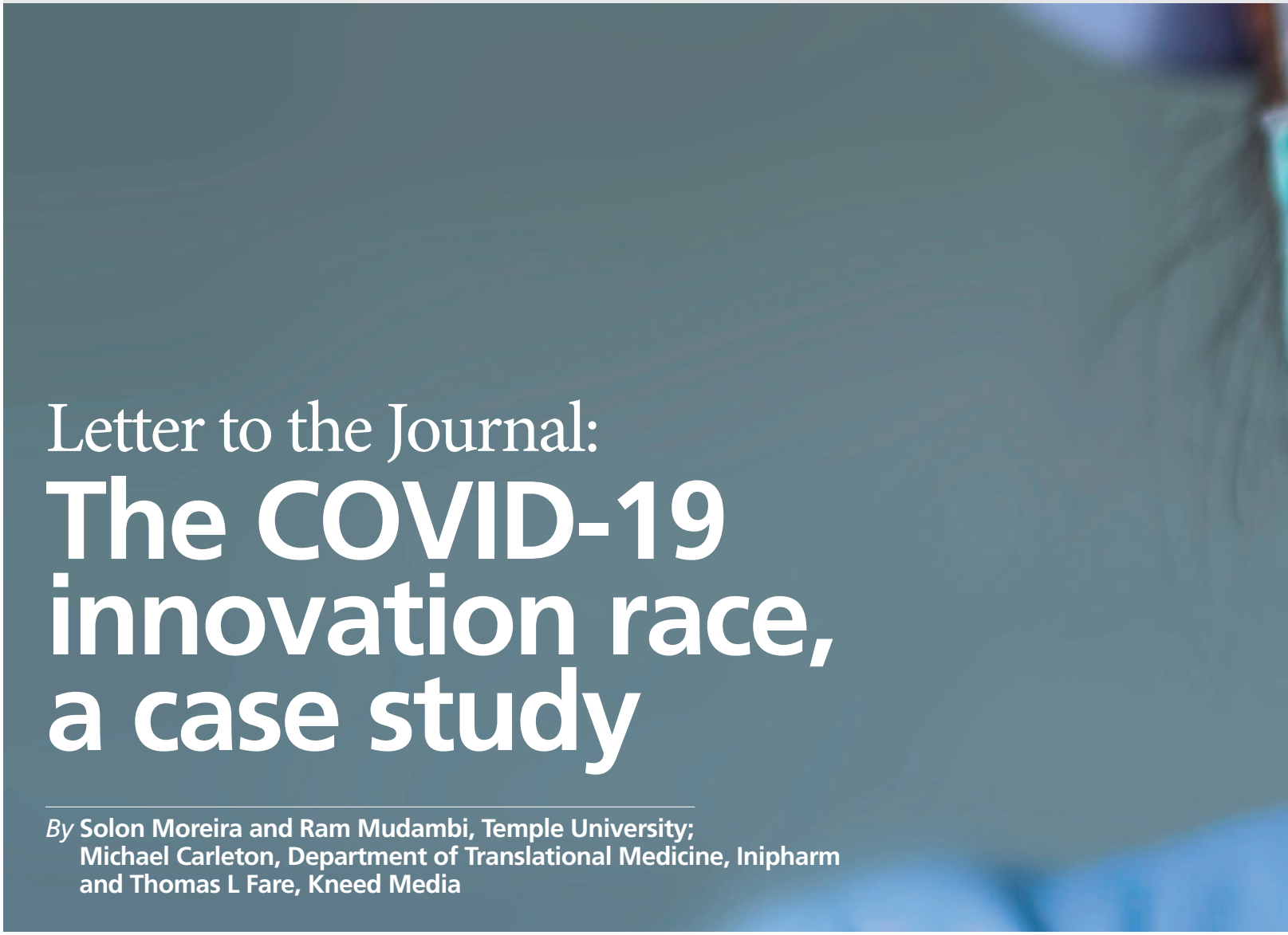

Letter to the Journal: The COVID-19 innovation race, a case study

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WITH THE widespread recognition of the severity of the COVID-19 pandemic in early 2020, the biopharmaceutical industry found itself on the frontline of a global crisis. Due to the nature of the SARS-Cov 2 virus, healthcare officials quickly realized that vaccines to protect against the virus would need to be rolled out literally in billions of doses. Political and healthcare officials determined that a host of measures were needed to halt and eradicate the growing reservoir of the virus in the world-wide population. Publicly financed investments were consequently made in therapies (e.g., antibody treatments) and vaccines that would enable a return to a sense of pre-pandemic normalcy following the current disruption of virtually all national and international activities. Clearly, successful vaccines would become instant blockbuster drugs with potential for year-over-year returns (assuming annual booster shots should be recommended).

