Operation Warp Speed: Schedule Compression in COVID-19 Response Projects

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Introduction

The COVID pandemic that swept the world during 2020 has had profound social and economic consequences that will have a long-term effect on economy and society (British Academy, 2021). It is by far the most serious crisis to hit the global economy since 1945, and the worst global pandemic since 1918. Extraordinary times call for extraordinary responses, and this paper will focus on radical changes to accepted practice in project organizing in response to calls from governments for solutions to the crisis. In particular, we will focus on schedule compression in order to deliver outputs to governments that could be used to mitigate the immediate impact of the pandemic on health, and, in the slightly longer term, provide a route map to the "new normal" of post-pandemic life. We will do this by taking materials collected for the development of teaching vignettes and cases (authors, 2021), expanding them, and then reviewing to identify their implications for theory in project organizing with particular attention to schedule compression.

Our approach will be in the spirit of engaged scholarship (Van de Ven, 2007) which is problem driven rather than theory driven, so we will not provide a literature review, but address directly the evidence of what has happened. A discussion section will then review these empirical reports for their implications for project organizing theory and a research agenda will be proposed in conclusion. Clearly, we have not engaged in fieldwork in order to collect our cases and vignettes. That has been impossible under current circumstances. In the spirit of schedule compression in COVID response more generally we are offering evidence from sources which are principally journalistic in order to provide a first analysis of what we believe are important changes in project organizing practice. Later, deeper research by others will doubtless revise some of our evidence and analysis, but we believe we will have contributed to project organizing research by taking important first steps in developing that research agenda.

We start by presenting two vignettes of specific COVID responses which offer insights into schedule compression through agile project organizing in two very different sectors and countries. The first is a COVID tracing app in Uruguay; the second is emergency field hospitals in England. The tech and construction sectors could not be more different in their accepted practices in project organizing, but we can see how construction learned from tech to produce remarkable results in terms of outputs. We then move on to our principal case – the remarkable global effort in vaccine development. Although the key players were national governments, the mobilization involved was truly global in terms of oversight, research and development (R&D), field trials, and manufacturing supply chains. In particular, we will see how the removal of liabilities for failure from suppliers enabled unprecedented schedule compression in vaccine development and hence a much more optimistic 2021 for the world than 2020. In discussion, we explore in detail the implications for agile approaches to project organizing, selectionism in project portfolios, project organizing at pace, and owner commercial strategies that enable schedule compression by suppliers. Suggestions for a research agenda follow.

"It was crazy": CoronavirusUY app

"It was crazy... we worked as a team, 24/7… on Friday March 13 we had nothing, and on Friday March 20 we had the app delivered." (Nicolás Jodal CEO of GeneXus, cited Financial Times 13/12/20). At the time, Uruguay had four confirmed cases of COVID, but Jodal instantly realised how an app could support the national response to the pandemic so he mobilized a

team of 150 people from 12 firms with the support from the Uruguayan government's Agency for e-Government and Information and Knowledge Society to develop the CoronavirusUY app (Financial Times, 25/12/20). All work was voluntary, free and seen as a civic duty. The app concept built on ideas from China and South Korea adapted to the needs of Uruguay. The initial aim was to connect the worried well to healthcare providers to prevent the health system being overwhelmed. Next came contact tracing; because they already had the app, Uruguay was chosen by Google and Apple as one of four countries to pilot their Exposure Notifications API.

At the start the team did not know if the project would be a success: it was formed by people who had never worked together; there was no development process; no formal communication channels across the team; and there were no written functional requirements. They embraced redundancy by using a number of teams working towards the same goal until a winning approach emerged based on "whichever was first and met quality standards". The app is credited with helping Uruguay's successful strategy of containment without recurring to mandatory lockdowns and very low infection rates (Fondo Monetario Internacional accessed 25/01/21).

"Forget all you know": Nightingale Hospitals

The Nightingale Hospital programme in response to the first wave of the COVID 19 pandemic delivered seven field hospitals to provide surge capacity for the existing National Health Service England (NHS) hospitals. They cost £220m and were delivered in less than three weeks – mainly located in exhibition centres which were closed due to the pandemic. On the owner side, the programme was initiated from the national centre rather than by NHS authorities. This allowed the establishment of much more rapid, inclusive, problem-solving orientated leadership of the programme (Herring, 2020). The NHS was supported by the military who could advise on logistics and the operation of field hospitals where the triage process is very different from the normal processes in NHS intensive care units, and learned some important leadership lessons (Bohmer et al, 2020). Once delivered, the hospitals were handed over to the appropriate Trusts in the region because NHS England does not operate hospitals itself.

