# A Shot in the Arm: The Effect of COVID-19 Vaccine News on Financial and Commodity Markets

## *Online Appendix*[*]

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This Draft: April 12, 2023

*Keywords*: COVID-19 vaccine; stock market; interest rates; commodities

*JEL classification*: F31; G12; G14; G15; I10; Q41

[*]We thank the editors, two anonymous referees, Aaron Burt, Adrian Fernandez-Perez, Andrea Heuson, Raquel López, Yueliang Lu, Alessio Piccolo, Peter von Allmen, and participants at the 2021 Liberal Arts Macro Conference, 2022 Financial Markets and Corporate Governance Conference, 2022 Commodity and Energy Markets Association Conference, 2022 Western Economic Association International Conference, 2022 FMA European Conference, 2022 FMA Annual Meeting, 2022 Southern Finance Association Conference, 2022 Southern Economic Association Conference, 2023 Eastern Finance Association Conference, and participants in the seminars at the Auckland Centre for Financial Research, International Capital Market Association Centre at the University of Reading, Skidmore College, and West Virginia University for their helpful comments. We also thank Zejun Jiang for assistance with collecting data about vaccine announcements from China and Shanxiang Yang for assistance with collecting data about COVID-19 cases.

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# 1 List of Vaccine Announcements

This section shows the list of vaccine announcements released by the four leading vaccine developers analyzed in our paper. Table A1 presents the list. There are 21, 58, 25, and 36 announcements for the Johnson & Johnson, Moderna, Oxford-AstraZeneca, and Pfizer-BioNTech vaccines, respectively, resulting in 140 announcements. The first vaccine announcement is on January 23, 2020 and the last one is on December 31, 2020. Section 3.1 in the paper provides details about the methodology used for collecting this data.

**Table A1: List of Vaccine Announcements**

| No. | Vaccine | Date | Time | Announcement | Day | Selected |
|---|---|---|---|---|---|---|
| 1 | Moderna | 01/23/20 | 09:15 | Moderna Announces Funding Award from CEPI (Coalition for Epidemic Preparedness Innovations) to Accelerate Development of Messenger RNA (mRNA) Vaccine Against Novel Coronavirus | 1 | Yes (1) |
| 2 | J&J | 01/29/20 | 08:48 | Johnson & Johnson Launches Multi-Pronged Response to Coronavirus Global Public Health Threat | 2 | No |
| 3 | J&J | 02/11/20 | 16:30 | Johnson & Johnson Announces Collaboration with U.S. Department of Health & Human Services to Accelerate Development of a Potential Novel Coronavirus Vaccine | 3 | Yes (1) |
| 4 | Moderna | 02/24/20 | 18:04 | Moderna Ships mRNA Vaccine Against Novel Coronavirus (mRNA1273) for Phase 1 Study | 4 | Yes (2) |
| 5 | J&J | 03/13/20 | 9:41 | Johnson & Johnson Announces Collaboration with the Beth Israel Deaconess Medical Center to Accelerate COVID-19 Vaccine Development | 5 | No |
| 6 | Pfizer-BioNTech | 03/13/20 | 15:25 | Pfizer Outlines Five-Point Plan to Battle COVID-19 | 5 | Yes(2) |
| 7 | Moderna | 03/16/20 | 12:42 | Moderna Announces First Participant Dosed in NIH-led (The National Institutes of Health) Phase 1 Study of mRNA Vaccine (mRNA-1273) Against Novel Coronavirus | 6 | No |
| 8 | Pfizer-BioNTech | 03/17/20 | 02:00 | Pfizer and BioNTech to Co-Develop Potential COVID-19 Vaccine | 7 | Yes (3) |
| 9 | Oxford-AstraZeneca | 03/24/20 | 12:51 | Oxford's COVID-19 Research Receives Government Funding | 8 | Yes (1) |
| 10 | Oxford-AstraZeneca | 03/27/20 | 16:30 | Oxford COVID-19 Vaccine Programme Opens for Clinical Trial Recruitment | 9 | Yes (2) |
| 11 | Moderna | 03/29/20 | 20:48 | Moderna Provides Update on the Impact of COVID-19 on Business Operations and Clinical Program Development | 9 | No |
| 12 | J&J | 03/30/20 | 07:22 | Johnson & Johnson Announces a Lead COVID-19 Vaccine Candidate; a Landmark New Partnership with U.S. Department of Health & Human Services; and Commitment to Supply One Billion Vaccines Worldwide for Emergency Pandemic Use | 9 | Yes (1) |
| 13 | Pfizer-BioNTech | 04/06/20 | 08:00 | Pfizer and The Pfizer Foundation Donate $40 Million in Charitable Grants, Expand Product Access and Mobilize Colleagues to Combat COVID-19 Pandemic | 10 | No |
| 14 | Pfizer-BioNTech | 04/09/20 | 07:50 | Pfizer and BioNTech Announce Further Details on Collaboration to Accelerate Global COVID-19 Vaccine Development | 11 | No |
| 15 | Pfizer-BioNTech | 04/09/20 | 07:50 | Pfizer Advances Battle Against COVID-19 on Multiple Fronts | 11 | No |
| 16 | Moderna | 04/14/20 | 07:00 | Moderna Highlights Highlights Opportunity of mRNA Vaccines at its First Vaccines Day | 12 | No |

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| 17 | Moderna | 04/16/20 | 17:55 | Moderna Announces Award from U.S. Government Agency BARDA (the Biomedical Advanced Research and Development Authority) for up to $483 Million to Accelerate Development of mRNA Vaccine (mRNA-1273) Against Novel Coronavirus | 13 | Yes (1) |
| 18 | Oxford-AstraZeneca | 04/17/20 | 13:07 | Five Oxford COVID-19 Projects Receive UK Research and Innovation (UKRI) Funding | 13 | Yes (1) |
| 19 | Pfizer-BioNTech | 04/22/20 | 00:00 | BioNTech and Pfizer Announce Regulatory Approval from German Authority Paul-Ehrlich-Institut to Commence First Clinical Trial of COVID-19 Vaccine Candidates | 14 | Yes (2) |
| 20 | Oxford-AstraZeneca | 04/23/20 | 07:36 | Oxford COVID-19 Vaccine Begins Human Trial Stage | 15 | Yes (2) |
| 21 | J&J | 04/23/20 | 18:51 | Johnson & Johnson Announces Collaboration to Expand Manufacturing Capabilities For its COVID-19 Vaccine Candidate in Support of the Company's Goal to Supply More Than One Billion Vaccine Doses Globally | 16 | No |
| 22 | Moderna | 04/27/20 | 16:30 | Moderna Announces IND (Investigational New Drug) Submitted to U.S. FDA (Food and Drug Administration) for Phase 2 Study of mRNA Vaccine (mRNA-1273) Against Novel Coronavirus | 17 | Yes (2) |
| 23 | Pfizer-BioNTech | 04/29/20 | 09:00 | BioNTech and Pfizer Announce Completion of Dosing for First Cohort of Phase 1/2 Trial of COVID-19 Vaccine Candidates in Germany | 18 | Yes (2) |
| 24 | Oxford-AstraZeneca | 04/30/20 | 11:00 | AstraZeneca and Oxford University Announce Landmark Agreement for COVID-19 Vaccine | 19 | Yes (3) |
| 25 | Moderna | 05/01/20 | 00:50 | Moderna and Lonza Announce Worldwide Strategic Collaboration to Manufacture Moderna's Vaccine (mRNA-1273) Against Novel Coronavirus | 20 | No |
| 26 | Pfizer-BioNTech | 05/05/20 | 06:45 | Pfizer and BioNTech Dose First Participants in the U.S. as Part of Global COVID-19 mRNA Vaccine Development Program | 21 | Yes (2) |
| 27 | Moderna | 05/12/20 | 08:00 | Moderna Receives FDA Fast Track Designation for mRNA Vaccine (mRNA1273) Against Novel Coronavirus | 22 | No |
| 28 | Moderna | 05/18/20 | 07:30 | Moderna Announces Positive Interim Phase 1 Data for its mRNA Vaccine (mRNA-1273) Against Novel Coronavirus | 23 | Yes (2) |
| 29 | Oxford-AstraZeneca | 05/18/20 | 10:32 | Funding and Manufacturing Boost for UK Vaccine Programme | 23 | Yes (1) |
| 30 | Oxford-AstraZeneca | 05/21/20 | 02:00 | AstraZeneca Advances Response to Global COVID-19 Challenge as It Receives First Commitments for Oxford's Potential New Vaccine | 24 | No |
| 31 | Oxford-AstraZeneca | 05/22/20 | 03:24 | Oxford COVID-19 Vaccine to Begin Phase II/III Human Trials | 25 | Yes (2) |
| 32 | Moderna | 05/29/20 | 16:52 | Moderna Announces First Participants in Each Age Cohort Dosed in Phase 2 Study of mRNA Vaccine (mRNA-1273) Against Novel Coronavirus | 26 | Yes (2) |