In a recent article, we outlined the nature of blockbuster innovation in the biopharmaceutical industry. In our analysis, we observed that, in common with many other mature industries,

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the biopharmaceutical industry is composed of a "core of dominant firms (that we are calling Majors) [that] co-exist symbiotically with a large number of smaller firms … often referred to as the 'competitive fringe'" (Mudambi *et al.*, 2020).[1] We will refer to the "competitive fringe" here as Small Innovators. Further, and more importantly, we documented that the majority of blockbuster drugs over the decades since 1980 had their origins in mergers and acquisitions and licensing deals between pharma Majors and Small Innovator firms. In other words, there is a 'division of labor' and financial resources in the world of biopharmaceutical innovation. Small Innovators largely undertake the early-stage invention activities involved in translating basic research from universities (often sponsored by government or foundations) and other public entities into practical commercial propositions. Often Small Innovators are spinouts of the work at universities or institutes, with researchers from these organizations as part of the start-up teams. The pharma Majors search in this Small Innovator population for commercially viable propositions, select the most promising, and

invest the enormous financial resources required to take them through clinical trials and approval for the final market.

The outcomes of the most recent innovation race to develop vaccines for COVID-19, undertaken on a global war footing, conform to the predictions of our model to a remarkable extent. As of early January 2021, three vaccines have been approved for use through emergency-use approved protocols. Two of these have been emergency-use approved or purchased in volume for use in the U.S, while three have been emergency-use approved or purchased for use in the U.K. (see **Table 1**).

In addition to these three emergency-use approved vaccines, numerous competitors

Table 1: Approved COVID-19 vaccines as of Dec 2020

	Pfizer/BioNTech	AstraZeneca/Jenner Institute (Oxford U)	Moderna
How it works	mRNA	Inactivated cold virus	mRNA
Percentage efficacy in clinical trials	95%	62 – 90%	94.1%
Emergency-use Approvals	US, UK	UK	US, UK
Production plans	50 million doses starting Dec 18, 2020; 1.3 billion in 2021 in US	20 million doses starting Dec 21, 2020; 80 million in 2021 in UK	3 billion planned for 2021 in US
Doses ordered (as of Dec 2020)	0.92 billion	2.72 billion	0.49 billion

Sources: (i) Three COVID vaccines compared, WebMD, Dec 28, 2020. Retrieved Jan 2, 2021. https://www.webmd.com/vaccines/covid-19-vaccine/news/20201214/closer-look-at-three-covid-19-vaccines; (ii) Nuki, P. 2020. Head to head: the Oxford and Pfizer coronavirus vaccines compared. *The Telegraph,* Dec 31. Retrieved Jan 2, 2021. https://www.telegraph.co.uk/global-health/science-and-disease/head-head-oxford-pfizer-coronavirus-vaccines-compared/; (iii) Duke Global Health Innovation Center, Weekly Vaccine Research Update, Dec 18, 2020. Retrieved Jan 3, 2021. https://launchandscalefaster.org/COVID-19.

remain in the field. These include several in Phase 3 trials (e.g., Johnson & Johnson, Novavax (Maryland), CanSino Biologics (China), Bharat Biotech (India)) as well as other candidates in Phase 2/3 (e.g., GSK/Medicago/Dynavax, Inovio Pharma/U of Pennsylvania/Center for Pharma Research Kansas City MO). While these candidates may eventually play a significant role as niche contributors, they will face competitive barriers of the installed base to distribute, store, and administer their respective candidates in follow-on vaccination campaigns.

Both the Pfizer/BioNTech and AstraZeneca/Oxford U vaccines arose with original research undertaken in smaller establishments with relatively less bureaucracy and flatter organizational structures. The pharma Majors (Pfizer and AstraZeneca respectively) provided the deep-pocketed funding necessary for the very expensive process of development and commercialization, including the stiff requirements of clinical trials. The emergency nature of the development process under a severe time crunch made the availability of vast financial resources even more important.