Rapid mobilization was possible because the Department for Health and Social Care used its existing ProCure 22 framework agreement with Principal Supply Chain Partners (PSCP) suppliers (https://procure22.nhs.uk/ accessed 08/03/21). Authors (2010) provides more detail on the earlier ProCure 21 framework. These existing relationships allowed the establishment of a much more rapid, inclusive, problem-solving orientated leadership of the programme. NHS ProCure22 set up a central Project Management Office to coordinate efforts by all 6 PSCPs in the framework and no significant disruptions to delivery were reported.

This case vignette focuses on one of the seven, the NHS Nightingale North West hospital located in the G-Mex Centre in Manchester. G-Mex had previously been scoped out by the Army and NHS representatives and the decision made to locate there. The Instruction to Proceed was received to the PSCP on 28th March; site works started on 30th March, and the facility was completed on 12th April – a schedule of 13 days. It opened the next day. In this time, the team delivered 750 beds at an effective rate of 30 minutes per bed. This included 14500 m2 of flooring; 149 km of cabling; 3.4km of partitions; and 7.24km of medical gas pipe.

The PSCP was Integrated Health Projects (IHP)– a joint venture of Vinci and Sir Robert McAlpine with NG Bailey installing services. The design team was Building Design Partnership and Mott McDonald acted as NHS project managers. The key design decisions were bed bay layout and overall layout isolating COVID-secure and other areas. The supply chain resourced these efforts by pulling people off other projects and working 24/7 to get the job done – the workforce on site peaked at 1000. This achievement depended on innovative

project management approach – they key message for the IHP Contracts Manager was "Forget all you know about normal healthcare construction – this is about constant problem-solving" (cited Bowker, 2020:19). As the services contractor stated, "It was not unusual for us to come together as a small group, identify a challenge, and then someone would literally sketch out an answer with pen and paper. We'd then agree it and make it happen" (cited Bowker, 2020: 21).

This constant problem solving was characterized (Bowker, 2020) by:

- reverse engineering; not really design and build, but more like build and verify by design.
- live beta testing of a full-scale bed bay mock-up assembled on day 2 confirming the dimensions needed by the nursing team and partition system layout.
- change control through a process of see a problem, develop an answer, test it, build it, all captured by an auditable document trail.
- clinical liaison providing the go-between, the translator and fixer joining up the thinking of the clinical teams and the IHP team.

However, the dynamism posed challenges for the Mott Macdonald project managers:

> Yes, we needed to crack on – see a problem, develop an answer, test it, build it – but we needed a paper trail too. Timesheets, materials, and orders, all had to be auditable. That's part of our job as project managers, as well as being the interface with the client team (cited Bowker, 2020: 20).

The innovative solutions included:

- Off-site manufacture (OSM) commenced on day one for the partition system and gantry framework carrying medical gas pipe.
- Flooring contractors across the North West worked together to complete the 14,500m^2 flooring inside the first week.
- Partition installation teams with over 50 men in two shifts working 24/7.
- Six lorries made a continuous circuit collecting medical pipework from the suppliers, delivering it to the factory for OSM, taking finished sections to site, and then returning to the supplier to begin again. In the second week the teams installed up to 30 metres of medical gas pipe every 150 seconds – by day nine all the beds were connected.

In contrast to this remarkable success in delivering outputs in the form of functioning field hospitals, the Nightingale programme is also an important lesson in the differences between outputs and outcomes in project organizing. The intended outcomes of providing COVID-related health-care services were not achieved. Only the London and Manchester Nightingales treated any patients during the first wave which was peaking just as they opened, and in both cases the numbers were very low. All the hospitals were held on standby during the second wave, but in the end have not been used for their original purpose. Some have been used as "overflow" for non-COVID patients to ease bed-blocking, and they have also been used as mass vaccination centres as that programme has accelerated. They were finally closed on March 31st 2021.

The principal problem is that patients are not treated by buildings, no matter how well designed, but by medical staff. The Nightingale programme did nothing to increase the supply of appropriately trained medical staff, particularly nurses. The assumption was that the regional NHS Trusts would second staff to the Nightingales, but this would have depleted the capacity

of existing hospitals. It made more sense from a staffing perspective to reorganize existing facilities to provide the additional beds required than to second staff to the new ones. These were sometimes located at a considerable distance from the normal place of work (interview, 19/02/21).

