stakeholder Concern	The stakeholder concern of teams is positively associated with responsiveness ($\beta = .710, p < .001$). Indirectly, stakeholder concern is also positively associated with Team Morale ($\beta = .383, p < .001$) and stakeholder satisfaction ($\beta = .486, p < .001$). Nevertheless, this positive effect is only present when responsiveness is high, i.e., fully mediated by responsiveness.	Product Owners can increase Stakeholder Concern by co-opting teams in product strategy formulation, goal setting, and collaboration with stakeholders. If Scrum teams are unable to release frequently in the first place, efforts must be undertaken to remove organizational constraints, increase automation and build technical skills.
Continuous Improvement	The degree to which teams engage in continuous improvement is positively associated with stakeholder concern ($\beta = .525, p < .001$). Contrary to our expectations, continuous improvement is not significantly associated with Responsiveness.	Scrum teams are advised to direct their continuous improvement process towards the five key factors identified in this study: responsiveness, stakeholder concern, team autonomy, management support, and continuous improvement. These factors are most likely to highlight constraints to team effectiveness stemming from internal or external factors to the team. In turn, organizations should broaden the autonomy of teams to encourage teams to take control over improvements.
Team Autonomy	Team Autonomy was positively associated with continuous improvement ($\beta = .635, p < .001$) and stakeholder concern ($\beta = .151, p < .05$).	Expand the autonomy of Scrum teams primarily in two areas. The first is internal to teams and concerns the degree to which its members are cross-functional. The second concerns constraints imposed by the organizational environment that limit control over tooling, team composition, choice of process, and Product Owners' mandate over their product.
Management support	Management Support was found to be positively associated with team autonomy ($\beta = .445, p < .001$), continuous improvement ($\beta = .635, p < .01$) and stakeholder concern ($\beta = .244, p < .001$), but no significant effect was found on Responsiveness.	Management can most effectively contribute to Scrum teams by increasing their autonomy, both in terms of self-management and product mandate. Train management in the skills needed to support rather than direct.

and countries (cf. Table 2), leading to generalizable results. However, we can not make conclusions for teams that apply Scrum to other domains than software engineering or teams in general.

The data collection was partially performed during the COVID-19 pandemic. Some of the scales, like "Team Morale" and "Psychological Safety", may have been scored differently because teams worked from home. We added a 2-item 7-point Likert scale for a subset of participants ($N = 857$) to assess the degree to which they expected their results to have been different outside of COVID-19. The mean score ($M = 2.76, SD = 1.78$) did not suggest a substantial impact.

Dependability & Construct. Triangulation was achieved through multiple cases over a period of five years. Nevertheless, we can not exhaustively rule out personal biases in the case studies. Thus, we used well-established methodological guidelines to explain the research process. Also, the case studies were performed to inform theory, so the emphasis lies on the second phase of our study. To maximize content validity for the second phase, we used existing validated scales where available. Where this was not the case, we derived scales from observations that recurred across cases. As a result, the proposed measurement model fit the data well. A heterotrait-monotrait (HTMT) analysis confirmed discriminant validity for all measures. The reliability for all measures exceeded the cutoff recommended in the literature ($CR >= .70$ [42]).

Our survey consisted of self-rated items. Although we statistically controlled for social desirability and common method bias, other confounding variables may have influenced how participants interpreted the items. This is particularly relevant to the measure for stakeholder satisfaction, where we asked team members how satisfied their stakeholders are. We cannot rule out that higher scores on stakeholder satisfaction are attributable to the self-perceived success of teams (*"We're doing great with Scrum, so our stakeholders must be happy."*). Future studies can validate our findings by asking stakeholders directly. The broad range of scores we observed on the various measures provides confidence that a broad range of Scrum teams participated. Furthermore, the size of our sample and the aggregation of individual-level responses to team-level aggregates reduce variability due to non-systematic individual bias.

Confirmability & Statistical conclusion. In this study, we used observations from thirteen exploratory case studies to inform a theoretical model about factors that contribute to the effectiveness of Scrum teams. In the second phase, we used Structural Equation Modeling (SEM) to test the entire model simultaneously, effectively including factor analysis and regression analysis in a single test [38], [39]. The resulting model fit the data well on all fit indices recommended by statistical literature and explained a substantial amount of variance in the dependent variables.

7 Conclusion

While the Agile Success Model provides a general theory for Agile projects performance [2], this paper focused on a theoretical model to understand how team-level factors interact to determine the effectiveness of Scrum teams. So far, Scrum teams and their internal dynamics are rarely at the center of scholarly investigations. This is surprising considering the prevalence of Scrum teams in today's IT organizations [4]. Nevertheless, a theory for Scrum teams offers practical guidance to organizations and practitioners on how to design, assess and support teams. The few studies that did explore Scrum teams (e.g. [13]) were based on field studies or research designs that limited their generalizability.

We applied a Mixed Methods approach by first collecting qualitative data from thirteen case studies and then performed a rigorous quantitative test of the resulting theoretical grounded theory with a large sample of Scrum teams ($N = 1.193$). In the data, we identified five high-order factors (responsiveness, stakeholder concern, continuous improvement, team autonomy, and management support), thirteen lower-order factors (e.g., value focus, Sprint Review quality, cross-functionality, and refinement). Then, based on patterns in the observational data and supported by extant literature, we proposed six hypotheses to explain how these factors conspire to make Scrum teams more or less effective, as defined by their ability to satisfy stakeholders on the one hand and experience high team morale on the other.

Our findings highlight the interplay between stakeholder concern and responsiveness as drivers of Scrum team effectiveness. The most effective teams are those that can frequently release *and* focus on the needs of their stakeholders, but not one or the other. In turn, this requires a high degree of team autonomy, continuous improvement, and support from management.

The model in this paper can act as a grounding framework to inform future research. Aside from the questions we already raised in the discussion, it is worthwhile to test the proposed causality with longitudinal or quasi-experiment designs. First, this may shed more light on which types of interventions are most relevant to practitioners and in which order. Second, it would be helpful to test the generalizability of this model to teams that use Scrum outside of software development. Finally, practitioners would benefit from focused investigations into the kinds of interventions that increase team autonomy, responsiveness, stakeholder concern, continuous improvement, or management support.

Supplementary Materials

A replication package for the sample study is available under a CC-BY-NC-SA 4.0 license at the following DOI: 10.5281/zenodo.4773874. The package includes supplementary tables, model definitions (AMOS), syntaxes for SPSS, and a fully anonymized, cleaned, and aggregated dataset of 1.193 Scrum teams.

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