



#virus

Data Science

Coronavirus Model Update

In *Modeling Coronavirus Progress*, January 31, 2020, we discussed how epidemiologists model outbreaks and used a simple version of the standard SEIR model to provide thresholds to help investors translate daily announced counts of cases in China into a gauge of whether containment efforts were curtailing the spread.

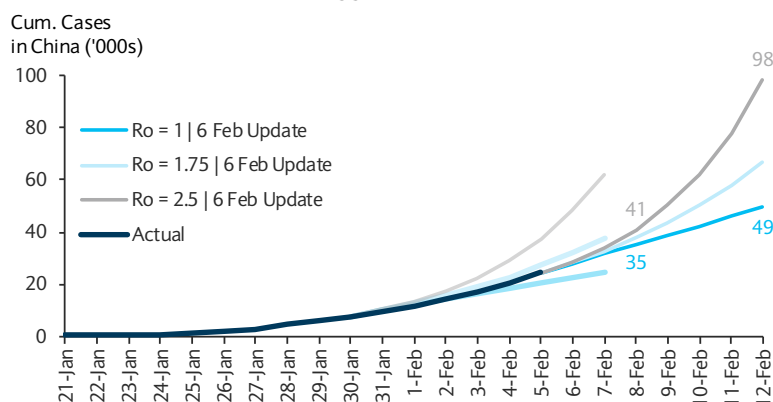
The key model parameter on which we are focused is the effective reproductive rate (R_0 , the number of new infections for each existing one). If the data are consistent with $R_0 > 1$, it implies exponential growth in the number of cases and an outbreak that is not yet on the path to containment. Data suggesting $R_0 < 1$ indicate that measures have been effective in cutting off new infections and can eventually be relaxed as exposed people leave the window of time when they could be infectious.

Our initial model fit suggested a R_0 of 2.31. From that, we created projections consistent with some critical values of R_0 . Since then, the data have tracked above the $R_0 = 1$ line, but below the $R_0 = 1.75$ line (Figure 1), suggesting progress but also the need for incremental control measures.

Because time spent on a given path renders the prior projections less meaningful, we re-fit the model to include data that have arrived since our initial publication (which represents a period after the most significant containment steps had been launched). We re-project from the current level to provide a new set of thresholds (Figure 1).

- From current levels, our new $R_0 = 1$ scenario implies the World Health Organization (WHO) reporting 35k cases in China in their Saturday, 8 February, situation update, and 49k by Wednesday, 12 February. If case growth remains above that line, containment measures are still likely to need to be expanded, rather than reduced.

FIGURE 1
Updated Case Growth Numbers Suggest



Source: WHO, Barclays Research

Barclays Capital Inc. and/or one of its affiliates does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision.

This is a Special Report that is not an equity or a debt research report under U.S. FINRA Rules 2241-2242.

FOR ANALYST CERTIFICATION(S) PLEASE SEE PAGE 2

FOR IMPORTANT FIXED INCOME RESEARCH DISCLOSURES, PLEASE SEE PAGE 2

FOR IMPORTANT EQUITY RESEARCH DISCLOSURES, PLEASE SEE PAGE 2

Special Report

Research

6 February 2020

Adam Kelleher**

+1 212 526 5697

adam.kelleher@barclays.com

BCI, US

Ryan Preclaw

+1 212 412 2249

ryan.preclaw@barclays.com

BCI, US

www.barclays.com

*** This author is a member of the Fixed Income, Currencies, and Commodities Research department and is not an equity or debt research analyst.*

Analyst Certification

We, Adam Kelleher and Ryan Preclaw, hereby certify (1) that the views expressed in this research report accurately reflect our personal views about any or all of the subject securities or issuers referred to in this research report and (2) no part of our compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed in this research report.

Important Disclosures:

Barclays Research is produced by the Investment Bank of Barclays Bank PLC and its affiliates (collectively and each individually, "Barclays").