"The Moderna vaccine represents a special case, particular to the current emergency."

The Moderna vaccine represents a special case, particular to the current emergency. The research underlying this vaccine was undertaken at the National Institutes of Health (NIH), and Moderna developed the vaccine with $483 million provided in April 2020 by the Warp Speed program of the U.S. government. We argue that the U.S. government and its agencies are unlikely to have a partnered with and funded a smaller firm like Moderna except in such extraordinary times. One could make the case that the U.S. government took on the role of a Major under these extenuating circumstances.

As for the other candidate vaccines in the pipeline, the active organizations include a mix of pharma Majors (Johnson & Johnson, GSK), smaller specialized firms (Inovio, Novavax), university research entities like the one at the University of Pennsylvania, and organizations in emerging economies backed by their national research establishments (CanSino Biologics in China, Bharat Biotech in India). Our model predicts that over time, partnerships of various kinds will arise among these active organizations, and that these will most likely be partnerships of a pharma Major allied small research-intensive entity.

Of final note, pharma companies (Majors and Small Innovators) will reap income from direct funds for manufacture and distribution of vaccines. Otherwise, according to the posting on the Center for Disease Control and Prevention's "Frequently Asked Questions" web page:

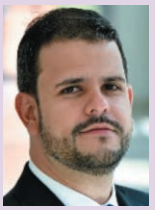
> *Vaccine doses purchased with U.S. taxpayer dollars will be given to the American people at no cost. However, vaccination providers will be able to charge an administration fee for giving the shot to someone. Vaccine providers can get this fee reimbursed by the patient's public or private insurance company or, for uninsured patients, by the Health Resources and Services Administration's Provider Relief Fund.*

In any case, the vaccines in this space can be rightly classified as blockbusters, especially with the potential to realize ongoing revenue from annual booster shots or vaccines that cover variants that arise in the populations, similar to the annual flu vaccine campaigns.

Thanks to investments by governments, companies, and investors, political and healthcare officials now have options to vaccinate the willing and able and treat those who cannot (or will not) be vaccinated. While restrictions are likely to remain in place for some time, we indeed start the new year with good news for all. JoPM

Reference

1. Ram Mudambi, Solon Moreira, Michael Carleton and Thomas Fare; Majors, Organizational Legitimacy and Rents from Blockbuster Innovation in the Biopharma Industry, *The Journal of Precision Medicine*, September 2020 [https://www.thejournalofprecisionmedicine.com/majors-organizational-legitimacy-and-rents-from-blockbuster-innovation-in-the-biopharma-industry/]



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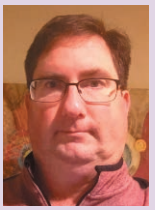
Solon is an assistant professor of strategy and entrepreneurship at Fox School of Business, Temple University. He received his PhD from Copenhagen Business School. Using the Biopharmaceutical industry as an empirical context, his research examines the link between innovation and firm performance. He is particularly interested in understanding how firms can tap into external sources of knowledge to adjust to a changing technological landscape.



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Michael is currently Vice President of Translational Medicine at Inipharm Inc. He obtained his B.A. and Ph.D. in microbiology from the University of Texas at Austin and was a Cancer Research Institute Postdoctoral Fellow and Young Arthritis Investigator at Fox Chase Cancer Center. Subsequent to his postdoctoral research, Michael served in a variety of R&D roles in biotech (Rosetta Inpharmatics, Matrix Genetics, Presage Biosciences, Mavupharma) and pharma (Merck and Bristol-Myers Squibb). Michael's research interests have spanned the entire oncology translational medicine spectrum from preclinical target validation and biomarker ID to Phase II/III clinical development. He has published over 30 peer reviewed research papers within a diverse set of scientific disciplines including oncology, immunology, genomics, virology and bacteriology. Michael is an inventor on over 10 patents, he has served as a reviewer for numerous journals and as a reviewer for the NCI special emphasis study section: SBIR Phase II Bridge Awards to Accelerate the Development of New Cancer Therapies, Biomarkers and Cancer Imaging Technologies Toward Commercialization. Most recently, Michael served as the Bristol-Myers Squibb representative on the joint steering committee for FNIH Partnership for Accelerating Cancer Therapies (PACT).

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