In the latter half of 2019, there were over 43k vacancies for nurses in the NHS (NAO, 2020). There are multiple reasons for this, but it meant that the NHS went into the pandemic seriously short of health care skills which the provision of extra bed capacity could do nothing about. In order to economise on their key constraint – health care staff – NHS Trusts were able to reorganize their hospitals to provide intensive care beds within existing facilities. For instance, London quickly doubled its number of intensive care beds to 1555 while the London ExCel Nightingale was being built. This doubling was at the cost of postponing many different aspects of non-COVID care, but the Nightingale beds would have made little difference to this trade-off. Built assets can only be an output from an investment project – it takes people using them to provide healthcare and other services to turn them into outcomes that add value for economy and society.

"Operation Warp Speed": The Global Vaccine Development Effort

Social lockdowns save lives but are unsustainable for anything above the shortest time period. Obtaining "herd immunity" naturally was deemed too deadly by all governments and so the only alternative was to develop a vaccine. The typical time taken to develop a vaccine is measured in years rather than months, so how has it been achieved at "warp speed" – or more precisely, in 326 days from the publication of the genetic sequence by the Chinese authorities on 11th January 2020 to the UK licensure of the Pfizer/BioNTech vaccine on 2nd December (www.cepi.net accessed 26/02/21)? The key is that project owners (in the form of governments responsible for national healthcare systems) have removed the liabilities for development project failure from suppliers (in the form of pharmaceutical companies large and small) by both pre-purchasing vaccines and funding research and development projects directly.

Generically, the lifecycle for pharmaceutical development projects follows the typical new product development lifecycle characterized by strong portfolio management and effective stage gates. The basic business model is that the suppliers of pharmaceuticals identify drug candidates – often by working in collaboration with universities – and then invest in their development. Once licensed the drug is then offered for sale to health care systems. Drug development projects face particular challenges because a candidate drug may fail at any gate for reasons beyond the control of the project team because, simply put, it does not work (Pisano, 1997). Vaccine development projects face even greater difficulties than most pharmaceutical development projects because 1) safety concerns are enhanced because they are injected into otherwise healthy people; 2) they need to be manufactured at a scale of billions of doses; and 3) the virus may naturally exhaust itself before the vaccine is ready which happened with earlier coronavirus epidemics. In vaccine development, "the greatest hurdle is translating basic science advances into real vaccines that can be produced in adherence to stringent regulatory requirements on a sufficient scale to have a meaningful public health impact" (Buckland, 2005): 516). This typically costs millions and takes years (Gouglas, Le, Henderson, Kaloudis, Danielsen, Hammersland et al., 2018), and only about 1 in 10 candidates make it from pre-clinical trials to licensure in 10 years (Pronker, Weenen, Commandeur, Claassen, & Osterhaus, 2013). The threats facing vaccine development projects are existential and the potential liabilities generated by those threats for pharmaceutical companies enormous.

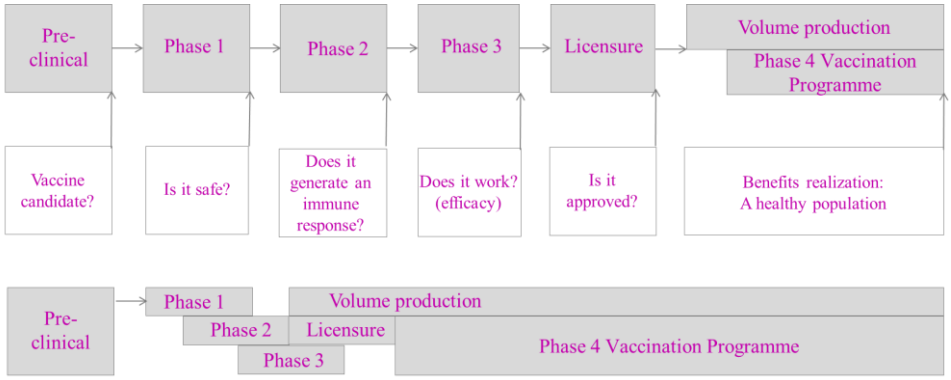

Figure 1 Schedule Acceleration in Vaccine Development
Source: authors, 2021: figure 9.7

In response to these threats, vaccine development projects by pharmaceutical companies traditionally move cautiously through tightly managed stage gates as shown in the upper half of figure 1 (Gouglas et al, 2018; (Lurie, Saville, Hatchett, & Halton, 2020). During the pre-clinical phase, candidate vaccines are identified for their potential to protect against the virus of concern drawing on prior scientific research and clinical experience, a process which may include animal testing for safety reasons. The candidate then enters Phase 1 which typically involves 25-30 closely monitored volunteers and principally assesses the safety of the vaccine candidate. Phase 2 follows with hundreds of volunteers, including a control group, to assess whether the candidate stimulates an immune response.