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| 33 | Oxford-AstraZeneca | 06/04/20 | 11:00 | AstraZeneca Takes Next Steps towards Broad and Equitable Access to Oxford University's COVID-19 Vaccine | 27 | No |
| 34 | J&J | 06/10/20 | 09:25 | Johnson & Johnson Announces Acceleration of its COVID-19 Vaccine Candidate; Phase 1/2a Clinical Trial to Begin in Second Half of July | 28 | Yes (2) |
| 35 | Moderna | 06/11/20 | 07:57 | Moderna Advances Late-Stage Development of its Vaccine (mRNA-1273) Against COVID-19 | 29 | No |
| 36 | Oxford-AstraZeneca | 06/13/20 | 09:00 | AstraZeneca to Supply Europe with up to 400 million Doses of Oxford University's Vaccine at No Profit | 30 | Yes (4) |
| 37 | Moderna | 06/25/20 | 07:30 | Moderna and Catalent Announce Collaboration for Fill-Finish Manufacturing of Moderna's COVID-19 Vaccine Candidate | 31 | No |
| 38 | Oxford-AstraZeneca | 06/28/20 | 07:41 | Trial of Oxford COVID-19 Vaccine Starts in Brazil | 32 | Yes (2) |
| 39 | Pfizer-BioNTech | 07/01/20 | 08:59 | Pfizer and BioNTech Announce Early Positive Data from an Ongoing Phase 1/2 Study of mRNA-based Vaccine Candidate Against SARS-CoV-2 | 33 | Yes (2) |
| 40 | Moderna | 07/08/20 | 09:44 | Moderna Completes Enrollment of Phase 2 Study of its mRNA Vaccine Against COVID-19 (mRNA-1273) | 34 | Yes (2) |
| 41 | Moderna | 07/09/20 | 08:00 | Moderna and ROVI (Laboratorios Farmacéuticos Rovi) Announce Collaboration for OUS Fill-Finish Manufacturing of Moderna's COVID-19 Vaccine Candidate | 35 | No |
| 42 | Pfizer-BioNTech | 07/13/20 | 06:45 | Pfizer and BioNTech Granted FDA Fast Track Designation for Two Investigational mRNA-based Vaccine Candidates Against SARS-CoV-2 | 36 | No |
| 43 | Moderna | 07/14/20 | 17:14 | Moderna Announces Publication in The New England Journal of Medicine of Interim Results From Phase 1 Study of Its mRNA Vaccine Against COVID-19 (mRNA-1273) | 37 | Yes (2) |
| 44 | Pfizer-BioNTech | 07/20/20 | 00:00 | Pfizer and BioNTech Announce Agreement with the United Kingdom for 30 Million Doses of mRNA-based Vaccine Candidate against SARS-CoV-2 | 38 | No |
| 45 | Pfizer-BioNTech | 07/20/20 | 08:45 | Pfizer and BioNTech Announce Early Positive Update from German Phase 1/2 COVID-19 Vaccine Study, Including First T Cell Response Data | 38 | Yes (2) |
| 46 | Oxford-AstraZeneca | 07/20/20 | 09:40 | COVID-19 Vaccine AZD1222 Showed Robust Immune Responses in all Participants in Phase I/II Trial | 38 | Yes (2) |
| 47 | Pfizer-BioNTech | 07/22/20 | 07:10 | Pfizer and BioNTech Announce an Agreement with U.S. Government for up to 600 Million Doses of mRNA-based Vaccine Candidate Against SARS-CoV-2 | 39 | Yes (4) |
| 48 | Moderna | 07/24/20 | 15:53 | Statement from Moderna on Patent Trial and Appeal Board (PTAB) Ruling | 40 | No |

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| 49 | Moderna | 07/26/20 | 10:22 | Moderna Announces Expansion of BARDA Agreement to Support Larger Phase 3 Program for Vaccine (mRNA-1273) Against COVID-19 | 41 | Yes (1) |
| 50 | Moderna | 07/27/20 | 06:52 | Moderna Announces Phase 3 COVE (Coronavirus Efficacy) Study of mRNA Vaccine Against COVID-19 (mRNA-1273) Begins | 41 | Yes (2) |
| 51 | Pfizer-BioNTech | 07/27/20 | 17:15 | Pfizer and BioNTech Choose Lead mRNA Vaccine Candidate Against COVID-19 and Commence Pivotal Phase 2/3 Global Study | 42 | Yes (2) |
| 52 | Moderna | 07/28/20 | 15:23 | Moderna Announces Publication in The New England Journal of Medicine of Non-Human Primate Preclinical Viral Challenge Study of its mRNA Vaccine Against COVID-19 (mRNA-1273) | 42 | No |
| 53 | J&J | 07/30/20 | 05:30 | Single Dose of Johnson & Johnson COVID-19 Vaccine Candidate Demonstrates Robust Protection in Pre-clinical Studies | 43 | Yes (2) |
| 54 | Pfizer-BioNTech | 07/31/20 | 05:15 | Pfizer and BioNTech to Supply Japan with 120 Million Doses of their BNT162 mRNA-based Vaccine Candidate | 44 | No |
| 55 | Pfizer-BioNTech | 08/05/20 | 08:00 | Pfizer and BioNtech to Supply Canada with their BNT162 mRNA-Based Vaccine Candidate | 45 | No |
| 56 | J&J | 08/05/20 | 08:30 | Johnson & Johnson Announces Agreement with U.S. Government for 100 Million Doses of Investigational COVID-19 Vaccine | 45 | Yes (4) |
| 57 | Moderna | 08/11/20 | 17:49 | Moderna Announces Supply Agreement with U.S. Government for Initial 100 Million Doses of mRNA Vaccine Against COVID-19 (mRNA-1273) | 46 | Yes (4) |
| 58 | Oxford-AstraZeneca | 08/14/20 | 07:13 | AstraZeneca Concludes Agreement with the European Commission for the Supply of up to 400 Million Doses of AZD1222 COVID-19 Vaccine | 47 | No |
| 59 | J&J | 08/14/20 | 09:58 | Johnson & Johnson Announces Collaboration in Principle with the United Kingdom on Additional Phase 3 Study and Agreement to Supply its COVID-19 Vaccine Candidate | 47 | No |
| 60 | Pfizer-BioNTech | 08/20/20 | 20:00 | Pfizer and BioNTech Share Positive Early Data on Lead mRNA Vaccine Candidate BNT162b2 Against COVID-19 | 48 | No |
| 61 | Moderna | 08/24/20 | 09:18 | Moderna Confirms Advanced Discussions with European Commission to Supply Europe with 80 Million Doses of mRNA Vaccine Against COVID-19 (mRNA-1273) | 49 | Yes (4) |
| 62 | Moderna | 08/26/20 | 08:53 | Moderna to Present New Interim Clinical Data About mRNA Vaccine Against COVID-19 (mRNA-1273) at Advisory Committee on Immunization Practices (ACIP) Meeting | 50 | No |
| 63 | Moderna | 08/28/20 | 06:19 | Moderna Confirms Discussions with the Ministry of Health, Labour and Welfare to Supply Japan with 40 Million Doses of mRNA Vaccine Against COVID-19 (mRNA-1273) | 51 | No |

