**Keeping Open Innovation Projects Alive:**

**A multiple Case Study of Covid-19 Ventilator Projects**

*Working Paper*

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**ABSTRACT**

We use a multiple case study to investigate antecedents of success in open innovation projects. Although open innovation is a long-standing topic, the literature on organizational roles during open innovation projects is fragmented and limited. This paper analyzes 12 case studies of open innovation projects during the Covid-19 demand shock for respiratory ventilators. We identify organizational roles and their impact in open innovation projects carried out under extreme conditions. Our analysis highlights three critical organizational roles determining successful or unsuccessful outcomes of open innovation: visionaries, curators, and experts. We illustrate our findings using the open innovation funnel phases. To the project management literature, we contribute new theoretical insights into organizational roles and success factors during open innovation projects. The findings help practitioners plan better collaborative responses to demand shocks and disruptions*.*

**Keywords:** open innovation, organizational roles, project management, covid-19

**INTRODUCTION**

*“They re-created a medical device. The whole project was a big innovation. The thinking process was innovation!”* (CEO, Penlon)

The Covid-19 pandemic brought a skyrocketing demand for ventilators. The volume and need for a speedy response imposed by this crisis were much higher than any single firm could hanlde. Individual firms—even the manufacturers of ventilators—did not have the resources readily available to react in an agile manner. Therefore, we witness a rise in firms turning to open innovation (Chesbrough, 2020) to accelerate the development of the required medical equipment. For most of the firms involved, they entered uncharted territory.

Chesbrough and Bogers (2014) define open innovation as “a distributed innovation process involving the purposive knowledge flows across organizational boundaries for monetary or non-monetary reasons.” Known examples of OI include how Procter & Gamble uses Connect and Develop to solicit collaborations from partners and how Amazon offers internal IT to external customers. Through these efforts, it can be observed that the application of open innovation in various types of firms accelerates the speed of product development (Chesbrough, 2020). However, despite the growth of literature in open innovation since the seminal work by Chesbrough in 2003, extant literature lacks evidence on the end-to-end innovation process (West and Bogers, 2014). Studies have primarily focused on front-end integration (West and Bogers, 2014). Furthermore, empirical studies explicating the actors in implementing open innovation are scarce (Lifshitz-Assaf, 2018). A study by Lifshitz-Assaf (2018) demonstrated how vital the role of the NASA actors is in influencing the nature and permeability of the knowledge flows.

This paper explores the open innovation phenomenon in responding to demand shocks during extreme situations. We explore open innovation through the lens of stakeholder theory. First, we explore stakeholder theory due to this topic’s differing views and fragmented nature (Friedman and Miles, 2002). Stakeholder theory identifies the roles of people who can affect or are affected by the project. However, from extant literature, this theory was studied from a project or firm-centric point of view. We explore the stakeholder theory through the prism of organizational roles as guiding open innovation process. The emphasis on team development in a highly stressed and disruptive environment has not been studied enough in the operations management domain. We aim to bridge this gap to provide insights for managers to develop better and advance performance in a multi-faceted project.

Additionally, we explore the project management literature to understand the mechanisms of open innovation ventilator projects. Project management can be defined as: “the application of knowledge, skills, tools and techniques to project activities to meet the project requirements” (PMBOK Guide, 2008, p. 37). Over the years, project management has become a generic concept encompassing various disciplines and theories applied to project work – including operations management. The overlap of project management and operations management often occurs during several points of the product life cycle – one of which is developing a new product. According to Söderlund (2004), despite the growing literature and handbooks on project management – there is still a lack of descriptive empirical research. Thus, we aim to address this gap through our empirical multiple-case study approach. The ventilators were developed through an open innovation environment where firms collaborated to develop a new product. This empirical data is uniquely set in the pandemic's boundary and presents an ideal context for the investigation.

Thus, this paper aims to address two overarching research questions: (RQ1) What are key organizational roles that lead to success in open innovation projects? (RQ2) How is the interplay between key organizational roles affecting open innovation project outcomes? We apply the combination of three themes: open innovation, stakeholder and role theory, and project management to develop stylized findings to provide more structure to the defined theoretical fields.

**LITERATURE REVIEW AND THEORETICAL** FOUNDATIONS

**Open innovation**

Henry Chesbrough introduced open innovation in his seminal work in 2003, where he contested the traditional R&D frameworks of closed firm boundaries (Chesbrough, 2003). Prior to the inception of this idea, firms held onto the philosophy of control to ensure and hide successful innovation. For some, the large amount of internal targeted investments paid off. However, this changed due to several factors called “erosion factors,*”* including, increased mobility of workers, more capable universities, technological advancements, and so on. According to its proponents, firms should therefore move towards adopting the open innovation model instead (Chesbrough and Bogers, 2014).