Phase 3 involves thousands of volunteers across multiple countries, half of whom are in a control group who receive a placebo, to see whether the candidate works in practice for different population groups. Phase 3 is a significant investment in its own right which needs to be supported by an initial investment in manufacturing facilities. The length of Phase 3 is indeterminate because it relies upon volunteers becoming infected "naturally" to test the efficacy of the candidate. Phases 2 and 3 are "blind" in that the investigators and participants do not know who has received the placebo. Once the data are in from Phase 3 trials they can be submitted to national regulatory authorities for licensure. Scale-up for volume manufacturing follows. Each of these phases is subject to oversight by external independent monitors to ensure rigor in the evaluation methods – this body is called the Data Safety Monitoring Board in the US. Finally, Phase 4 is monitoring the continued safety and effectiveness of the vaccine during inoculation programmes delivered by health care systems (Kim et al., 2021). Where the virus generates significant variants, development becomes an annual cycle as is the case with flu vaccines, but without the requirement for extensive trials.

This schedule can often take years because gate reviews need all the data from the preceding phase. Schedule compression in vaccine development essentially involves taking decisions at gates on incomplete information thereby generating the threat of wasted investment if the candidate fails during later phases. Innovations in scientific research had already compressed

the pre-clinical phase by "structure-based antigen design, computational biology, protein engineering, and gene synthesis [which] have provided the tools to now make vaccines with speed and precision" (Graham, 2020: 1). For instance, the Oxford/Astra Zeneca vaccine candidate was "designed" drawing on years of scientific research by the Jenner Institute on earlier SARS viruses over a weekend in January 2020 as soon as the genetic sequence had been received (Panorama, 2020). However, the trial phases are not so easily compressed. Instead, they must be overlapped as shown in the lower half of figure 1 (Hanney, Wooding, Sussex, & Grant, 2020); Lurie, 2020). This overlapping – or concurrency in project organizing terms – is a major threat to the successful delivery of the project (Morris, 1994). How, therefore, was this achieved successfully for so many vaccine candidates for the severe acute respiratory syndrome coronavirus (SARS-CoV2) which causes COVID-19 disease?

Supplier	Development	Manufacturing and Delivery	Pre-order doses (sub-set of manufacturing & delivery support)
Johnson & Johnson	$456m	$1bn	100m
Moderna	$955m	$1.5bn	100m
Oxford/ Astra Zeneca		$1.2bn	300m
Novavax		$1.6bn	100m
Pfizer/BioNTech			100m
Sanofi/GSK		$2bn	100m

Table 1 Operation Warp Speed Support to Vaccine Suppliers (source Financial Times 26/11/20)

Operation Warp Speed was the US $10bn public-private partnership launched in May 2020 principally to develop COVID vaccines. It provided finance to suppliers as shown in Table 1. Other western countries also provided support to these same suppliers, as did not-for-profit organizations such as the Coalition for Epidemic Preparedness Innovations (CEPI) which is funded by the likes of the Wellcome Trust and the Gates Foundation, as well as some western governments. As implied in Table 1, governments took a portfolio approach to the projects they financed. Western governments typically pre-purchased ~5 different vaccines because they could not know 1) which would survive clinical trials; 2) when they would be approved; 3) how well they would work; 4) how well manufacturing facilities would scale up. As of 1st December 2020, six western countries (counting the EU as one) had ordered four or more doses per capita for a two-dose regime (Financial Times 16/12/20). The remarkable success of the various development projects (only Sanofi/GSK from Table 1 hit major challenges during Phase 2) means that many western health care systems have a potential surplus of vaccines and are starting to make commitments to donating surplus vaccines to COVAX, the international alliance committed to distributing vaccines to developing countries.