All authors contributing to this research report are Research Analysts unless otherwise indicated. The publication date at the top of the report reflects the local time where the report was produced and may differ from the release date provided in GMT.

Availability of Disclosures:

For current important disclosures regarding any issuers which are the subject of this research report please refer to <https://publicresearch.barclays.com> or alternatively send a written request to: Barclays Research Compliance, 745 Seventh Avenue, 13th Floor, New York, NY 10019 or call +1-212-526-1072.

Barclays Capital Inc. and/or one of its affiliates does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that Barclays may have a conflict of interest that could affect the objectivity of this report. Barclays Capital Inc. and/or one of its affiliates regularly trades, generally deals as principal and generally provides liquidity (as market maker or otherwise) in the debt securities that are the subject of this research report (and related derivatives thereof). Barclays trading desks may have either a long and / or short position in such securities, other financial instruments and / or derivatives, which may pose a conflict with the interests of investing customers. Where permitted and subject to appropriate information barrier restrictions, Barclays fixed income research analysts regularly interact with its trading desk personnel regarding current market conditions and prices. Barclays fixed income research analysts receive compensation based on various factors including, but not limited to, the quality of their work, the overall performance of the firm (including the profitability of the Investment Banking Department), the profitability and revenues of the Markets business and the potential interest of the firm's investing clients in research with respect to the asset class covered by the analyst. To the extent that any historical pricing information was obtained from Barclays trading desks, the firm makes no representation that it is accurate or complete. All levels, prices and spreads are historical and do not necessarily represent current market levels, prices or spreads, some or all of which may have changed since the publication of this document. Barclays Research Department produces various types of research including, but not limited to, fundamental analysis, equity-linked analysis, quantitative analysis, and trade ideas. Recommendations and trade ideas contained in one type of Barclays Research may differ from those contained in other types of Barclays Research, whether as a result of differing time horizons, methodologies, or otherwise. In order to access Barclays Statement regarding Research Dissemination Policies and Procedures, please refer to <https://publicresearch.barclays.com/S/RD.htm>. In order to access Barclays Research Conflict Management Policy Statement, please refer to: <https://publicresearch.barclays.com/S/CM.htm>.

All pricing information is indicative only. Unless otherwise indicated, prices are sourced from Refinitiv and reflect the closing price in the relevant trading market, which may not be the last available price at the time of publication.

Types of investment recommendations produced by Barclays FICC Research:

In addition to any ratings assigned under Barclays' formal rating systems, this publication may contain investment recommendations in the form of trade ideas, thematic screens, scorecards or portfolio recommendations that have been produced by analysts in FICC Research. Any such investment recommendations produced by non-Credit Research teams shall remain open until they are subsequently amended, rebalanced or closed in a future research report. Any such investment recommendations produced by the Credit Research teams are valid at current market conditions and may not be otherwise relied upon.

Disclosure of other investment recommendations produced by Barclays FICC Research:

Barclays FICC Research may have published other investment recommendations in respect of the same securities/instruments recommended in this research report during the preceding 12 months. To view all investment recommendations published by Barclays FICC Research in the preceding 12 months please refer to <https://live.barclays.com/go/research/Recommendations>.

Important Disclosures (EQUITY RESEARCH):

Barclays Research is produced by the Investment Bank of Barclays Bank PLC and its affiliates (collectively and each individually, "Barclays").

All authors contributing to this research report are Research Analysts unless otherwise indicated. The publication date at the top of the report reflects the local time where the report was produced and may differ from the release date provided in GMT.

Availability of Disclosures:

Where any companies are the subject of this research report, for current important disclosures regarding those companies please refer to <https://publicresearch.barclays.com> or alternatively send a written request to: Barclays Research Compliance, 745 Seventh Avenue, 13th Floor, New York, NY 10019 or call +1-212-526-1072.

The analysts responsible for preparing this research report have received compensation based upon various factors including the firm's total revenues, a portion of which is generated by investment banking activities, the profitability and revenues of the Markets business and the potential interest of the firm's investing clients in research with respect to the asset class covered by the analyst.