Chesbrough and Bogers (2014) define open innovation as “a distributed innovation process involving the purposive knowledge flows across organizational boundaries for monetary or non-monetary reasons.” This model—often represented as a sieve funnel—redefines the firm boundary in innovation projects. What was earlier a closed boundary was “opened” up and allowed firms outside the firm boundaries to take part in the process. Through these collaborations, firms can harness outside ideas to advance their business while leveraging internal ideas. The original process of Chesbrough in 2003 has then evolved with the concept of “coupled” flow by Enkel *et al*. (2009)– a two-way interaction between firms and innovative actors outside of the firm. This collaborative exchange beyond boundaries, where different actors can work together to grow a commercial idea, has trumped the early Schumpeterian model of a lone entrepreneur introducing innovations to the market (Laursen and Salter, 2006).

This shift has led to a higher focus on networks and relationships between the firm and its external environment in shaping performance. Several studies have shown favorable outcomes from cooperation and boundary-spanning searchers beyond technological and organizational boundaries (Rosenkopf and Nerkar, 2001; Shan *et al.*, 1994). The importance of external sources of knowledge is undisputable, leading to the rise of diversified literature from collective innovation, user innovation, and technological change.

**Stakeholder theory via organizational roles**

The concept of roles is one of the most central in social sciences Driskell *et al.*, (2017). However, despite this centrality, there has yet to be a single scientific origin or core definition of roles. The discussion on roles in organizations has been part of the conversation in the strategic management literature in the curation of strategy. Among them is the stakeholder theory, coined by Freeman (1984). According to Freeman (1984), the stakeholder theory was developed to provide a framework for managers to manage unprecedented environmental turbulence. In spite of this view, the importance of the role in strategy development has been a controversial discussion, with some authors Ansoff (1957), viewing stakeholders as a small contributor as compared to others (1984)

Freeman’s seminal work (1984) presented the stakeholder theory as a pragmatic approach to strategy to achieve superior performance in an organization. In one of his works, he described them as“those groups without whose support the organization would cease to exist” (Freeman and Reed, 1983, p. 89). Freeman’s classical definition of a stakeholder is “any group or individual who can affect or is affected by the achievement of the organization's objectives” (p 46). Since then, the stakeholder theory has continued to be used by numerous authors (Laplume *et al.*, 2008).

Despite the numerous citations of stakeholder theory, Laplume et al. (2008) describe the paradoxical state of the development of stakeholder theory where such a timely theory is so underdeveloped. Discussion on stakeholder theory has also been directed toward the moderating role of organizational culture and managerial orientation (e.g., Buysse & Verbeke; Jones et al., 2007 (Laplume *et al.*, 2008). Stakeholder theory focuses on the effect of a firm’s performance or strategy development. However, the integration of stakeholders and organization into a meaningful framework is lacking despite the focus on stakeholders. The current discussions are often based on varying definitions with fragmented data, resulting in a lack of holistic explanation to accurately describe stakeholders’ role in firm performance. Extant literature which focuses on the part of stakeholders in the development of a project or strategy of an organization appears fragmented at best.

On a more microscopic level of managers within the stakeholders, Mintzberg’s (1985) summary of the three roles of managers gained significant traction. He proposed three types of roles a manager has – (1) interpersonal roles, (2) informational roles, 3) decisional roles. The interpersonal role is exemplified through leadership qualities, a figurehead role and a liaison person. The informational role is related to the retrieval and dissemination of information—lastly, the decisional role functions as an entrepreneur or negotiator representing the organizations in significant negotiations. The three categories add structure to the broad definitions of stakeholders but only focus on the managerial aspects of stakeholders. Although Stewart et al. (2005) highlight that no universally accepted taxonomy exists, Driskell et al. (2017) contest this view and explain that the lack of such a taxonomy is due to the inability of one way of characterizing team roles. A lack of resources is an obvious reason, as roles within teams are changing and need to be adapted to the demands. From their studies, Driskell et al. (2017) presented a clustered analysis that resulted in 13 different types of role taxonomies. However, their studies lack the study of the context or conditions in which these roles would be exhibited. In contrast, Ollila and Elmquist (2011) present a single case study with a fixed context but admit to the limited generalizability of the study.

Thus, in this paper, we aim to address the gap by conceptualizing the value of roles in the context of open innovation during extreme times. Furthermore, as the organizational roles of a project may not necessarily be solely within the firm, we extend our discussion to the ecosystem in which the project is developed.

**Project Management literature**

The management of projects has grown in importance due to its considerable economic impact across different sectors (Davis, 1969; Svejvig and Andersen, 2015; Turner and Müller, 2003). This places project management as a central element in innovation (Shenhar and Dvir, 1996). Due to the relevance of project management in practice, studies have been conducted focusing on different facets. For example, studies conducted by Pinto and Covin (1989) suggest that the critical success factors differ not only from project types but also from the different states of the lifecycles. The behavior changes according to lifecycles were explained by Adams and Barnd (1997) and apply to both projects or programs. They explained the differences between the need for cross-firm collaborations, which they coin as programs instead of the project (Adams and Barnd, 1997).