The UK took an explicit portfolio approach to vaccine development funding. The UK Vaccines Task Force was established in April 2020 led by a seconded venture capitalist with the authority to "co-ordinate the end-to-end process of vaccine development, from discovery through clinical trials to distribution, including both domestic and international sourcing and licensing" (cited Financial Times 19/03/21), As a result, by mid-February 2021, the UK had ordered a portfolio

of over 400m doses of vaccine from seven different suppliers, with the largest orders going to suppliers which committed to establish manufacturing facilities in the UK (Astra Zeneca, Valneva, CureVac and Novavax) each with a different vaccine technology (Financial Times, 10/02/21).

In China, the government used two existing national-level research programmes – the National Key R&D Programmes funded by the Ministry of Science and Technology and the special research programmes funded by the National Natural Science Foundation of China (NSFC) – to fund a series of research and development projects across five different vaccine technologies from January 2020 onwards. The principal suppliers are Sinopharm and Sinovac working closely with universities (Murphy, 02/12/20). By March 17th 2021, 15 projects had entered into the clinical development stage, among which 5 have entered Phase 3 of clinical trials. To effectively facilitate and coordinate the R&D processes of these projects, in January 2020 the Chinese government established a vaccine development coordination group in the Joint Prevention and Control Mechanism of the State Council composed of 13 ministries including the National Health Commission, the Ministry of Science and Technology and the National Medical Products Administration. This powerful administrative mechanism helped to coordinate more efficiently related resources and facilitated regulatory oversight and approval of these development projects.

One study (Zhang et al., 2021) reports on results of the Phase 2 and 3 trials in China, the interpreted results indicate that the vaccine was "suitable for emergency use". CoronaVac underwent Phase 3 trials in a number of countries including: Turkey, Indonesia, Brazil, Chile and Peru. The results indicate 50% efficacy at preventing disease. Sinovac has been approved and used in high risk groups in China since July 2020 (BBC, 14/01/21). On 30th December 2020 Sinopharm announced that the Phase 3 trials showed 79% effectiveness. Singapore, Malaysia, Philippines, Brazil, Peru, Colombia and Chile have signed deals with Sinovac and Indonesia began its vaccination programme in January 2021 (BBC, 14/01/21). Several nations including the UAE, Bahrain, Pakistan, Egypt, Serbia and Hungary had approved the Sinopharm vaccine by March 10th 2021 (Financial Times, 10/03/21).

Commented [GW1]: Which one?

On August 11th 2020, Russia announced the launch of Sputnik V, adenovirus-based vaccine candidate against COVID-19. The Russian state funded the Gamaleya Research Institute of Epidemiology and Microbiology, Moscow to develop the Sputnik V vaccine (Balakrishnan, 2020; Burki, 2020). Sputnik V is named after the Soviet-era space programme. It has been approved for use in Hungary and is establishing a manufacturing operation in Italy funded by the Russian Direct Investment Fund, the country's sovereign wealth fund (Financial Times, 10/03/21). Neither the Russian nor Chinese governments appear to have used the pre-order strategy for supporting vaccine development projects. Russia has received international requests for 1 billion doses of its Sputnik V vaccine. Russian news agency TASS reported that the country would supply more than 2 million doses of Sputnik V to Kazakhstan. The Russian Government has approved two other Russian developed vaccines: EpiVacCorona, produced by Vektor Institute in Novosibirsk, and CoviVac, from the Chumakov Centre in St Petersburg. EpiVacCorona uses no live virus and relies on synthetic peptide antigens, based on a selection of those found within SARS-Cov-2. CoviVac uses an inactivated cold virus in the "whole virion" technology, similar to the vaccine candidate developed by the Chinese company Sinovac and the Indian company Bharat Biotech. Scientists in Russia are working on versions of the initial Sputnik V vaccine: one that needs to be stored at freezer temperature, one that can be stored in a range of standard refrigerators and a single dose alternative (Sputnik V light) (Baraniuk, 2021). Peru, Argentina, Bolivia and Panama have also contracted with Sputnik V (Horwitz & Carin, 2021).