Research analysts employed outside the US by affiliates of Barclays Capital Inc. are not registered/qualified as research analysts with FINRA. Such non-US research analysts may not be associated persons of Barclays Capital Inc., which is a FINRA member, and therefore may not be subject to FINRA Rule 2241 restrictions on communications with a subject company, public appearances and trading securities held by a research analyst's account.

Analysts regularly conduct site visits to view the material operations of covered companies, but Barclays policy prohibits them from accepting payment or reimbursement by any covered company of their travel expenses for such visits.

Barclays Research Department produces various types of research including, but not limited to, fundamental analysis, equity-linked analysis,

quantitative analysis, and trade ideas. Recommendations contained in one type of Barclays Research may differ from those contained in other types of Barclays Research, whether as a result of differing time horizons, methodologies, or otherwise.

In order to access Barclays Statement regarding Research Dissemination Policies and Procedures, please refer to

<https://publicresearch.barcap.com/S/RD.htm>. In order to access Barclays Research Conflict Management Policy Statement, please refer to:

<https://publicresearch.barcap.com/S/CM.htm>.

Legal entities involved in producing Barclays Research:

Barclays Bank PLC (Barclays, UK)

Barclays Capital Inc. (BCI, US)

Barclays Bank Ireland PLC, Frankfurt Branch (BBI, Frankfurt)

Barclays Bank Ireland PLC, Paris Branch (BBI, Paris)

Barclays Bank Ireland PLC, Milan Branch (BBI, Milan)

Barclays Securities Japan Limited (BSJL, Japan)

Barclays Bank PLC, Hong Kong branch (Barclays Bank, Hong Kong)

Barclays Capital Canada Inc. (BCCI, Canada)

Barclays Bank Mexico, S.A. (BBMX, Mexico)

Barclays Securities (India) Private Limited (BSIPL, India)

Barclays Bank PLC, India branch (Barclays Bank, India)

Barclays Bank PLC, Singapore branch (Barclays Bank, Singapore)

Barclays Bank PLC, DIFC Branch (Barclays Bank, DIFC)

Disclaimer:

This publication has been produced by Barclays Research Department in the Investment Bank of Barclays Bank PLC and/or one or more of its affiliates (collectively and each individually, "Barclays"). It has been prepared for institutional investors and not for retail investors. It has been distributed by one or more Barclays affiliated legal entities listed below. It is provided to our clients for information purposes only, and Barclays makes no express or implied warranties, and expressly disclaims all warranties of merchantability or fitness for a particular purpose or use with respect to any data included in this publication. To the extent that this publication states on the front page that it is intended for institutional investors and is not subject to all of the independence and disclosure standards applicable to debt research reports prepared for retail investors under U.S. FINRA Rule 2242, it is an "institutional debt research report" and distribution to retail investors is strictly prohibited. Barclays also distributes such institutional debt research reports to various issuers, media, regulatory and academic organisations for their own internal informational news gathering, regulatory or academic purposes and not for the purpose of making investment decisions regarding any debt securities. Media organisations are prohibited from re-publishing any opinion or recommendation concerning a debt issuer or debt security contained in any Barclays institutional debt research report. Any such recipients that do not want to continue receiving Barclays institutional debt research reports should contact debtresearch@barclays.com. Clients that are subscribed to receive equity research reports, will not receive certain cross asset research reports co-authored by equity and FICC research analysts that are distributed as "institutional debt research reports" unless they have agreed to accept such reports. Eligible clients may get access to such cross asset reports by contacting debtresearch@barclays.com. Barclays will not treat unauthorized recipients of this report as its clients and accepts no liability for use by them of the contents which may not be suitable for their personal use. Prices shown are indicative and Barclays is not offering to buy or sell or soliciting offers to buy or sell any financial instrument.