However, despite its growing use in practice, the literature on project management is relatively young to cover the complexity of Open innovation projects. While some scholars have attempted to provide structure to project management, there is still a lack of empirical evidence in the literature (e.g. Dvir, 2004; Shenhar and Dvir, 1996…). While definitions and concepts have been derived from proviwhatding structure, empirical evidence of the success and failures of managing open innovation are seen to be fragmented, at best. We contribute by conducting a practical case study on open innovation during COVID-19 pandemic, striving innovate on scaling up ventilator production. Due to high level of complexity and the regulatory requirements, many projects failed. Yet, the successful cases reveal the certain roles and behaviors needed to manage complexity in each of open innovation stages. This contribution allows to build a rich understanding for researchers and practitioners.

# METHODOLOGY

We apply a multiple case-study approach to generate theory from empirical data (Eisenhardt and Graebner, 2007; Glaser and Strauss, 1967; Yin, 1989). The inductive methodology is a good fit in this context as it provides a deep immersion into the focal phenomenon with an openness to rich data (e.g. texts, observations). Furthermore, by applying an inductive approach, we can better understand the mechanisms behind the complexity of the success and failure cases of ventilator projects, which is important but poorly understood and overlooked.

During the pandemic, firms collaborated through open innovation with a common goal – to produce ventilators (Corsini *et al.*, 2021; Netland, 2020). Ventilators were breathing devices which aided in the breathing of patients affected by Covid-19. During the onset of the pandemic, there was a lack of ventilators globally. This context can be linked to *"Grand Challenges",* defined as highly significant yet potentially solvable problems (Eisenhardt *et al.*, 2016). Based on Eisenhardt *et al.* (2016), applying inductive methods is beneficial to advance current grand challenges knowledge as there is a limited theory on the issues without a clear answer. Hence, we apply a multiple case study approach to investigate the mechanisms behind the success and failure cases. Our multiple case study approach adds to the ability of replication logic leading to a more parsimonious theory than using single cases (Miles and Huberman, 1994; Yin, 1994). We can identify the relationships between the various roles salient across the open innovation projects as well as the outcomes which follow.

**Data Collection**

We apply a multiple case study approach, where we collected empirical data based on 12 ventilator project case studies (Eisenhardt, 1989). The external validity is increased because the comparative results could be analyzed through 'within-case' and 'cross-case' analyses, thereby utilizing a replication logic (Yin, 1989). We address the aspect of reliability through the case's design, collection of data, and data analysis.

Firstly, a detailed case protocol was designed to facilitate systematic data collection and analysis. The case protocol was developed through a series of discussions with other researchers. To identify the respondents, we used secondary data sources to identify current projects on ventilators (e.g. internet, newspapers, and magazines…). Additionally, through our interviews with some of the respondents, further respondents were identified through purposive and snowball sampling procedures, as explained by Miles and Huberman (1994). We explicitly sought a balanced sample that was not limited to only successful repurposing initiatives. The respondents were selected based on their direct involvement in the development of the ventilators. The number of respondents per case study were also dependent on the information level and content shared. When the theoretical saturation is reached, we halt our process of sourcing more respondents for the project. Thus, as observed, for some projects the number of respondents were slightly skewed.

Next, we conducted a semi-structured interview through an online interface due to the pandemic situation. These interviews were recorded (unless disallowed) and finally transcribed, ensuring high reliability (McCutcheon and Meredith, 1993). The interview lasted between 50 minutes to 110 minutes. The transcribed text and notes are then sent to the interviewee for verification after the interview (Yin, 1989). In addition to the primary data collected, we supplement the semi-structured interviews with secondary data obtained from the respondents and from the internet. An example of the secondary data obtained from our respondent is illustrated in Figure 1 below.

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Insert Figure 1 about here

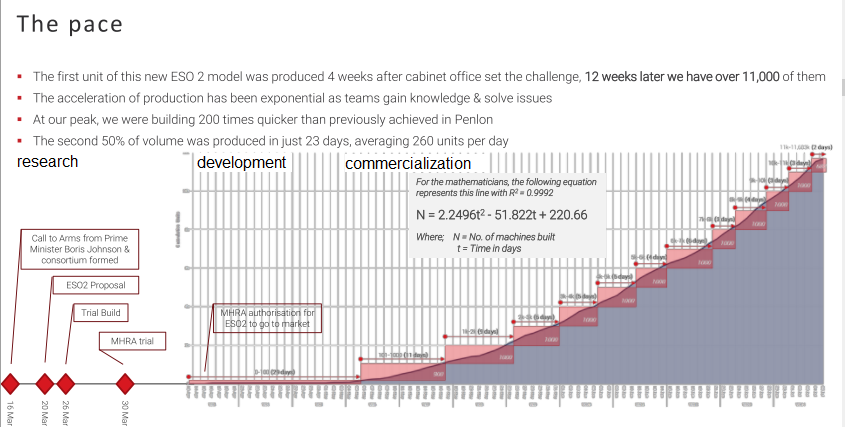


Figure 1. A chart from Penlon's open innovation project (courtesy of Ventilator Challenge UK[[1]](#footnote-2))