One remarkable unintended consequence of this massive public subsidy to vaccine suppliers is a complete reconfiguration of the structure of supply for vaccines. Prior to 2020, the four main global players were GSK, Merck, Sanofi and Pfizer; currently only Pfizer has a viable product. These incumbents are "amazingly large businesses with apparently high barriers to entry. It's very, very expensive to build one of these vaccine facilities," (cited Financial Times 16/02/20) and were perceived as risk averse, preferring to rely on their established approaches. Merck has dropped out completely; GSK and Sanofi are partnering with biotech companies comparable to BioNTech but are off the pace. Astra Zeneca was not a player in the vaccines market until it won the right to develop Oxford's vaccine thanks to its commitment to provide at cost to developing countries through COVAX; it is now the largest global supplier of COVID vaccines. This lack of experience may be behind some of the well-publicized challenges that Astra Zeneca has faced with regulators and contract manufacturers (Financial Times, 26/03/21). Gamaleya has also become a significant player in global markets, although Sinopharm is struggling to make an impact (Financial Times, 09/03/21).

A further schedule compressing innovation is the development of "rolling" regulatory approval (Hanney et al, 2020). Normally, national regulators wait until Phases 1 to 3 are complete before starting their evaluation prior to licensure. The rolling approach involves the regulator in engaging with the data as it is being released by the trial phases, and this, too, has compressed the development process. The output of the development process is a safe vaccine with a known efficacy at preventing infection such as 91.6% for Gamaleya Sputnik V (Logunov, Dolzhikova, Zubkova, Tukhvatullin, Shcheblyakov, Dzharullaeva et al., 2020). Following licensure, manufacturing facilities can be ramped up and vaccine doses delivered to healthcare systems so that benefits realization can begin and the output of a safe and effective vaccine can be transformed into the outcome of pandemic suppression.

Clearly, there are advantages in being a larger country in this effort, but some smaller countries have also been able to engage with the development process through participating in Phase 3 trials. For instance, suppliers from countries such as China which had successfully suppressed the virus through lockdowns were obliged to test their vaccines candidates in other countries which had been less successful. In June 2020, Sinopharm signed an agreement with the United Arab Emirates (UAE) to implement Phase 3 clinical trials under the supervision of its Ministry of Health and Prevention (MOHAP). In September 2020, the UAE authorised the emergency use of the Sinopharm vaccine for frontline workers, which made the UAE the first nation worldwide to authorise the emergency use of COVID-19 vaccines developed by a Chinese supplier and it announced on December 9th, 2020, that it had licensed the Sinopharm vaccine – the first nation worldwide to license a Chinese vaccine, including China itself. In January 2021, an agreement to manufacture the vaccine in UAE was announced. Similarly, Israel was able to secure early supplies of the Pfizer/BioNTec vaccine by agreeing to share fully the data collected by their healthcare systems during Phase 4 (Financial Times 26/01/21).

For the western-based vaccine suppliers which remain dominant in global markets, there is a very clear lesson in how schedule compression was achieved. Quite simply, owners in the shape of national governments responsible for their health care systems removed the liabilities for failure at stage gates but providing massive development support direct to suppliers and pre-purchasing programmes thereby removing the liabilities in the form of wasted investment for the failure of vaccine candidates during trials. This then unleashed a wave of process innovation (Pisano, 1997) including the introduction of rolling licensure. In combination, these innovations meant that large stockpile of vaccines were available as soon as licensure was achieved to enter benefits realization in Phase 4. There have been many moments of crisis in the global vaccine development programme, and there will continue to be so, but overall the programme has been one of considerable success based on international collaboration in the

face of a common threat. In the UK, at least, the crucial decisions taken in April 2020 were consciously seen as a £13.5bn gamble in which the UK decided to "pay high, pay early and ensure that it works…… [but] imagine if it hadn't come off and we had spent all that taxpayers' money" (cited Kuenssberg, 2021).

Discussion

A first theme arising from these vignettes and cases is agility. The last 20 years has seen the rise of "agile" strategies for project delivery, the most popular of which is Scrum (Serrador & Pinto, 2015). However, agile is more than just a project methodology, it is a project delivery narrative (authors 2021b) supported by a "manifesto" and proselytizers who are true believers in the new method and its innate superiority over waterfall delivery strategies – it is one type of project DNA. Agile project delivery works very well for small, stand-alone projects that deliver direct to users who can readily transform the agile outputs into usable outcomes but once agile teams are included within multi-team delivery organizations then problems start (Dikert, Paasivaara, & Lassenius, 2016; Hobbs & Petit, 2017). While timeboxing has many advantages, this is only made possible by flexing scope rather than schedule. Where the scope is delivered to the final user (such as the CoronavirusUY app on a mobile phone), then few problems arise, but once another project team is the "user" of the outputs from the sprints then problems arise if that output does not allow the second team to do its work as planned. The relative autonomy of Scrum teams, while having important incentive properties, also poses challenges if they choose to work on aspects of scope that are not priorities at the level of the project as a whole.