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| 64 | J&J | 08/31/20 | 08:55 | Johnson & Johnson Announces Agreement in Principle with Government of Canada to Supply its COVID-19 Vaccine Candidate | 52 | No |
| 65 | Oxford-AstraZeneca | 08/31/20 | 16:30 | Development of COVID-19 Vaccine AZD1222 Expands into US Phase III Clinical Trial Across All Adult Age Groups | 53 | Yes (2) |
| 66 | Oxford-AstraZeneca | 08/31/20 | 16:30 | AstraZeneca's Scientific and Social Commitment for COVID-19 Vaccine | 53 | No |
| 67 | J&J | 09/08/20 | 06:30 | Biopharma Leaders Unite to Stand with Science | 54 | No |
| 68 | Moderna | 09/08/20 | 06:30 | Biopharma Leaders Unite to Stand with Science | 54 | No |
| 69 | Oxford-AstraZeneca | 09/08/20 | 10:00 | Biopharma Leaders Unite to Stand with Science | 54 | No |
| 70 | Pfizer-BioNTech | 09/08/20 | 10:00 | Biopharma Leaders Unite to Stand with Science | 54 | No |
| 71 | Pfizer-BioNTech | 09/09/20 | 06:15 | Pfizer and BioNTech to Potentially Supply the EU with 200 Million Doses of mRNA-based Vaccine Candidate Against SARS-CoV-2 | 55 | Yes (4) |
| 72 | Oxford-AstraZeneca | 09/09/20 | 09:00 | Statement on AstraZeneca Oxford SARS-CoV-2 Vaccine, AZD1222, COVID-19 Vaccine Trials Temporary Pause | 55 | No |
| 73 | Oxford-AstraZeneca | 09/12/20 | 09:20 | COVID-19 Vaccine AZD1222 Clinical Trials Resumed in the UK | 56 | Yes (2) |
| 74 | Pfizer-BioNTech | 09/12/20 | 10:45 | Pfizer and BioNTech Propose Expansion of Pivotal COVID-19 Vaccine Trial | 56 | Yes (2) |
| 75 | Pfizer-BioNTech | 09/15/20 | 13:45 | Pfizer Investor Day Features Significant Number of Pipeline Advances for COVID-19 Programs and Across Numerous Therapeutic Areas | 57 | No |
| 76 | Moderna | 09/22/20 | 12:22 | Canada Exercises Increased Option for 20 Million Doses of mRNA Vaccine Against COVID-19 (mRNA-1273) | 58 | No |
| 77 | J&J | 09/23/20 | 06:45 | Johnson & Johnson Announces Initiation of Pivotal Global Phase 3 Clinical Trial of Janssen's COVID-19 Vaccine Candidate | 59 | Yes (2) |
| 78 | J&J | 09/25/20 | 15:09 | Johnson & Johnson Posts Interim Results from Phase 1/2a Clinical Trial of its Janssen COVID-19 Vaccine Candidate (This statement was updated on October 4, 2020 to include additional information) | 60 | Yes (2) |
| 79 | J&J | 09/28/20 | 17:45 | Johnson & Johnson's One Dose COVID-19 Vaccine Trial with 60,000 Volunteers in Final Testing Phase | 61 | No |
| 80 | Moderna | 09/29/20 | 18:17 | Moderna Announces Publication in The New England Journal of Medicine of Interim Results From Older Adult Age Cohorts in Phase 1 Study of its mRNA Vaccine Against COVID-19 (mRNA-1273) | 62 | Yes (2) |

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| 81 | Oxford-AstraZeneca | 10/02/20 | 03:30 | COVID-19 Vaccine AZD1222 Clinical Trial Resumed in Japan, Follows Restart of Trials in the UK, Brazil, South Africa and India | 63 | No |
| 82 | J&J | 10/04/20 | N/A | Update on Interim Results from Phase 1/2a Clinical Trial of its Janssen COVID-19 Vaccine Candidate | 64 | Yes (2) |
| 83 | Pfizer-BioNTech | 10/06/20 | 07:00 | BioNTech and Pfizer Initiate Rolling Submission to European Medicines Agency for SARS-CoV-2 Vaccine Candidate BNT162b2 | 65 | No |
| 84 | Moderna | 10/08/20 | 06:50 | DARPA (The Defense Advanced Research Projects Agency) Awards Moderna up to $56 Million to Enable Small-Scale, Rapid Mobile Manufacturing of Nucleic Acid Vaccines and Therapeutics | 66 | Yes (1) |
| 85 | J&J | 10/08/20 | 07:50 | Johnson & Johnson Announces European Commission Approval of Agreement to Supply 200 Million Doses of Janssen's COVID-19 Vaccine Candidate | 66 | Yes (4) |
| 86 | J&J | 10/12/20 | 21:16 | Johnson & Johnson Temporarily Pauses All Dosing in Our Janssen COVID-19 Vaccine Candidate Clinical Trials | 67 | No |
| 87 | Moderna | 10/13/20 | 11:04 | Moderna Announces Initiation of Rolling Submission to Health Canada for mRNA Vaccine Against COVID-19 (mRNA-1273) | 67 | No |
| 88 | Moderna | 10/14/20 | 08:00 | Moderna Receives Confirmation of Eligibility for Submission of Marketing Authorization Application to the European Medicines Agency for mRNA Vaccine Against COVID-19 (mRNA-1273) | 68 | No |
| 89 | Moderna | 10/22/20 | 09:47 | Moderna Completes Enrollment of Phase 3 COVE Study of mRNA Vaccine Against COVID-19 (mRNA-1273) | 69 | Yes (2) |
| 90 | J&J | 10/23/20 | 15:21 | Johnson & Johnson Prepares to Resume Phase 3 ENSEMBLE Trial of its Janssen COVID-19 Vaccine Candidate in the U.S. | 70 | Yes (2) |
| 91 | Oxford-AstraZeneca | 10/23/20 | 15:30 | FDA Authorises Restart of the COVID-19 AZD1222 Vaccine US Phase III Trial | 70 | Yes (2) |
| 92 | Moderna | 10/26/20 | 07:00 | Moderna Announces Supply Agreement with the Ministry of Public Health to Supply Qatar with mRNA Vaccine Against COVID-19 (mRNA-1273) | 71 | No |
| 93 | Moderna | 10/27/20 | 09:00 | UK Medicines and Healthcare products Regulatory Agency Begins Rolling Review of Moderna's mRNA Vaccine Against COVID-19 (mRNA-1273) | 72 | No |
| 94 | Moderna | 10/29/20 | 02:00 | Moderna Partners with Takeda and the Government of Japan to Supply 50 Million Doses of mRNA Vaccine Against COVID-19 (mRNA-1273) to Japan | 73 | No |
| 95 | Pfizer-BioNTech | 11/09/20 | 06:45 | Pfizer and BioNTech Announce Vaccine Candidate Against COVID-19 Achieved Success in First Interim Analysis from Phase 3 Study | 74 | Yes (2) |