In our samples, we examine the contextual factors that may affect the projects' successful or unsuccessful outcomes. Contextual factors such as governance, funding, and institutional factors were analyzed to ensure the findings were not affected by contextual factors. While cases collected differed in terms of location, size, and function allocation, they were conducted during a similar time when the demand for ventilators was high. In addition, the product of focus was similar – ventilation devices used for the use of Covid-19. We acknowledge that the complexity of the ventilation devices may vary from one another due to the different development and prototyping methods of each team. However, the product functionality and application were similar – to be used to treat Covid-19 patients during emergency use. Additionally, the time frame and environment of which it was developed and manufactured were also similar across the cases. Hence, the antecedents of the success or failures of the projects can be analyzed and study. Rather, the rarity of case studies being in the similar context such as this is high resulting in our results being even more relevant given the controlled environmental setting of this real-life projects. Hence, with these being kept constant, we could better analyze the open innovation model and organizational roles involved.

**Data analysis**

We conducted an open coding to ensure adherence to the informant terms, labelled first-order coding (Braun and Clarke, 2006; Gioia *et al.*, 2013; King, N. and Horrocks, 2010). From this approach, we arrive at 183 first-order codes. It was followed by investigating similarities and differences among the categories, similar to an axial coding approach that eventually reduces our codes to 31 second-order codes. From these second-order codes, we then evaluated these against emergent theoretical constructs (Fisher and Aguinis, 2017).

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Insert Table 1 about here

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**Insert table of an overview of case studies**

***Analyzing the impact of stakeholders in the open innovation***

We seek to identify critical organizational roles in open innovation projects. Particularly, we examine how the presence or absence of specific roles acts as a determinant for the outcome of the project.

***Analyzing open innovation in the context of disruption***

We explore the effects of open innovation observed in the context of disruption. We focus on the interplay of roles across OI phases of ventilator projects and add two new preliminary phases explaining success of these projects via the prism of interplay of roles.

***Exploring the relationship between the phase of Open innovation with the organizational roles***

Based on the project management literature, the lifecycles phase affects the evolution of organizational roles. Thus, we apply this lens to identify changes if any organizational roles are identified throughout the project's lifecycle.

**Data rigor and validity**

To ensure data triangulation, three researchers facilitated "convergent perceptions" (Eisenhardt, 1989). In addition, three researchers conducted the coding individually and then reviewed to cross-validate the typology or recurring themes and codes (Lee, 1999). Therefore, this ensured the high reliability and rigor of our study.

# KEY FINDINGS AND RESULTS

Through the application of our conceptual framework, our data revealed that actors were central proponents of the open innovation phenomenon. Furthermore, we identified that during times of disruption, the actors within the team mattered in determining the success or failure of the project. The three core actors identified were: (1) the visionary, (2) the executor, and (3) the rulekeeper. In the following section, we describe the three core actors observed across the 12 case studies conducted. The summary of the codes and how they are categorized are shown in Table 2 and Table 3 below:

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Insert Table 2 about here

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**The three key stakeholders in open innovation projects**

***The visionary***

From our case studies, we label the first salient stakeholder role observed as the *visionary.* We identify *the visionary* role as the initiator of the project with a clear goal to develop the ventilators. Akin to literature, the visionary can be classified as a leader with a high task orientation and functions as a guide to achieving tasks. In addition, they serve as the energizer and motivator, which energizes the team (Bons and Fiedler, 1976; Driskell *et al.*, 2017). Using the view of Mintzberg (1975), identifying the visionary corresponds to the merging of the functions of the interpersonal and decisional roles.

Across the case studies, we observe that *the visionary* is identified by deciding to manufacture the ventilator which would reach the market. This decision-making step is a large differentiating point of identification of the role of *the visionary*, where they have a clear goal in mind defined from the very start of the project. For example, in UKVC, *the visionary* decided to build a project team to respond to the call to arms for the emergency: "*I filled the silence in the team when I said - so I will bring some companies together to rise to the challenge"*. *The visionary* in UKVC had experience with industry projects. He has leadership experience and decided to pioneer and kick-start a team in response to the pandemic.

Similarly, in Projecto Masi, the visionary called his team members and said, *"is it feasible for us to build ventilators?".* It was this question that led to the collaboration of his firm with the various stakeholders. Similarly, the drive and motivation can be seen through the quote from SpiroWave he said - *"We cannot let this happen. Um, we are going to build ventilators."And they looked at me like I am crazy, we were up against the odds. People were dying. It was a dark, scary moment."*

Similar situations were reflected in the other cases, where *the visionary* was identified as the actor who initiated the response to start designing and manufacturing ventilators. Again, this is consistent with the literature in leadership, where we observe that a leader's role is goal setting and team building.

***The executor***

In our case study, we define the *executor role* through team members with the know-how to manufacture the ventilators. In the context of our case studies, they are primarily comprised of software engineers, mechanical engineers, and clinicians. We identified the presence of *the executor* roles through the description of the team members who developed the product based on their capabilities and know-how. As illustrated by Katz and Tushman (1981), these are identified as the gatekeepers in research and development facilities. They explained the role of these gatekeepers as key individual technologies which are strongly connected to both internal and external sources of information. These studies often see gatekeepers as project supervisors (Fleming and Waguespack, 2007; Katz and Tushman, 1981). Fleming and Waguespack (2007) discuss the relationship between future leaders with the contribution from the technical components of a project.