Without limiting any of the foregoing and to the extent permitted by law, in no event shall Barclays, nor any affiliate, nor any of their respective officers, directors, partners, or employees have any liability for (a) any special, punitive, indirect, or consequential damages; or (b) any lost profits, lost revenue, loss of anticipated savings or loss of opportunity or other financial loss, even if notified of the possibility of such damages, arising from any use of this publication or its contents.

Other than disclosures relating to Barclays, the information contained in this publication has been obtained from sources that Barclays Research believes to be reliable, but Barclays does not represent or warrant that it is accurate or complete. Barclays is not responsible for, and makes no warranties whatsoever as to, the information or opinions contained in any written, electronic, audio or video presentations of third parties that are accessible via a direct hyperlink in this publication or via a hyperlink to a third-party web site ("Third-Party Content"). Any such Third-Party Content has not been adopted or endorsed by Barclays, does not represent the views or opinions of Barclays, and is not incorporated by reference into this publication. Third-Party Content is provided for information purposes only and Barclays has not independently verified its accuracy or completeness.

The views in this publication are solely and exclusively those of the authoring analyst(s) and are subject to change, and Barclays Research has no obligation to update its opinions or the information in this publication. Unless otherwise disclosed herein, the analysts who authored this report have not received any compensation from the subject companies in the past 12 months. If this publication contains recommendations, they are general recommendations that were prepared independently of any other interests, including those of Barclays and/or its affiliates, and/or the subject companies. This publication does not contain personal investment recommendations or investment advice or take into account the individual financial circumstances or investment objectives of the clients who receive it. The securities and other investments discussed herein may not be suitable for all investors. Barclays is not a fiduciary to any recipient of this publication. Investors must independently evaluate the merits and risks of the investments discussed herein, consult any independent advisors they believe necessary, and exercise independent judgment with regard to any investment decision. The value of and income from any investment may fluctuate from day to day as a result of changes in relevant economic markets (including changes in market liquidity). The information herein is not intended to predict actual results, which may differ substantially from those reflected. Past performance is not necessarily indicative of future results. The information provided does not constitute a financial benchmark and should not be used as a submission or contribution of input data for the purposes of determining a financial benchmark.

United Kingdom: This document is being distributed (1) only by or with the approval of an authorised person (Barclays Bank PLC) or (2) to, and is directed at (a) persons in the United Kingdom having professional experience in matters relating to investments and who fall within the definition of "investment professionals" in Article 19(5) of the Financial Services and Markets Act 2000 (Financial Promotion) Order 2005 (the "Order"); or (b) high net worth companies, unincorporated associations and partnerships and trustees of high value trusts as described in Article 49(2) of the Order; or (c) other persons to whom it may otherwise lawfully be communicated (all such persons being "Relevant Persons"). Any investment or investment activity to which

this communication relates is only available to and will only be engaged in with Relevant Persons. Any other persons who receive this communication should not rely on or act upon it. Barclays Bank PLC is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority and is a member of the London Stock Exchange.

European Economic Area ("EEA"): This material is being distributed in the EEA by Barclays Bank PLC. Barclays Bank PLC is not registered in France with the Autorité des marchés financiers or the Autorité de contrôle prudentiel.

Americas: The Investment Bank of Barclays Bank PLC undertakes U.S. securities business in the name of its wholly owned subsidiary Barclays Capital Inc., a FINRA and SIPC member. Barclays Capital Inc., a U.S. registered broker/dealer, is distributing this material in the United States and, in connection therewith accepts responsibility for its contents. Any U.S. person wishing to effect a transaction in any security discussed herein should do so only by contacting a representative of Barclays Capital Inc. in the U.S. at 745 Seventh Avenue, New York, New York 10019.

Non-U.S. persons should contact and execute transactions through a Barclays Bank PLC branch or affiliate in their home jurisdiction unless local regulations permit otherwise.

This material is distributed in Canada by Barclays Capital Canada Inc., a registered investment dealer, a Dealer Member of IIROC (www.iiroc.ca), and a Member of the Canadian Investor Protection Fund (CIPF).