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| 96 | Pfizer-BioNTech | 11/11/20 | 06:15 | Pfizer and BioNTech Reach an Agreement to Supply the EU with 200 Million Doses of Their BNT162b2 mRNA-Based Vaccine Candidate Against SARS-CoV-2 | 75 | Yes (4) |
| 97 | Moderna | 11/11/20 | 16:01 | Moderna Has Completed Case Accrual for First Planned Interim Analysis of its mRNA Vaccine Against COVID-19 (mRNA-1273) | 76 | No |
| 98 | Moderna | 11/13/20 | 07:18 | Swissmedic Begins Rolling Review of Moderna's mRNA Vaccine Against COVID-19 (mRNA-1273) | 77 | No |
| 99 | J&J | 11/14/20 | 09:34 | Johnson & Johnson and U.S. Department of Health & Human Services Expand Agreement to Support Next Phase of COVID-19 Vaccine Candidate Research and Development | 78 | Yes (1) |
| 100 | J&J | 11/15/20 | N/A | Johnson & Johnson Initiates Second Global Phase 3 Clinical Trial of its Janssen COVID-19 Vaccine Candidate | 78 | Yes (2) |
| 101 | Moderna | 11/16/20 | 06:52 | Moderna Announces Longer Shelf Life for its COVID-19 Vaccine Candidate at Refrigerated Temperatures | 78 | No |
| 102 | Moderna | 11/16/20 | 06:56 | Moderna's COVID-19 Vaccine Candidate Meets its Primary Efficacy Endpoint in the First Interim Analysis of the Phase 3 COVE Study | 78 | Yes (2) |
| 103 | Pfizer-BioNTech | 11/16/20 | 08:00 | Pfizer Update on Our U.S. COVID-19 Vaccine Candidate Distribution Preparedness | 78 | No |
| 104 | Moderna | 11/17/20 | 09:11 | Moderna Announces Supply Agreement with United Kingdom Government to Supply mRNA Vaccine Against COVID-19 (mRNA-1273) if Approved for Use | 79 | No |
| 105 | Moderna | 11/17/20 | 09:18 | European Medicines Agency Begins Rolling Review of Moderna's mRNA Vaccine Candidate Against COVID-19 (mRNA-1273) | 79 | No |
| 106 | Pfizer-BioNTech | 11/18/20 | 06:59 | Pfizer and BioNTech Conclude Phase 3 Study of COVID-19 Vaccine Candidate, Meeting All Primary Efficacy Endpoints | 80 | Yes (2) |
| 107 | Oxford-AstraZeneca | 11/19/20 | 12:08 | Oxford Coronavirus Vaccine Produces Strong Immune Response in Older Adults | 81 | Yes (2) |
| 108 | Pfizer-BioNTech | 11/20/20 | 06:45 | Pfizer and BioNTech to Submit Emergency Use Authorization Request Today to the U.S. FDA for COVID-19 Vaccine | 82 | No |
| 109 | Oxford-AstraZeneca | 11/23/20 | 02:00 | AZD1222 Vaccine Met Primary Efficacy Endpoint in Preventing COVID-19 | 83 | Yes (2) |
| 110 | Moderna | 11/25/20 | 06:49 | Moderna Announces the European Commission's Approval of Advance Purchase Agreement for Initial 80 Million Doses of mRNA Vaccine Against COVID-19 (mRNA-1273) | 84 | Yes (4) |
| 111 | Moderna | 11/29/20 | 08:37 | Moderna Announces Amendment to Current Supply Agreement with United Kingdom Government for an Additional 2 Million Doses of mRNA Vaccine Against COVID-19 (mRNA-1273) | 85 | No |

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| 112 | Moderna | 11/30/20 | 06:59 | Moderna Announces Primary Efficacy Analysis in Phase 3 COVE Study for Its COVID-19 Vaccine Candidate and Filing Today with U.S. FDA for Emergency Use Authorization | 85 | No |
| 113 | J&J | 12/01/20 | 08:41 | Johnson & Johnson Announces Initiation of Rolling Submission for its Single-dose Janssen COVID-19 Vaccine Candidate with the European Medicines Agency | 86 | No |
| 114 | Pfizer-BioNTech | 12/02/20 | 02:05 | Pfizer and BioNTech Achieve First Authorization in the World for a Vaccine to Combat COVID-19 | 87 | Yes (5) |
| 115 | Moderna | 12/03/20 | 05:07 | Moderna Provides Updates on the Clinical Development and Production of Its COVID-19 Vaccine Candidate | 88 | No |
| 116 | Moderna | 12/04/20 | 08:27 | Moderna Announces Amendment to Supply Agreement with the Ministry of Health of Israel to Supply Additional Doses of mRNA Vaccine Against COVID-19 (mRNA-1273) | 89 | No |
| 117 | Moderna | 12/07/20 | 09:27 | Canada Exercises Increased Option for Total of 40 Million Doses of mRNA Vaccine Candidate Against COVID-19 (mRNA-1273) | 90 | No |
| 118 | Moderna | 12/08/20 | 08:00 | Switzerland Exercises Increased Option for 7.5 Million Doses of mRNA Vaccine Against COVID-19 (mRNA-1273) | 91 | No |
| 119 | Oxford-AstraZeneca | 12/08/20 | 11:00 | AZD1222 Oxford Phase III Trials Interim Analysis Results Published in The Lancet | 91 | Yes (2) |
| 120 | Moderna | 12/10/20 | 07:00 | Moderna Announces First Participants Dosed in Phase 2/3 Study of COVID-19 Vaccine Candidate in Adolescents | 92 | Yes (2) |
| 121 | Pfizer-BioNTech | 12/10/20 | 11:43 | Pfizer and BioNTech Announce Publication of Results from Landmark Phase 3 Trial of BNT162b2 COVID-19 Vaccine Candidate in The New England Journal of Medicine | 92 | No |
| 122 | Pfizer-BioNTech | 12/10/20 | 18:50 | Pfizer and BioNTech Receive FDA Advisory Committee Vote Supporting Potential First Emergency Use Authorization for Vaccine to Combat COVID-19 in the U.S. | 93 | No |
| 123 | Moderna | 12/11/20 | 16:30 | U.S. Government Exercises 1st Option for Additional 100 Million Doses of Moderna's COVID-19 Vaccine Candidate | 94 | Yes (4) |
| 124 | Pfizer-BioNTech | 12/11/20 | 23:12 | Pfizer and BioNTech Celebrate Historic First Authorization in the U.S. of Vaccine to Prevent COVID-19 | 94 | Yes (5) |
| 125 | Pfizer-BioNTech | 12/12/20 | 16:58 | U.S. CDC Committee of Independent Health Experts Recommends Vaccination with Pfizer and BioNTech COVID-19 Vaccine for Persons Ages 16 Years and Older | 94 | No |
| 126 | Moderna | 12/16/20 | 09:31 | Moderna Confirms Supply Agreement with the Ministry of Health to Supply Singapore with mRNA Vaccine Against COVID-19 (mRNA-1273) | 95 | No |
| 127 | Oxford-AstraZeneca | 12/17/20 | 11:20 | Oxford Vaccine Stimulates Broad Antibody and T Cell Functions | 96 | Yes (2) |

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| 128 | Moderna | 12/17/20 | 17:27 | Moderna Receives FDA Advisory Committee Vote Supporting Emergency Use for Moderna's Vaccine Against COVID-19 in the United States | 97 | No |
| 129 | Moderna | 12/18/20 | 08:00 | European Commission Exercises Option for Additional 80 Million Doses of Moderna's COVID-19 Vaccine Candidate | 97 | Yes (4) |
| 130 | Moderna | 12/18/20 | 19:46 | Moderna Announces FDA Authorization of Moderna COVID-19 Vaccine in U.S. | 98 | Yes (5) |
| 131 | Moderna | 12/19/20 | 21:44 | U.S. CDC (Centers for Disease Control and Prevention) Advisory Committee on Immunization Practices Recommends Vaccination with Moderna's COVID-19 Vaccine for Persons 18 Years and Older | 98 | No |
| 132 | Pfizer-BioNTech | 12/21/20 | 09:21 | Pfizer and BioNTech Receive CHMP (the Committee for Medicinal Products for Human Use) Positive Opinion for their COVID-19 Vaccine | 98 | No |
| 133 | Pfizer-BioNTech | 12/21/20 | 14:09 | Pfizer and BioNTech Receive Authorization in the European Union for COVID-19 Vaccine | 98 | Yes (5) |
| 134 | Pfizer-BioNTech | 12/23/20 | 07:00 | Pfizer and BioNTech to Supply the U.S. with 100 Million Additional Doses of COVID-19 Vaccine | 99 | Yes (4) |
| 135 | Moderna | 12/23/20 | 11:20 | Health Canada Authorizes Moderna COVID-19 Vaccine in Canada | 99 | No |
| 136 | Pfizer-BioNTech | 12/29/20 | 13:11 | Pfizer and BioNTech to Supply the European Union with 100 Million Additional Doses of COMIRNATY® | 100 | Yes (4) |
| 137 | Moderna | 12/29/20 | 16:08 | Moderna Confirms Discussions With the Government of South Korea to Supply South Korea With 40 Million Doses of COVID-19 Vaccine | 101 | No |
| 138 | Oxford-AstraZeneca | 12/30/20 | 02:00 | AstraZeneca's COVID-19 Vaccine Authorised for Emergency Supply in the UK | 101 | Yes (5) |
| 139 | Moderna | 12/31/20 | 09:14 | Moderna Confirms 40 Million COVID-19 Vaccine Dose Supply Agreement with the Government of the Republic of Korea | 102 | No |
| 140 | Moderna | 12/31/20 | 09:22 | Moderna Announces Publication of Results from the Pivotal Phase 3 Trial of the Moderna COVID-19 Vaccine in The New England Journal of Medicine. | 102 | No |

This table lists the date, time, and title of the announcements about the Johnson & Johnson, Moderna, Oxford-AstraZeneca, and Pfizer-BioNTech vaccines from January 23, 2020 to December 31, 2020. There are 140 announcements. Time is Eastern Time. Day shows how multiple announcements combine into a single trading day when more than one announcement occurs on the same day (or on two consecutive days if the announcement(s) on the first day occurred after the stock market closed at 16:00 on the previous trading day). There are 102 trading days with announcements. The Column Selected shows whether the announcement meets one of the five selection criteria described in Section 4.1: 1) funding for the vaccine development, 2) research and discovery stage or three phases of clinical development, 3) initiation of collaboration between institutions developing the vaccines, 4) government supply agreements signed with the U.S. or the European Commission, or 5) government authorization.