In our case studies, we observe that the roles of an executor are portrayed through recruiting team members with the know-how. In the context of the ventilator projects, the know-how could be segregated to several phases. First, we identify the core domain knowledge, such as capabilities of the ventilator manufacturing or healthcare experience. For example, in the case Ventura CPAP, the team comprised of a high level of knowledge of the clinical and healthcare system – *“I already worked at the University hospital of one which has the highest number of ICU beds, and everyday we had a call with he lead consultant of the ICU to update the status of the Project.”.* Similarly, in project MVM – it was described as *"10 people from, um, MIT, which were, uh, w- uh, just really worked 24/7 just to support…". In project, ZephyrPlus, they also mentioned the importance of the domain knowledge through their quote – “We had calls with the expert from Germany and they helped accelerate our design processes and guided us through”.*

Another aspect of executors was seen from the manufacturing and engineering knowledge such as in the case of SpiroWave, it was elaborated as – *“I had experience in mechanical engineering and thus contributed to the design and development aspect as well as the quality and inspection side*." In Projecto Masi, the software engineer was described as a fully competent individual – *"he worked like magic… we just need to tell him what we needed, and he would deliver, we were extremely lucky."* In other instances, such as in In the case of Ventura CPAP, the executor brought their skills and speed, which accelerated the project - *"Very fast planning and training processes, fast adaptations, focused on what is really the best, more precision and more speed".* Similarly, in the case of ZephyrPlus, the executor contributed through their expertise in the manufacturing domain - *"We asked them how they would design their production lines and used their expertise for that.”.*

***The rulekeeper***

This section defines *the rulekeeper* as the stakeholder influencing the project's outcome (Friedman and Miles, 2002; Laplume *et al.*, 2008). We extract attributes from the study Agle et al. (1999) conducted to identify the stakeholder perceptions – and focus on power and legitimacy. In our analysis, we recognize *the rulekeeper* as the governmental and regulatory body with the ability to do two things: 1) the approval of the ventilators for clinical use; 2) the demand orders determined by the governmental body. By combining these factors, we apply this definition in identifying the presence or absence of the rulekeeper role in our case studies.

Due to the complexity of the pandemic situation, there were additional organizational intricacies to overcome before the manufacturing of the ventilators. In the case of Projecto Masi they worked closely with *the rulekeeper* from the onset of the project to overcome the curfew imposed in the area *– "we had close connections with the government and this helped with permissions with the curfew period"*. In the case of SpiroWave, the collaboration with the *rulekeeper* helped in the development of the ventilators –“*We started working with the FDA probably around day seven. The city had provided security and, uh, medical staff, and took really good care of us. And most of us never went home to see anybody”.* Similarly, the presence of *the rulekeeper* actors were also identified as the stakeholder with the power to influence the outcome. This role is exemplified in the case of UKVC, where they helped in the sourcing the raw materials *– "…to source international parts, we worked very closely with the Cabinet Office to use, uh, their relationships with, um, uh, embassies overseas..”.* In another case study, SARAO, the role of the rulekeeper was in the distribution *"…but we didn't do that by our own, we handed it over to the Department of Health who are then responsible for actually delivering the devices.* Similarly, in the case of the Ventura CPAP, the rulekeeper was observed as the regulators – *“We started talking to the MHRA on day 2 or 3.”*

We explored the 11 different cases using this lens of actors. The successful cases critically differed in terms of the dynamics between these roles and the involvement of each role. In what follows, we first explain these dynamics in successful cases and then compare them with unsuccessful ones leading us to our stylized findings.

**Stylized Finding 1 - The power of the triangle – visionary, executor and rulekeeper actors to ensure a successful outcome**

Consistent with studies (e.g. Driskell *et al.*, 2017; Laplume *et al.*, 2008…) , we observe that the case studies which demonstrated a salient role interplay between the three roles identified led to a successful outcome – *visionary*, *executor* and *rulekeeper*.

The early involvement of *rulekeeper* played a pivotal role in success. For instance, in the case study Ventura CPAP, we observe that the *rulekeeper* were kept close and were constantly involved with the project team. The *rulekeeper* was engaged from the beginning by ensuring *“It was possible to work so well through the good connections of the firms and the support of the government (they also worked really fast).”* For the case study Ventura CPAP, the accelerated speed was made possible due to the iterations between the executor and the rulekeeper. Through this involvement in the initiation phase, the team was able to meet the regulatory body's requirements for the ventilator, eventually leading to the production of certified ventilators for the market.

Similarly, findings from the case study UKCV highlighted the rarity but the importance of this collaboration through the quote - "*I think it's so important and we see industry and government coming together, we broke the normal environment*". The interplay between the *rulekeeper* and *executor* could not be further stressedas it was seen as imperative.