This material is distributed in Mexico by Barclays Bank Mexico, S.A. This material is distributed in the Cayman Islands and in the Bahamas by Barclays Capital Inc., which it is not licensed or registered to conduct and does not conduct business in, from or within those jurisdictions and has not filed this material with any regulatory body in those jurisdictions.

Japan: This material is being distributed to institutional investors in Japan by Barclays Securities Japan Limited. Barclays Securities Japan Limited is a joint-stock company incorporated in Japan with registered office of 6-10-1 Roppongi, Minato-ku, Tokyo 106-6131, Japan. It is a subsidiary of Barclays Bank PLC and a registered financial instruments firm regulated by the Financial Services Agency of Japan. Registered Number: Kanto Zaimukyokuchō (kinsho) No. 143.

Asia Pacific (excluding Japan): Barclays Bank PLC, Hong Kong Branch is distributing this material in Hong Kong as an authorised institution regulated by the Hong Kong Monetary Authority. Registered Office: 41/F, Cheung Kong Center, 2 Queen's Road Central, Hong Kong.

All Indian securities-related research and other equity research produced by Barclays' Investment Bank are distributed in India by Barclays Securities (India) Private Limited (BSIPL). BSIPL is a company incorporated under the Companies Act, 1956 having CIN U67120MH2006PTC161063. BSIPL is registered and regulated by the Securities and Exchange Board of India (SEBI) as a Research Analyst: INH000001519; Portfolio Manager INP000002585; Stock Broker/Trading and Clearing Member: National Stock Exchange of India Limited (NSE) Capital Market INB231292732, NSE Futures & Options INF231292732, NSE Currency derivatives INE231450334, Bombay Stock Exchange Limited (BSE) Capital Market INB011292738, BSE Futures & Options INF011292738; Depository Participant (DP) with the National Securities & Depositories Limited (NSDL): DP ID: IN-DP-NSDL-299-2008; Investment Adviser: INA000000391. The registered office of BSIPL is at 208, Ceejay House, Shivasagar Estate, Dr. A. Besant Road, Worli, Mumbai – 400 018, India. Telephone No: +91 2267196000. Fax number: +91 22 67196100. Any other reports produced by Barclays' Investment Bank are distributed in India by Barclays Bank PLC, India Branch, an associate of BSIPL in India that is registered with Reserve Bank of India (RBI) as a Banking Company under the provisions of The Banking Regulation Act, 1949 (Regn No BOM43) and registered with SEBI as Merchant Banker (Regn No INM000002129) and also as Banker to the Issue (Regn No INBI00000950). Barclays Investments and Loans (India) Limited, registered with RBI as Non Banking Financial Company (Regn No RBI CoR-07-00258), and Barclays Wealth Trustees (India) Private Limited, registered with Registrar of Companies (CIN U93000MH2008PTC188438), are associates of BSIPL in India that are not authorised to distribute any reports produced by Barclays' Investment Bank.

This material is distributed in Singapore by the Singapore branch of Barclays Bank PLC, a bank licensed in Singapore by the Monetary Authority of Singapore. For matters in connection with this material, recipients in Singapore may contact the Singapore branch of Barclays Bank PLC, whose registered address is 10 Marina Boulevard, #23-01 Marina Bay Financial Centre Tower 2, Singapore 018983.

This material is distributed to persons in Australia by Barclays Bank PLC. None of Barclays Bank PLC, nor any other Barclays group entity, holds an Australian financial services licence and instead relies on an exemption from the requirement to hold such a licence. This material is intended to only be distributed to "wholesale clients" as defined by the Australian Corporations Act 2001. This material is distributed in New Zealand by Barclays Bank PLC, but it has not been registered, filed or approved by any New Zealand regulatory authority or under or in accordance with the Financial Markets Conduct Act of 2013, and this material is not a disclosure document under New Zealand law.