# 2 Impact of Vaccine Announcements on Days Preceding and Following the Announcements

This section tests for any potential impact that the vaccine announcements might have in the days preceding or following the announcements. We estimate the following equation (1):

$$R_t = \alpha_0 + \sum_{l=1}^{L} \alpha_l R_{t-l} + \sum_{k=-3}^{3} \beta_k Ann_{t+k} + \epsilon_t, \tag{1}$$

As in equation (1) in the paper, $R_t$ is the S&P 500 index log return on day $t$, $\alpha_0$ is a constant, and the return lags account for possible autocorrelation of returns. The optimal number of return lags, $L$, is determined with the Schwarz information criterion, resulting in seven lags. $Ann_t$ is an indicator variable that takes on the value of one if there is an important vaccine announcement on day $t$ and zero otherwise.

In comparison to equation (1) in the paper, we include leads and lags of the announcement indicator variable. The coefficients of the leads ($k > 0$) measure any potential pre-announcement price moves, i.e., any possible anticipation of the announcement. The coefficients of the lags ($k < 0$) measure any potential post-announcement price moves. We include three leads and three lags, corresponding to three days before and three days after the announcement, respectively.

Column (1) of Table A2 shows the ordinary least squares estimation results. The coefficient estimates of the leads and lags of the vaccine indicator variable are not statistically significant at the 10% level, indicating that there is no statistically significant pre-announcement or post-announcements price impact.[1]

[1] When a similar regression is estimated with one or two leads and lags of the announcement indicator variable, the coefficient estimates of the leads and lags are also not statistically significant.

**Table A2: Test for Pre-announcement and Post-announcement Effects**

| | OLS Regression |
|---|---|
| Lead 3 | 0.135 (0.331) |
| Lead 2 | −0.268 (0.272) |
| Lead 1 | −0.455 (0.325) |
| Announcement | 0.850 (0.239)*** |
| Lag 1 | 0.069 (0.253) |
| Lag 2 | −0.238 (0.324) |
| Lag 3 | −0.231 (0.262) |
| Constant | 0.074 (0.213) |

This table shows the results of estimating equation (1) that regresses the daily log return, $R_t$, on a constant, seven lags of return as well as three leads, the contemporaneous value and three lags of the indicator variable that takes on the value of one if there is an important vaccine announcement on that day and zero otherwise. The log return is computed as $R_t = ln(P_t/P_{t-1}) * 100$ where $P_t$ is the closing value of the S&P500 on day $t$. For conciseness, the return lags are not reported and are available upon request. The sample period is from January 22, 2020 to December 31, 2020 and includes 240 trading days. The sample contains 57 trading days with important vaccine announcements selected as described in Section 4.1. Standard errors are shown in parentheses. *, **, and *** indicate, statistical significance at 10%, 5%, and 1% levels, respectively.

# 3 Impact of Vaccine Announcements on Stocks of Leading Vaccine Companies

This section analyzes the impact of the vaccine announcements listed in Table A1 on stock prices of the companies that developed the vaccines: AstraZeneca, BioNTech, Johnson & Johnson, Moderna, and Pfizer. We eliminate four announcements by University of Oxford that occur before the partnership between AstraZeneca and University of Oxford was formed on April 30, 2020 (announcements #9, #10, #18, and #20 in Table A1).

We begin by estimating the following equation using the ordinary least squares (OLS):

$$R_t = \alpha_0 + \sum_{l=1}^{L} \alpha_l R_{t-l} + \beta Ann_t + \epsilon_t, \qquad (2)$$

where $R_t$ is the log return for a given vaccine company on day $t$,[2] $\alpha_0$ is a constant, and the return lags account for possible autocorrelation of returns. The optimal number of

[2] We use returns rather than abnormal returns in this estimation because it is conceivable that the vaccine announcements moved the entire stock market rather than only stocks of the companies developing the vaccines, which would have affected the expected market return and possibly also the factors (for example, the small-minus-big market capitalization factor and the high-minus-low book-to-market ratio factor) typically used in the abnormal return computation.

return lags, $L$, is determined with the Schwarz information criterion and results in zero lags for BioNTech and Moderna and one lag for the other three companies. $Ann_t$ is an indicator variable that takes on the value of one if there is a vaccine announcement about this company on that day and zero otherwise. Since our sample includes only positive news about the vaccine development as described in Section 3 of the paper, a positive coefficient on the announcement indicator variable, $\beta$, means that the good news increases the return.

Table A3 reports the results. For conciseness, the coefficients on the return lags are not reported and are available upon request. The coefficient on the announcement indicator variable is significant for all four companies involved in development of the vaccines that have been approved in the U.S. (BioNTech, Johnson & Johnson, Moderna, and Pfizer). This means that the company stock returns are higher on days when these companies release the vaccine announcements. The Moderna and BioNTech stock prices on average move by 3.2% and 4.8%, respectively, on the vaccine announcement days. This impact is large probably because the COVID-19 vaccine is a substantial part of business in these corporations. The magnitude of the Johnson & Johnson and Pfizer stock price moves is lower (1.1% and 1.6%, respectively), perhaps because they are larger corporations diversified into other products.

The coefficient is not significant for AstraZeneca. Although the AstraZeneca vaccine was approved in the EU and other regions, the vaccine was lagging behind the Johnson & Johnson, Moderna, and Pfizer-BioNTech vaccines in the U.S. approval process. Also, on June 4, 2020 AstraZeneca released announcement #33 in Table A1 in which Pascal Soriot, AstraZeneca Chief Executive Officer, announced: *"We are working tirelessly to honour our commitment to ensure broad and equitable access to Oxford's vaccine across the globe and at no profit. Today marks an important step in helping us supply hundreds of millions of people around the world, including to those in countries with the lowest means..."* Perhaps investors considered this pricing decision and predicted the U.S. approval challenges and therefore did not react to the vaccine announcements as enthusiastically.

To gain a perspective on the economic significance of the Table A3 results, we compute

**Table A3: Impact of Vaccine Announcements on Leading Vaccine Company Stocks**

| | AstraZeneca | BioNTech | J & J | Moderna | Pfizer | Random Effects |
|---|---|---|---|---|---|---|
| Announcement | 0.288 | 4.805** | 1.107** | 3.247*** | 1.620*** | 2.580*** |
| | (0.372) | (2.046) | (0.473) | (1.079) | (0.506) | (0.475) |
| Constant | −0.017 | −0.306 | −0.048 | −0.007 | −0.236 | −0.168 |
| | (0.157) | (0.496) | (0.129) | (0.437) | (0.147) | (0.241) |
| Other company ann. | | | | | | 0.116 |
| | | | | | | (0.357) |
| Trading days | 240 | 240 | 240 | 240 | 240 | 240 |
| Trading days with ann. | 19 | 32 | 19 | 50 | 32 | 99 |

This table shows the results of estimating equation (2) that regresses the daily log return, $R_t$, on a constant and an indicator variable that takes on the value of one if there is a vaccine announcement about the given company on that day and zero otherwise. We include one lag in the AstraZeneca, Johnson & Johnson (J & J), and Pfizer equations; for conciseness, the coefficients on the return lags are not reported and are available upon request. The return is computed as $R_t = ln(P_t/P_{t-1}) * 100$ where $P_t$ is the closing stock price of the given company on day $t$. The sample period is from January 22, 2020 to December 31, 2020. Heteroskedasticity consistent standard errors are shown in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

cumulative stock returns by multiplying the coefficient estimate on the announcement indicator for each vaccine company by their announcement days. Moderna, BioNTech, Pfizer, and Johnson & Johnson earned approximately 162%, 154%, 52%, and 21% on their announcement days, respectively, and these returns accounted for a majority of total returns earned by these companies even though most trading days did not have announcements.