In the context of the pandemic, due to the uncertainty in the regulatory framework, it was vital for the different actors to collaborate and iteratively communicate to achieve a successful project outcome. As described as, "*We were aiming at a moving target.* The changing requirements deemed the close collaboration necessary to ensure the speed and direction of development of the product.

In other case studies (i.e Projecto Masi, UKVC, SARAO) , the close interplay between the actors was vital for removing roadblocks that stemmed from the conditions of the pandemic. Complications such as curfew and border restrictions further added to the challenge of building the ventilator. For case study Projecto Masi, *the rulekeeper* helped remove roadblocks which arose, as explained: *"we had close connections with the government, and this helped with permissions for curfew period".* Another example was the relationship between *the visionary-executor-rulekeeper* where the network effect of this connection removed the roadblock of border restrictions.

As exemplified in the international collaboration in the case study MVM, *"Contacts we knew to help in different way*". When faced with a challenge in acquiring the required part of the manufacture, they turned to their fellow executor or visionary to tap upon the supply chain network. Once they have identified the material source, the close interaction with the rulekeeper provides input on the feasbility of the part. This is all conducted agile, which was a critical component during a disruptive open innovation project collaboration.

**Stylized Finding 2 – When does the power of triangle matter? - Two new preliminary phases for open innovation**

Through the observation of roles, we also superimpose this analysis across the various phases based on the lens of open innovation. As shown in the Table 4 below, we present provide an overview of the phases where the organizational roles presence was found. From this analysis, we infer that there are two new phases of open innovation projects, that occur before innovation funnel starts – the initiation phase, and the team formation phase.

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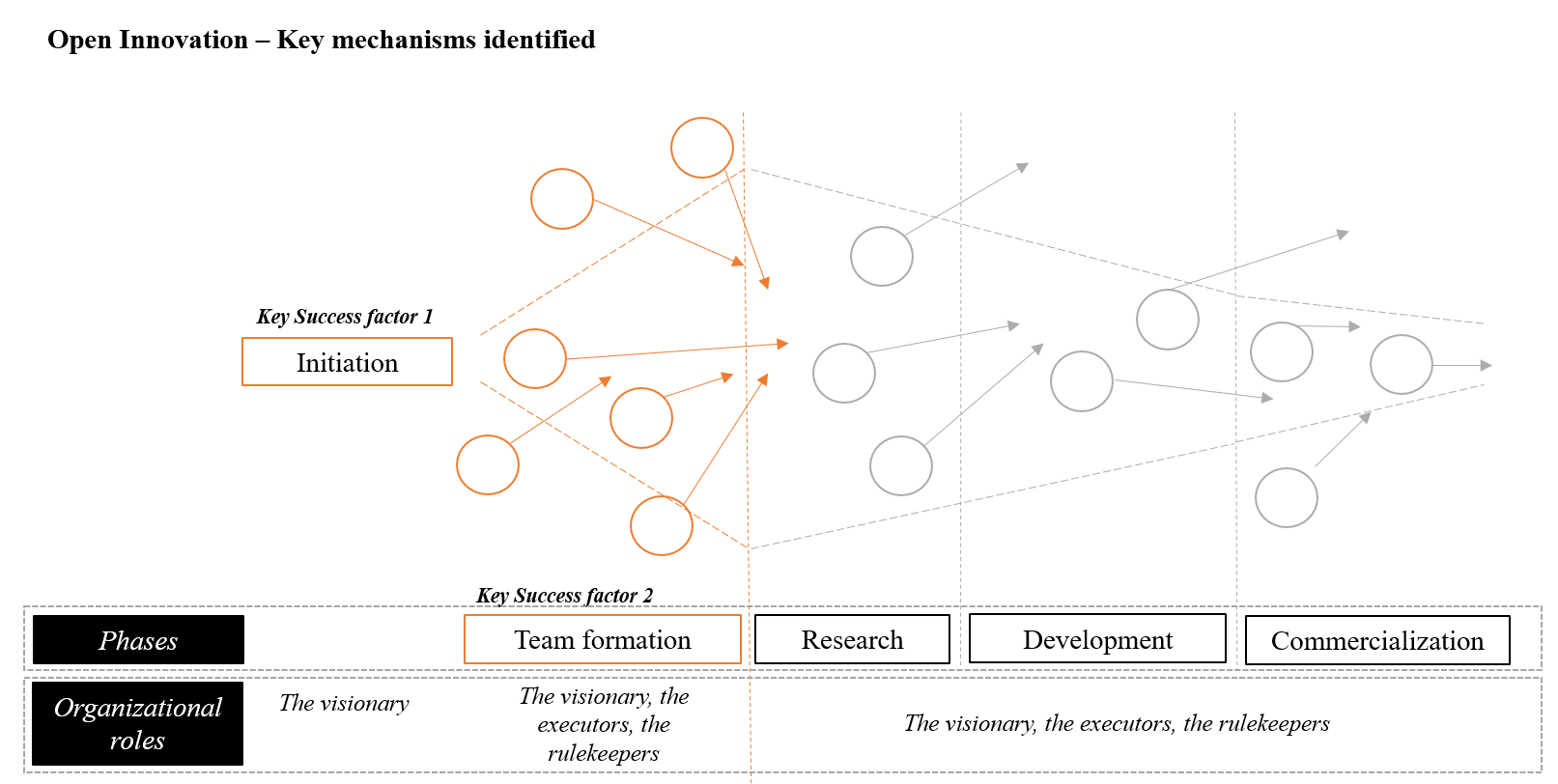
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Firstly, the *initiation phase*. Projects with successful outcomes, stemmed from this phase which is led by *the visionary*. Our findings demonstrated that in this phase, the presence of the visionary which acts as the motivator and leader to initiate the project eventually led to a successful outcome.