These considerations encourage hybrid approaches (Bianchi, Marzi, & Guerini, 2020) in which agile methods form part of the delivery strategy within an overall linear project life-cycle. The Nightingale case offers some indications of how this might be done. There is no question of flexing scope in a health care facility. Unless everything works to the required standards of care, nothing does – work packages are highly integrated and cannot be time-boxed. The solution was "extreme teaming" (Edmondson and Harvey, 2017) in which project organizing is fundamentally a problem-solving discipline (authors, 2021), not an administrative discipline relying on standardized methodologies. For vaccine development, there is no question of flexing scope for schedule – any vaccine candidate must achieve the highest standards of safety and efficacy against internationally recognized protocols before it can move into Phase 4 benefits realization. One of the reasons for the weaker performance of successful Chinese vaccines in the international markets is the lack of perceived transparency in their adherence to these protocols (Financial Times, 24/03/21). Vaccine development needs to use schedule compression while retaining the waterfall approach.

The CoronavirusUY vignette, while adhering to broadly agile principles, does reveal some interesting aspects. In essence, Jodal ran a "hackathon" which is form of crowdsourcing-based open innovation for software development. However, the unusual aspects were incentivization through "civic duty" rather than the cash prizes which were used in European COVID hackathons (Bertello et al, 2021), and the rapid adoption and benefits realization by the Uruguayan government. Hackathons are a particular 21st century example of a much older framework for the management of innovation projects with a history extending at least back to the cash prize for solving the problem of measuring longitude in the 18th century (Sobel, 1996). That prize was funded by the UK government, but more recent initiatives have tended to be privately funded (Eggers & O'Leary, 2009). One example is X PRIZE (www.xprize.org) which is credited with initiating the private sector space flight industry. Further research would be warranted on how the project outputs from hackathons and other forms of open innovation can be transformed into successful outcomes.

A second theme on project decision-making under high levels of uncertainty. Traditional approaches to project organizing rely upon "instructionism" in decision-making (Pich et al, 2002) involving detail project planning and extensive use of risk management techniques supported by contingencies to absorb the liabilities for possible threat events. More recent approaches (Morris, 1994; authors, 2010) stress the importance of learning in the project lifecycle managed through repeated cycles of decision-making structured by stage gates as shown in the upper level of figure 1. However, such learning is time-consuming and always faces the threat of unk-unks derailing the project completely. Under very high levels of uncertainty – and we would add severe schedule compression – neither of these approaches is adequate and "selectionism" is preferred defined as "several project teams pursuing different solutions for the same problem and retaining the one with the best outcome" (Pich, Loch, & Meyer, 2002): 1020). Selectionism is clearly at work in the hackathon approach to app development, and also the schedule compressed approach to vaccine development in the lower level of figure 1. However, the vaccine case differs from selectionism in traditional project portfolio management (Pich et al, 2002; (Wheelwright & Clark, 1992) because the portfolio is held by the owner (i.e. governments responsible for health care systems) and not the suppliers of vaccines each of which is working on only one or vaccine two candidates.

A third theme is that while project typologies (Dvir, 2007; Shenhar & Dvir, 2007); figure 1.2; authors 2021 figure 2.6) often identify *pace* as a project organizing contingency factor, there has been remarkably little research on this dimension. Wearne and White-Hunt (2014) provide case studies of emergency projects principally to restore failed infrastructure. In such cases, the project mission is clear – reinstate infrastructure services to their previous levels – but how to do it is not, and the project team is unformed. In disaster projects which overwhelm the local capacity to respond, multi-national teams are rapidly formed which requires the development of "swift trust" within and across the participating project teams (McLaren & Loosemore, 2019). Although vaccine development and the Nightingale hospitals were delivered by existing teams working in new ways, the CornonavirusUY app mobilized people who had not worked together before. More research is required on how project pace as a contingency variable shapes project organizing.

Our final theme identifies the importance of owner commercial strategies (authors, 2021) in enabling schedule compression in project organizing. Research on inter-organizational relations (IORs) has developed rapidly over recent years (Lumineau & Oliveira, 2018; Oliveira & Lumineau, 2019; Roehrich, Selviaridis, Kalra, Van der Valk, & Fang, 2019). IORs can be defined as "strategically important cooperative relationships between a focal organization and one or more other organizations to share or exchange resources with the goal of improved performance" (Parmigiani & Rivera-Santos, 2011): 1109), and concern here is the "vertical" IOR between buyers and suppliers on complex projects. We conceptualize this relationship as the *commercial interface* (authors 2014) between the owner organization which develops the business case for a complex project and the suppliers which provide the human and technological resources required by the owner to achieve the outcomes desired in that business case.