Equation (2) includes only announcements of the given company. To allow for the possibility that the company returns are also affected by announcements made by the other four companies, we control for the other company announcements.

We use the random effects panel estimator:

$$R_{it} = \alpha_0 + \sum_{l=1}^{L} \alpha_l R_{it-l} + \beta Ann_{it} + \gamma AnnOther_{it} + \delta_t + \epsilon_{it}, \tag{3}$$

where $Ann_{it}$ is an indicator variable that takes on the value of one if there is a vaccine announcement about company $i$ on that day and zero otherwise, $AnnOther_{it}$ is an indicator variable that takes on the value of one if there is an announcement about any of the other vaccines included in our analysis on that day and zero otherwise, and $\delta_t$ stands for the random time effects.[3] The model does not include cross-section random effects because Lagrange multiplier tests for random effects indicate that cross-section effects are redundant.

The last column of Table A3 shows the results. The coefficient on the announcement indicator variable is 2.58 and significant at the 1% level, confirming the results from estimating equation (2). The coefficient on the announcements about the other vaccines is not significant.

In another robustness check, we add the other company announcements to equation (2) estimated with OLS for each company separately. For example, the AstraZeneca equation then includes an additional indicator variable that takes on the value of one if there is an announcement by BioNTech, Johnson & Johnson, Moderna, and/or Pfizer on that day and zero otherwise. The coefficient estimates on the announcement indicator variable are very similar to those reported in Table 2. The coefficients on the announcements about the other vaccines are not significant. These estimates are available upon request.

# 4 Supplementary Material for Section 4.2.2 What Drives the Reaction of Stock Prices?

This section provides supplementary material for Section 4.2.2 What Drives the Reaction of Stock Prices? As Section 4.2.2 explains, news announcements move stock prices if the announcements convey information about the expected corporate cash flows or the expected discount rate (consisting of the expected risk-free interest rate and the equity risk premium) used to discount the cash flows (for example, Boyd, Hu, and Jagannathan (2005)). We investigate which of these three channels drives the reaction of the stock markets to the vaccine announcements by decomposing the aggregate stock returns.

[3] In this estimation we include the four University of Oxford vaccine announcements that were made before the AstraZeneca and University of Oxford partnership was formed on April 30, 2020. For all five vaccine companies, these four announcements are classified as announcement about the other vaccines.

We estimate the daily cash flow news and the discount rate news for the S&P 500 index using the return decomposition approach proposed by Campbell and Shiller (1988). Campbell and Shiller (1988) derive the following accounting identity that decomposes the unexpected stock returns into news about future dividends and future discount rates:

$$r_{t+1} - E_t r_{t+1} = (E_{t+1} - E_t)\sum_{j=0}^{\infty}\rho^j \Delta d_{t+1+j} - (E_{t+1} - E_t)\sum_{j=1}^{\infty}\rho^j \Delta r_{t+1+j} = N_{CF,t+1} - N_{DR,t+1}, \quad (4)$$

where $r_{t+1}$ is a log stock return, $E_t$ and $E_{t+1}$ are expectations at time $t$ and $t+1$, $\Delta d_{t+1}$ is a one-period change in the log dividends, $\rho$ is a constant discount factor, $N_{CF,t+1}$ is news about future cash flows, and $N_{DR,t+1}$ is news about future discount rates. To construct the time series of the aggregate cash flow news and the aggregate discount rate news, we follow Campbell and Vuolteenaho (2004) and estimate the first-order vector autoregression (VAR):

$$\mathbf{z_{t+1}} = \mathbf{a} + \mathbf{B}\mathbf{z_t} + \mathbf{u_{t+1}}, \quad (5)$$

where $\mathbf{z_{t+1}}$ is a vector of state variables, $\mathbf{a}$ and $\mathbf{B}$ are coefficient matrices, and $\mathbf{u_{t+1}}$ is a vector of shocks. The excess stock market return is the first state variable in the VAR, and the other state variables are selected to model the time variation in expected returns. The discount rate news can then be computed as:

$$N_{DR,t+1} = \mathbf{e1'}\lambda\mathbf{u_{t+1}}, \quad (6)$$

where $\mathbf{e1}$ is a vector with the first element equal to one and the other elements equal to zero, and $\lambda \equiv \rho\mathbf{B}(\mathbf{I} - \rho\mathbf{B})^{-1}$ is a matrix that captures the long-term effects of VAR innovations on the state variables. We set the daily discount factor $\rho$ equal to 0.9998 (0.95 annualized following Campbell and Vuolteenaho (2004)). Campbell (1993) shows that $\rho$ is related to the average consumption-wealth ratio. Specifically, $\rho = 1 - exp(c - w)$, where $c$ and $w$ are the natural logs of consumption and total wealth, respectively; therefore, setting $\rho$ equal to 0.95 assumes that investors consume about 5% of their wealth per year on average. We then calculate the cash flow news using the market return shock and the discount rate news:

$$N_{CF,t+1} = (\mathbf{e1'} + \mathbf{e1'}\lambda)\mathbf{u_{t+1}}. \quad (7)$$

This calculation treats the cash flow news as a residual. In principle, it is possible to model the cash flow news directly. For example, Chen and Zhao (2009) do this by constructing cash flow proxies from annual financial statements data. However, this approach cannot be used to construct a daily time series of the aggregate cash flow news.

Following Atilgan, Bali, and Demirtas (2015), we use a return decomposition based on a daily VAR that includes the log excess return of the S&P 500 index, the dividend yield of the S&P 500 index, the relative Treasury bill rate (the difference between the three-month Treasury bill rate and its moving average over the last 12 months), the credit spread (the difference between the Moody's BAA and AAA bond yields), and the term spread (the difference between the 10-year and three-month constant maturity Treasury yields). The dividend yield of the S&P 500 index is obtained from the OptionMetrics database. All interest rates are obtained from the FRED database. The dividend yield, the relative Treasury bill rate, the credit spread, and the term spread are commonly used predictors of equity market returns (Campbell, 1991; Campbell & Vuolteenaho, 2004; Bernanke & Kuttner, 2005; Fama & French, 1989), and Atilgan et al. (2015) use the same predictors in their return decomposition. To simplify the interpretation of the VAR coefficient estimates, we standardize all VAR variables except the market excess return to a mean of zero and standard deviation of one.

We estimate the VAR using daily data from January 2017 to December 2020. The coefficient estimates are shown in Table A4. All predictor variables except the relative Treasury bill rate are statistically significant in the market excess return equation. The dividend yield positively predicts excess stock returns. The credit spread and the term spread are also significant predictors of next-day returns. There is also some evidence of next-day reversal in the market return. The $R^2$ of the return equation is approximately 9.3%.

We conduct several robustness checks. The results for the cash flow and discount rate news are similar if we shorten the period used in computing the moving average for the

Table A4: Vector Autoregression (VAR) Parameter Estimates

| | Constant | $r^e_{m,t}$ | $DY_t$ | $RTB_t$ | $TS_t$ | $CS_t$ | $R^2$ |
|---|---|---|---|---|---|---|---|
| $r^e_{m,t+1}$ | 0.057 | −0.267*** | 0.190*** | 0.048 | 0.166*** | 0.378*** | 0.093 |
| | (0.040) | (0.086) | (0.103) | (0.072) | (0.060) | (0.127) | |
| $DY_{t+1}$ | −0.002 | 0.020** | 1.002*** | 0.009** | 0.004 | 0.014* | 0.995 |
| | (0.002) | (0.009) | (0.005) | (0.004) | (0.004) | (0.008) | |
| $RTB_{t+1}$ | −0.001 | −0.0002 | 0.004 | 0.999*** | 0.010*** | 0.009** | 0.998 |
| | (0.001) | (0.002) | (0.003) | (0.002) | (0.002) | (0.004) | |
| $TS_{t+1}$ | −0.002 | −0.011 | −0.018 | 0.003 | 0.972*** | −0.021** | 0.971 |
| | (0.005) | (0.007) | (0.011) | (0.005) | (0.007) | (0.010) | |
| $CS_{t+1}$ | 0.001 | −0.005 | −0.108** | −0.029* | −0.068*** | 0.827*** | 0.910 |
| | (0.010) | (0.022) | (0.041) | (0.016) | (0.016) | (0.044) | |

This table shows the OLS parameter estimates for the first-order VAR including a constant, the log excess return of the S&P 500 index ($r^e_{m,t}$), the dividend yield of the S&P 500 index ($DY_t$), the relative Treasury bill rate ($RTB_t$), the term spread ($TS_t$), and the credit spread ($CS_t$). All variables are measured at daily intervals. All variables except the market excess return are standardized to a mean of zero and standard deviation of one. The sample period is from January 2017 through December 2020 and contains 1,006 daily observations. Heteroskedasticity consistent standard errors are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

relative Treasury bill rate, replace the relative Treasury bill rate with a simple daily change in the Treasury bill rate or shorten the sample period used to estimate the VAR to 2018-2020. The results are also similar if we remove the remaining autocorrelation at higher lags from the estimated cash flow news and discount rate news using an autoregressive model.