This *initiation phase* is then followed by a critical point, where, contrary to the traditional open innovation diagram, the funnel expands before constricting again. We label this phase the *team formation phase*. This phase is often seen as the determining point of failure or success. Case studies that did not engage in three identified stakeholders, demonstrated an unsuccessful outcome. We infer that the organizational roles involved in these early stages are critical in determining the project's success.

Additionally, team formation is a crucial decision-making point for developing ventilators (a product new to the team members). This engagement and decision-making of product and process require differentiated successful and unsuccessful outcomes. We summarize our findings in a framework in Figure 2, and in the following section we elaborate the mechanisms behind the two different phases through the saliency of the organizational roles.



**Stylized Finding 3 – When the triangle is broken: Why Open innovation of firms fail**

We noticed that for the cases ZephyrPlus, Noccarc, Breathe, TVP, and Jenton, the missing actors from the three identified stakeholders from the team forming phase resulted in an unsuccessful outcome of the project.

For instance, in the case of solely *executor*, case the product design failed to reach the market during the crisis. We attribute this loss to the absence of the essential actors – the visionary and the rulekeeper. For Breathe’s case, *the executor* possessed the know-how and continued with the development of the prototype by collaborating with other executors. However, due to the lack of involvement of *the rulekeeper*, the protype was not utilized during the pandemic, resulting in an unsucessful outcome.

On the other hand, in the case of TVP and Jenton the project was kick-started by *the visionary*, similar to our success cases. However, what differed was the involvement of the executor and *rulekeeper*. In the case of TVP, the product development was driven by the *visionary* with technical knowledge. However, despite being highly knowledgeable, they did not have prior knowledge in the field – *"we did not have the know-how despite being engineers and what I would describe as clever". They also highlighted the need for executor with high knowledge through their quote of* – "*It would have been extremely helpful if there was a zoom call for experts to share what they knew to provide the basic foundations that we would need”.*

In the case of Jenton, *the rulekeeper* were not involved due to the prioritization from the government and thus, this project received a lack of involvement from *the rulekeeper* side. This resulted in delayed product approval; hence, it did not reach the market during the pandemic. Similarly, we observe that in the case of ZephyrPlus, where all the necessary process was all the necessary processes were ready for production. Still, in the end, they could not secure the demand from the governmental end due to the lack of communication and involvement with the *rulekeeper* from an early stage.

A similar observation was seen in the case of Noccarc where every component was ready for assembly. However, despite being prepared for production, there was no demand from the government side. The delayed communication resulted in a loss of time and resources for all the stakeholders involved in the project. This surprise could have been circumvented if *the rulekeeper* had been involved in the project. Due to the lack of involvement from *the rulekeeper* side, the visionary and executor were working based on a tunnel vision, and when everything was ready to scale up, the government did not require any more devices.

**Stylized Finding 4 – When the project is not initiated right – executor role as the initiator**

In this section, we elaborate on case study Breathe, where *the executor* initiated the project. In this case, it all started as elaborated by the project initiator *– "at the beginning it was just like two people in at the beginning it was just like two people in the basement, a colleague of mine and me, um, just assembling some hardware stuff.* In this case, they gathered a team with the know-how on how to develop the product.

However, in contrast to the other cases, Breathe lacked two actors – *the visionary* and *the rulekeeper*. As elaborated, the project is being driven by executor – people who possess the know-how, which is critical but lacks an essential leadership quality to steer the project in the direction required. The project Breathe team comprised of engineers to develop a product. Through this circle, they assimilated other engineers and shared the necessary know-how to develop the prototype into a final product. Due to this open innovation assimilation of knowledge, they have also managed to attract visibility which led to funding from external parties. However, the product has not yet been successfully tested by real subjects, nor has it reached the market.

This highlights the importance of the other two actors in the open innovation projects, as described by the project member *– "it would be also very helpful if we could actually go visit hospitals to better understand the requirements".* The prototype was developed based on the theoretical understanding of the design requirements. The triangle was broken due to the lack of input from the other vital actors.Lacking vital insights from the other actors and being led solely by an executor, this project failed to obtain a successful outcome. The goals articulated by the members were to ensure the project continued in development, expressed as - *"our roles in this project is to keep momentum high…".* In contrast to teams led by *visionary*, such as in Projecto Masi, the goal was *"…to build ventilators for the people.*

**DISCUSSION**

**Contribution to theory**

Our study provides three unique contributions to the literature: (1) we combined the stakeholder theory to identify critical actors in open innovation projects; (2) we extended the open innovation framework with two new phases supporting the context of disruption; (3) we identified the two key phases in an open innovation project.