Middle East: Nothing herein should be considered investment advice as defined in the Israeli Regulation of Investment Advisory, Investment Marketing and Portfolio Management Law, 1995 ("Advisory Law"). This document is being made to eligible clients (as defined under the Advisory Law) only. Barclays Israeli branch previously held an investment marketing license with the Israel Securities Authority but it cancelled such license on 30/11/2014 as it solely provides its services to eligible clients pursuant to available exemptions under the Advisory Law, therefore a license with the Israel Securities Authority is not required. Accordingly, Barclays does not maintain an insurance coverage pursuant to the Advisory Law.

This material is distributed in the United Arab Emirates (including the Dubai International Financial Centre) and Qatar by Barclays Bank PLC. Barclays Bank PLC in the Dubai International Financial Centre (Registered No. 0060) is regulated by the Dubai Financial Services Authority (DFSA). Principal place of business in the Dubai International Financial Centre: The Gate Village, Building 4, Level 4, PO Box 506504, Dubai, United Arab Emirates. Barclays Bank PLC-DIFC Branch, may only undertake the financial services activities that fall within the scope of its existing DFSA licence. Related financial products or services are only available to Professional Clients, as defined by the Dubai Financial Services Authority. Barclays Bank PLC in the UAE is regulated by the Central Bank of the UAE and is licensed to conduct business activities as a branch of a commercial bank incorporated outside the UAE in Dubai (Licence No.: 13/1844/2008, Registered Office: Building No. 6, Burj Dubai Business Hub, Sheikh Zayed Road, Dubai City) and Abu Dhabi (Licence No.: 13/952/2008, Registered Office: Al Jazira Towers, Hamdan Street, PO Box 2734, Abu Dhabi). This material does not constitute or form part of any offer to issue or sell, or any solicitation of any offer to subscribe for or purchase, any securities or investment products in the UAE (including the Dubai International Financial Centre) and accordingly should not be construed as such. Furthermore, this information is being made available on the basis that the recipient acknowledges and understands that the entities and securities to which it may relate have not been approved, licensed by or registered with the UAE Central Bank, the Dubai Financial Services Authority or any other relevant licensing authority or governmental agency in the UAE. The content of this report has not been approved by or filed with the UAE Central Bank or Dubai Financial Services Authority. Barclays Bank PLC in the Qatar Financial Centre (Registered No. 00018) is authorised by the Qatar Financial Centre Regulatory Authority (QFCRA). Barclays Bank PLC-QFC Branch may only undertake the regulated activities that fall within the scope of its existing QFCRA licence. Principal place of business in Qatar: Qatar Financial Centre, Office 1002, 10th Floor, QFC Tower, Diplomatic Area, West Bay, PO Box 15891, Doha, Qatar. Related financial products or services are only available to Business Customers as defined by the Qatar Financial Centre Regulatory Authority.

Russia: This material is not intended for investors who are not Qualified Investors according to the laws of the Russian Federation as it might contain

information about or description of the features of financial instruments not admitted for public offering and/or circulation in the Russian Federation and thus not eligible for non-Qualified Investors. If you are not a Qualified Investor according to the laws of the Russian Federation, please dispose of any copy of this material in your possession.

IRS Circular 230 Prepared Materials Disclaimer: Barclays does not provide tax advice and nothing contained herein should be construed to be tax advice. Please be advised that any discussion of U.S. tax matters contained herein (including any attachments) (i) is not intended or written to be used, and cannot be used, by you for the purpose of avoiding U.S. tax-related penalties; and (ii) was written to support the promotion or marketing of the transactions or other matters addressed herein. Accordingly, you should seek advice based on your particular circumstances from an independent tax advisor.

© Copyright Barclays Bank PLC (2020). All rights reserved. No part of this publication may be reproduced or redistributed in any manner without the prior written permission of Barclays. Barclays Bank PLC is registered in England No. 1026167. Registered office 1 Churchill Place, London, E14 5HP. Additional information regarding this publication will be furnished upon request.