Table A5 shows correlations of the VAR residuals and their correlations with the estimated cash flow shocks and discount rate shocks in our sample period from January 22, 2020 to December 31, 2020. The unexpected market returns are strongly negatively correlated with the credit spread innovations. In periods of market stress, stock prices decline and credit conditions tighten simultaneously. The correlations of return innovations with cash flow shocks and discount rate shocks are 0.80 and -0.68, respectively. News of higher expected cash flows and lower expected returns leads to higher current stock returns. There is some negative correlation between the cash flow shocks and discount rate shocks. This is consistent with a declining equity risk premium in good economic times when the expectations of corporate cash flows increase (for example, Campbell and Cochrane (1999)).

We then estimate OLS regressions of the cash flow news and discount rate news on the

**Table A5: Correlations of Cash Flow News, Discount Rate News, and VAR Residuals**

| | $r_m^e$ shock | $DY$ shock | $RTB$ shock | $TS$ shock | $CS$ shock | $N_{CF}$ |
|---|---|---|---|---|---|---|
| $DY$ shock | −0.013 | | | | | |
| $RTB$ shock | 0.211*** | 0.352*** | | | | |
| $TS$ shock | 0.326*** | −0.334*** | −0.301*** | | | |
| $CS$ shock | −0.225*** | 0.211*** | 0.063 | −0.126* | | |
| $N_{CF}$ | 0.804*** | −0.054 | −0.139** | 0.228*** | 0.239*** | |
| $N_{DR}$ | −0.678*** | −0.045 | −0.525*** | −0.263*** | 0.671*** | −0.107* |

The table shows Pearson correlations of residuals from the VAR with the estimated cash flow news and discount rate news. The sample period is from January 22, 2020 through December 31, 2020 and contains 240 daily observations. *, **, *** indicate that the correlation is statistically significant at 10%, 5%, and 1% levels, respectively.

vaccine news indicator variable. The results are reported in Table 4 in the paper along with the related discussion.

# 5 Impact of Vaccine Announcements on Developed and Emerging Stock Markets

This section tests whether the impact of vaccine announcements differs between developed and emerging markets. We estimate the following panel regression:

$$R_{i,t} = \alpha_0 + \alpha_1 R_{i,t-1} + \gamma EM_i + \beta_1 Ann_t + \beta_2 Ann_t * EM_i + \theta_i + \epsilon_{i,t}, \quad (8)$$

where $R_{i,t}$ is defined as the log return for the given market $i$ on day $t$, $EM_i$ is an indicator variable equal to one for emerging markets and zero otherwise, and $\theta_i$ stands for the market-specific random effects (i.e., cross-section random effects). We use the MSCI Classification of markets from `https://www.msci.com/market-classification/`. Australia, Canada, Hong Kong, Japan, South Korea, the U.S. and the European countries are classified as developed markets while China, India, Mexico, Nigeria, and South Africa are classified as emerging markets. We include returns for the 19 stock indices analyzed in the paper (the U.S. stock market analyzed in Table 2 and 18 other stock markets analyzed in Table 5). Table A6 reports the results. The coefficient $\beta_2$ is not statistically significant. Therefore, developed and emerging markets do not differ in their reaction to vaccine announcements.

**Table A6: Test for a Difference in the Impact of Vaccine Announcements on Developed and Emerging Stock Markets**

| | |
|---|---|
| Announcement | 0.602 (0.223)*** |
| Announcement*EM | −0.085 (0.143) |
| EM | 0.097 (0.067) |
| Constant | −0.161 (0.120) |
| Number of time periods (Trading days) | 249 |
| Number of cross-sections (Markets) | 19 |
| Total panel observations | 4,535 |

This table shows the results of estimating equation (8) that regresses the log return, $R_{i,t}$ for market $i$ on day $t$, on a constant, one lag of the return, a dummy variable $EM_i$ equal to one for emerging markets and zero otherwise, an indicator variable that takes on the value of one if there is a vaccine announcement on that day and zero otherwise, and an interaction term multiplying this vaccine announcement variable by $EM_i$. The estimation uses a set of vaccine announcements selected as described in Section 4.1. The random effects panel estimator is used. The sample period is from March 23, 2020 to December 31, 2020. Standard errors corrected for correlations across markets are shown in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

# 6 Robustness Checks

This section provides supplementary material for robustness checks mentioned in Section 5 in the paper: where we control for announcements about vaccines developed in China (Section 6.1), the U.S. macroeconomic news announcements (Section 6.2), a general measure of COVID-19 related uncertainty (Section 6.3), and the U.S. daily COVID-19 cases (Section 6.4). Our results are robust in all these tests.

## 6.1 Vaccine Announcements from China

Our analysis includes announcements about the Johnson & Johnson, Moderna, Oxford-AstraZeneca, and Pfitzer-BioNTech vaccines because they are the four vaccines approved in the EU, the U.K., or the U.S. However, a possibility arises that our results are driven by announcements about vaccines not approved in EU, the U.K., or the U.S. but approved in another country. The two such vaccines with the largest market are the Sinopharm-BIBP and Sinovac vaccines developed in China. We collect announcements about these two vaccines from the Sinopharm and Sinovac websites as well as multiple Chinese online media sources and use the time of the first mention of each announcement as the announcement time. There are 30 and 33 announcements for the Sinopharm-BIBP and Sinovac vaccines, respectively.[4] One Sinovac vaccine announcement is negative and we eliminate it following our methodology from Section 3.1. Some announcements occur on the same day; we therefore have 44 trading days with announcements about the Sinopharm-BIBP and/or Sinovac vaccines, 25 of which coincide with the Johnson & Johnson, Moderna, Oxford-AstraZeneca, and/or Pfitzer-BioNTech announcement days.

We estimate OLS regression as in Column (2) of Table 2 while including these announcements as a control variable. Column (1) of Table A7 reports the results. The coefficient on the announcements from China is not statistically significant. The coefficient on our main announcement variable is 0.853 statistically significant at 1% level, which is similar to the coefficient of 0.878 with the same significance level reported in Table 2, indicating that our results are not driven by announcements about the vaccines developed in China.[5]

We also consider the possibility that the announcements about China's vaccines did not affect the U.S. stock market but affected stock markets of countries where the vaccines were expected to be distributed such as the stock markets in China, Hong Kong, or more generally Asia. The results, available upon request, again show statistically insignificant coefficients for the announcements from China while the results from Section 4.2.3 remain unaffected.

These results come with a caveat related to the timeliness and accuracy of the Chinese vaccine announcement data. Our identification strategy requires that we correctly assign

[4] A list of the Sinopharm-BIBP and Sinovac announcements is available upon request.

[5] This estimation uses all Sinopharm-BIBP and Sinovac vaccine announcements. It is possible that some of these announcements are more impactful. We therefore use the methodology described in Section 4.1 to identify more impactful announcements by selecting announcements about the vaccine development stages. There are 21 such announcements. We repeat the estimation while including only these selected 21 announcements. The results (that come with the small sample caveat) are similar.