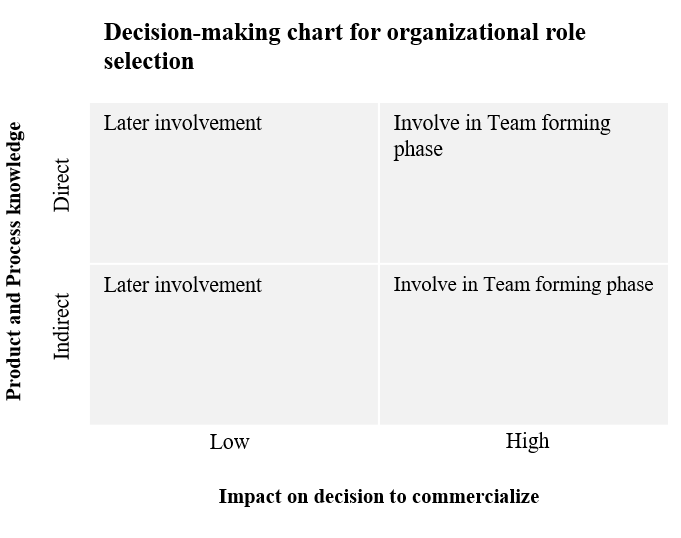
Firstly, we identified three critical stakeholders in disruptive open innovation projects. The three stakeholders identified are (1) *the visionary*; (2) *the executor*; (3) *the rulekeeper*. For each role, we defined the parts and how they impact the outcome of the project based on our empirical findings in the cases. In line with the literature on team roles, the roles are dynamic, as we observed new roles through our empirical investigation of open innovation in disruptive context (Driskell *et al.*, 2017). Additionally, our study demonstrates the need to understand the types of team roles required in the projects' development phase, which requires an accelerated response. We identify that an unsuccessful outcome would be met once the triangle is broken, where one of the three critical stakeholders was absent. Such as, in the case of the Noccarc where *the rulekeeper* were not part of the team formation phase, the ventilator project did not succeed as there was no demand at the end of the project development phase.

Secondly, this research extends the current open innovation framework by Chesbrough (2003). We propose an extended version of the existing framework with two key factors identified in the context of disruption. The first factor is the initiation phase, which is vital to be kick-started by the visionary. This phase is followed by the team forming phase, which we identify as a crucial period in determining the project's outcome.

Few studies have highlighted failures in open innovation. We highlighted 5 failed cases and highlighted the factors of failure. While Lifshitz-Assaf indicates that failure in open innovation projects at NASA was mainly due to the lack of identity change amongst individuals, we highlight the importance of critical stakeholders and their involvement in the open innovation project. In the next section, our matrix to identify stakeholder is presented are managerial use.

**Managerial implications**

Our findings have implications for managers or executives involved in collaborative open innovation projects. Since the results are from a complex and time-critical phenomenon, they can be extrapolated to help managers strategize effectively in an uncertain environment. We argue that this context is unique and valuable for extracting learnings due to the condensed nature of the setting. We propose a 2x2 framework to guide practitioners in charting their open innovation projects.

The framework shown demonstrates two important components in identifying organizational roles, impact on the decision to commercialize, and product and process knowledge. These two criteria were important in determining the success or failures of the teams in our case studies. Often, there was direct knowledge of product and process but lack the know-how commercialization.

Thus, with this matrix, we provide a more framework for future managers to better ensure the team is formed with the optimal capabilities. As hindsight is often much easier than during the time of crisis and thus, we aim to prepare better managers to thrive in the face of potentially adverse situations. Through this, we believe managers can better understand the various elements of working with cross-functional teams outside of the firms. With the rapid change of the environment and development, the context of collaborations outside the firm's boundaries is now increasingly important.

**Limitations**

Our study uses a qualitative case study approach focused solely on ventilator projects. Although it offers rich insights from empirical data, it provides one side of data analysis. In future research, a quantitative comparative study could be conducted to investigate the different configurations of the identified factors, which would result in a successful outcome. Moreover, the framework presented could be applied to case studies in another context of disruptions or grand challenges to ensure better generalizability of the framework.

**CONCLUSION**

This study recognizes the extant work conducted on roles and stakeholders but concurrently identified a gap in role forming in the context of open innovation. Our empirical study attempt to bridge this gap through the proposal of a triangle of the three actors. Additionally, we developed an extended open innovation model to explain how open innovation is conducted during disruption. This framework also highlights what we found as two critical points in determining the success of the project – the initiation phase and the team forming phase. Lastly, we proposed a 2x2 framework for managers to better identify the members within their teams with hope that we can slightly alleviate the huge burden in their decision making processes.

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