If we leave aside CoronavirusUY app development because the project was, in effect, decommercialized by casting participation as a "civic duty" we can see that for both the Nightingale Hospitals and vaccine development, the owner removed all liabilities for to deliver an output from the suppliers by using reimbursable contracts in which all the costs incurred by suppliers are reimbursed by owners. So, the North West Nightingale project manager's chief task was tracking all the costs incurred by the delivery team working at breakneck speed and reporting them to the NHS for reimbursement to the members of IHP. Fortunately, this was in the context of the collaborative relationships across the commercial interface already

established within the ProCure22 framework. There was, therefore, relatively low threat of the project not delivering the required output ready for health care because the output standards to be achieved were clear, and all the resources required – human and technological required were available if only by diverting them from lower priority projects for the same owner.

The case of vaccine development was rather more radical. Owners took on all the risks liabilities for vaccine candidate failure that would normally have been borne by suppliers through both development support and pre-purchase agreements costing billions. This enabled development projects to move from instructionism carefully organized to manage the threat of candidate failure during trials to selectionism in which competing candidates raced to reach the project completion point of licensure. The result was a complete upheaval in the structure of supply in the sector with suppliers that had never made a profit before (Novavax and Moderna) hitting the jackpot with innovative mRNA technologies (as did Pfizer/BioNTech) and entrepreneurial upstarts (Astra Zeneca) entering the market while established players (Merck, Sanofi, GSK) were apparently trapped by their established ways of doing things. Russian suppliers (Gamaleya) have also successfully entered international markets, and Chinese suppliers will likely follow. IORs have received little attention in project organizing research (von Danwitz, 2018), yet they are clearly central to how projects are organized. Much more research is required on this aspect of project organizing.

Research Agenda

In our discussion of the cases and vignettes, we have identified four themes which we believe warrant much greater attention in project organizing research. These are:

- Agile project organizing as a project delivery strategy outside those areas which can flex the output to hold budget and schedule steady and the role of hackathons;
- Selectionism as a project shaping strategy;
- Pace as a project organizing contingency;
- Relationships across the commercial interface how they enable (or not) schedule compression and other innovations in project organizing.

In our analysis, there is also a broader set of research questions raised by our research into the response-by-projects to the COVID-19 pandemic. Across all sectors of response, project organizing has been central – for identification of therapeutics drugs for COVID 10 treatment; the development of mass-scale test and trace systems for infection control; the design and implementation of economic support schemes for individuals and businesses; procurement and distribution of personal protective equipment (PPE) to hospitals and care homes; and – perhaps most crucially – the shaping and delivery of mass inoculation schemes to realize the benefits of the vaccine development projects. Performance on these has, to say the least, been variable around the world with no clear patterns. International comparative analysis of these projects would reveal enormous insights into project organizing in its institutional context (Geraldi & Morris, 2011).

Overall, we can identify a "projectification" (Lundin, Arvidsson, Brady, Ekstedt, Midler, & Sydow, 2015) of COVID-19 response which is likely to have much wider ramifications across economy and society. Research on projectification to date has been largely descriptive, analysing the implications of the projectification of society since the mid-1960s as an autonomous process of development. More recent changes have changed is descriptive perspective to a normative on in which we should change to a "mission economy" to address the "grand challenges" we face (Mazzucato, 2021). It has already been suggested that the UK strategy for vaccine development is a successful example of this new approach (Balawejder,

Sampson, & Stratton, 2021). This is an important debate for the all those researchers working on projects as a field of study.

Conclusions

In this paper we have provided an initial analysis of project responses to the COVID-19 pandemic by developing two vignettes and one case study from secondary, but authoritative, sources. We worked in the spirit of engaged scholarship driven by the problem rather than the theory, but in doing so we have identified four distinct themes for empirical research into schedule compression for pandemic response – agile, selectionism, pace and the commercial interface – which we believe have more general implications for project organizing research. We have also identified an important theoretical development to which analysis of COVID response will likely make a significant contribution – the mission orientated economy. This paper is just a start in what we hope will be a growing research agenda with multiple contributions from across the field.

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