**Table A7: Impact of Vaccine Announcements on U.S. Stock Market with Additional Control Variables**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Announcement | 0.853*** | 0.880*** | 0.874*** | 0.972*** |
| | (0.231) | (0.232) | (0.230) | (0.226) |
| Constant | −0.191 | −0.168 | −0.295 | −0.175 |
| | (0.170) | (0.155) | (0.247) | (0.162) |
| Vaccine announcements from China | 0.198 | | | |
| | (0.214) | | | |
| U.S. macroeconomic announcements | | 0.035 | | |
| | | (0.142) | | |
| Infectious disease tracker | | | 0.008 | |
| | | | (0.014) | |
| U.S. COVID-19 cases | | | | −0.199 |
| | | | | (0.573) |
| Trading days | 240 | 240 | 240 | 221 |
| Trading days with announcement | 57 | 57 | 57 | 57 |

All specifications show results of estimating regressions similar to that in equation (2) that regresses the daily log return, $R_t$, on a constant, seven lags of return, and an indicator variable that takes on the value of one if there is a vaccine announcement on that day and zero otherwise. The log return is computed as $R_t = ln(P_t/P_{t-1}) * 100$ where $P_t$ where $P_t$ is the closing value of the S&P500 on day $t$. Trading days with announcement indicate the number of days with the Johnson & Johnson, Moderna, Oxford-AstraZeneca, and/or Pfitzer-BioNTech vaccines; all specifications use the set of vaccine announcements selected as described in Section 3.1. Column (1) includes an indicator variable that takes on the value of one if there is an announcement about the Sinopharm-BIBP and/or Sinovac vaccines developed in China on that day and zero otherwise; there are 44 trading days with these announcements, 25 of which coincide with the Johnson & Johnson, Moderna, Oxford-AstraZeneca, and/or Pfitzer-BioNTech announcement days. Column (2) includes the average surprise of 16 U.S. macroeconomic announcements described in Section 6.2. 154 days in the sample contain at last one of these macroeconomic announcements. Column (3) includes the Infectious Disease Tracker variable from Baker, Bloom, Davis, and Terry (2020). Column (4) includes the U.S. COVID-19 cases. The OLS regression is used. For conciseness, the return lags are not reported and are available upon request. The sample period is from January 22, 2020 to December 31, 2020. White (1980) standard errors are shown in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

the announcement release to the date and time when the news was first received by the markets. We use the date and time of the announcement release stated on the Sinopharm and Sinovac websites and Chinese online media sources. If the news were received by the markets before this date and time, the reaction of the markets to the announcement at the official release would be muted and potentially non-existent. Evidence of Chinese data being received by the markets prior to the official release has been documented in previous literature. For example, Reuters Staff (2011) discuss a case of two government officials imprisoned for leaking macroeconomic data. Some studies, such as Koch-Weser (2013), have pointed to data quality issues. However, Chow (2006) argues that China's data is to a great extent reliable and Baum, Kurov, and Wolfe (2015) show that Chinese macroeconomic data moves global markets in spite of any potential information leakage.

## 6.2 U.S. Macroeconomic Announcements

This robustness check controls for scheduled U.S. macroeconomic news. We use 16 macroeconomic announcements based on Kurov, Sancetta, Strasser, and Wolfe (2019). Following the literature on macroeconomic announcements (for example, Kurov et al. (2019)), we compute a standardized surprise for each announcement release as the difference between the actual announced value and the Bloomberg consensus forecast value divided by the standard deviation of the announcement surprises for that particular announcement. All 16 announcements are released monthly except for the Initial Jobless Claims released weekly; since our sample period is relatively short, we aggregate surprises for the 16 announcements into a single variable.[6] Specifically, we compute the average standardized surprise for all announcements released on a given day $t$. We estimate a regression as in Column (2) of Table 2 while including this average surprise as a control variable.

The results are reported in Column (2) of Table A7. The coefficient on the announcement variable is 0.880 and statistically significant at 1% level, which is identical to the result in Table 2, indicating that our results are not driven by the U.S. macroeconomic news. The

[6]We follow Kurov et al. (2019) who identify 16 scheduled U.S. macroeconomic announcements that move intraday S&P 500 index futures returns at 1% significance level: ADP Employment Change, Change in Nonfarm Payrolls, Conference Board Consumer Confidence, the Consumer Price Index (CPI), Durable Goods Orders, Existing Home Sales, Gross Domestic Product (GDP), Housing Starts, Industrial Production, Initial Jobless Claims, ISM Manufacturing Index, ISM Services Index, New Home Sales, Pending Home Sales, Retail Sales Advance, and the University of Michigan Sentiment (preliminary). When computing the mean surprise, we reverse the sign of the CPI and Initial Jobless Claims surprises because their positive surprises have a negative effect on stock prices in Kurov et al. (2019). Since the Initial Jobless Claims showed enormous surprise values at the beginning of the COVID-19 recession due to mass layoffs, we repeat the analysis without the three largest observations of Initial Jobless Claims surprises on March 26, April 2, and April 9 of 2020 to ensure that our results are not driven by these outliers. In addition, we repeat the analysis while excluding all employment announcements (ADP Employment Change, Change in Nonfarm Payroll, and Initial Jobless Claims). These results (available upon request) are almost identical to the results in Table A7 Column (2).

coefficient estimate of the average macroeconomic surprise is not statistically significant. Two possible reasons may account for this finding. First, according to the estimates of Kurov et al. (2019) based on intraday data, the average effect of the 16 macroeconomic announcements on the S&P500 index is approximately 0.14%. In comparison, the standard deviation of daily S&P500 returns for our sample period is 2.24% in Table 1. This makes it difficult to discern the effect of these announcements in daily data. Second, Andersen, Bollerslev, Diebold, and Vega (2007) show that the reaction of the stock market to macroeconomic news depends on the state of the economy. Specifically, good macroeconomic news is often bad news for stocks during economic expansions because it makes tightening of monetary policy likelier. Our sample includes a deep but short recession induced by the pandemic followed by a robust economic recovery aided by extraordinary monetary and fiscal support. Therefore, good economic news during the expansion reduces the expected fiscal stimulus and makes normalization of monetary policy likelier, resulting in insignificant average effect of macroeconomic news on U.S. stock prices in our sample period.

## 6.3 Infectious Disease Tracker

Baker et al. (2020) show that uncertainty skyrocketed at the onset of the pandemic. They discuss that uncertainty enveloped many aspects of the COVID-19 disease such as infectiousness of the virus, lethality, testing accuracy, and implementation of mitigation measures. Therefore it is possible that our results are driven by news about these other aspects of the pandemic rather than our vaccine announcements. Baker et al. (2020) construct a daily measure of COVID-19 related uncertainty, called Infectious Disease Tracker, based on newspaper-based economic uncertainty, uncertainty in business expectation surveys, and stock market volatility and show that this variable is a real-time, forward-looking uncertainty measure. We obtain data for this variable from the FRED database. We estimate a regression similar to that in Column (2) of Table 2 while including this variable. Column (3) of Table A7 reports the results. The coefficient on the infectious disease tracker is not statistically significant. The coefficient on the announcement variable is 0.874 statistically significant at 1% level, which is similar to the coefficient of 0.878 with the same significance level in Column (2) of Table 2, indicating that our results are not driven by this general measure of COVID-19 related uncertainty.

### 6.4 U.S. COVID-19 Cases

Similarly to other countries, the U.S. experienced several waves of COVID-19 cases. In this section, we analyze the impact of the daily U.S. cases using data from Our World in Data website.[7] We compute the relative change from the previous available day as $\frac{COVID\ Cases_t - COVID\ Cases_{t-1}}{COVID\ Cases_{t-1}}$ where $COVID\ Cases_t$ is the number of new COVID-19 cases on day $t$. This variable has data for 221 out of our 240 trading days because of zero cases at the beginning of the sample. We estimate a regression similar to that in Column (2) of Table 2 while including this variable. Column (4) of Table A7 reports the results. The coefficient on the U.S. COVID-19 cases variable is not statistically significant. The coefficient on the announcement variable is 0.972 and statistically significant at 1% level, which is similar to the coefficient of 0.878 with the same significance level in Column (2) of Table 2, indicating that our results are not driven by the U.S. COVID-19 cases.

[7]The website is `ourworldindata.org/covid-cases`.

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