

This report is neither intended to be distributed to Mainland China investors nor to provide securities investment consultancy services within the territory of Mainland China. This report or any portion hereof may not be reprinted, sold or redistributed without the written consent of J.P. Morgan.



Big Data and AI Strategies

Summary of JPM Cross Asset, Equity & Strategy Research as well as Industry Developments in 2H20



Big Data and AI Strategies

Berowne Hlavaty ^{AC}

(61-2) 9003-8602
berowne.d.hlavaty@jpmorgan.com
J.P. Morgan Securities Australia Limited

Robert Smith, PhD

(61-2) 9003-8808
robert.z.smith@jpmorgan.com
J.P. Morgan Securities Australia Limited

Evan Hu

(852) 2800-8508
Evan.hu@jpmorgan.com
J.P. Morgan Securities (Asia Pacific) Limited/ J.P. Morgan Broking (Hong Kong) Limited

Global Head of Quantitative & Derivatives Strategy

Marko Kolanovic, PhD

(1-212) 272-1438
marko.kolanovic@jpmorgan.com
J.P. Morgan Securities LLC

Dubravko Lakos-Bujas

(1-212) 622-3601
dubravko.lakos-bujas@jpmorgan.com
J.P. Morgan Securities LLC

Arun Jain

(1-212) 622-9454
arun.p.jain@jpmorgan.com
J.P. Morgan Securities LLC

Peng Cheng, CFA

(1-212) 622-5036
peng.cheng@jpmorgan.com
J.P. Morgan Securities LLC

Ada Lau

(852) 2800-7618
ada.lau@jpmorgan.com
J.P. Morgan Securities (Asia Pacific) Limited/ J.P. Morgan Broking (Hong Kong) Limited

Priyanka Ranjan

(9122) 6157-3294
priyanka.ranjan@jpmorgan.com
J.P. Morgan India Private Limited

Khuram Chaudhry

(44-20) 7134-6297
khuram.chaudhry@jpmorgan.com
J.P. Morgan Securities plc

Ayub Hanif, PhD

(44-20) 7742-5620
ayub.hanif@jpmorgan.com
J.P. Morgan Securities plc

Dobromir Tzotchev, PhD

(44-20) 7134-5331
dobromir.tzotchev@jpmorgan.com
J.P. Morgan Securities plc

See page 46 for analyst certification and important disclosures, including non-US analyst disclosures.

J.P. Morgan 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.

www.jpmorganmarkets.com

Table of Contents

J.P. Morgan Research Contacts	3
Executive Summary	5
Super-Human AI.....	6
2021 Forecasts	8
2H20: J.P. Morgan Equity Research	10
COVID-19 Trackers and Reports.....	11
Alt-Data & Data-Driven Reports	13
Machine Learning Reports	16
NLP Reports	18
Conferences, Forums and Tutorials	19
DeepFin Machine Learning Tutorials in 2020	19
Industry Developments and News	21
ML&AI Developments.....	22
Natural Language Processing (NLP).....	23
Natural Language Understanding (NLU)	24
Natural Language Generation (NLG).....	25
Chat Bots	26
Ethical Issues of AI	27
DeepFakes	29
Machine Learning (ML) Techniques & Tools	30
Automated Machine Learning	35
Data & Labels	36
Quantum Computing	38
CPU, GPU, TPU, IPU, RPU & Other Hardware Developments.....	39
Wetware – Human Computer Interfaces.....	41
Healthcare and COVID-19	42
Software (S/W) & Tool Developments	43
Recommended Reading	44
J.P. Morgan Alternative Data Tools & APIs	45
DataQuery	45
J.P. Morgan Developer	45
Data feeds	45

J.P. Morgan Research Contacts

Global Equity Research

Adrian E Huerta

US Machinery, Engineering & Construction /
Latin America Cement & Construction /
Latin America Real
J.P. Morgan Casa de Bolsa, S.A. de C.V.,
J.P. Morgan Grupo Financiero
adrian.huerta@jpmorgan.com

Alan Hon

Utilities and Environmental
J.P. Morgan Securities (Asia Pacific)
Limited /
J.P. Morgan Broking (Hong Kong) Limited
alan.hon@jpmorgan.com

Alberto Lopez Rueda

EMEA Data-Driven Research
J.P. Morgan Securities plc
alberto.lopezrueda@jpmorgan.com

Alexia S. Quadrani

Media
J.P. Morgan Securities LLC
alexia.quadrani@jpmorgan.com

Andrew C. Steinerman

Business & Information Services
J.P. Morgan Securities LLC
andrew.steinerman@jpmorgan.com

Ankur Rudra

Technology, IT Services, Telecoms &
Internet
J.P. Morgan India Private Limited
ankur.rudra@jpmorgan.com

Anthony Paolone

REITs
J.P. Morgan Securities LLC
anthony.paolone@jpmorgan.com

Ashik Musaddi

European Insurance
J.P. Morgan Securities plc
ashik.x.musaddi@jpmorgan.com

Bob Chen

Emerging Companies
J.P. Morgan Securities Australia Limited
bob.chen@jpmorgan.com

Brandt Montour

Leisure
J.P. Morgan Securities LLC
brandt.a.montour@jpmorgan.com

C. Stephen Tusa

Electrical Equipment & Multi-Industry
J.P. Morgan Securities LLC
stephen.tusa@jpmorgan.com

Celine Pannuti

European Consumer Goods and
Beverages
J.P. Morgan Securities plc
celine.pannuti@jpmorgan.com

Chetan Udeshi

European Chemicals
J.P. Morgan Securities plc
chetan.x.udeshi@jpmorgan.com

Christopher Brown

UK Investment Companies
J.P. Morgan Securities plc
christopher.brown@jpmorgan.com

Cory Kasimov

Biotechnology – Large Cap
J.P. Morgan Securities LLC
cory.w.kasimov@jpmorgan.com

David H Perry

European Airlines, Aerospace &
Defence
J.P. Morgan Securities plc
david.h.perry@jpmorgan.com

David Karnovsky

Media
J.P. Morgan Securities LLC
david.karnovsky@jpmorgan.com

David Low

Australia Healthcare
J.P. Morgan Securities Australia
Limited
david.low@jpmorgan.com

Deepika Mundra

India Insurance, Hotels, Transport
and Logistics
J.P. Morgan India Private Limited
deepika.mundra@jpmorgan.com

Domingos Falavina

Latin American Financials
J.P. Morgan Securities LLC
domingos.falavina@jpmorgan.com

Don Carducci

Australian Gaming & Internet/Media
J.P. Morgan Securities Australia
Limited
donald.n.carducci@jpmorgan.com

Doug Anmuth

Internet - Large Cap / Mid & Small
Cap
J.P. Morgan Securities LLC
douglas.anmuth@jpmorgan.com

Elodie Rall

European Construction, Building
Materials & Infrastructure
J.P. Morgan Securities plc
elodie.rall@jpmorgan.com

Estelle Weingrod

European Food Retail, Hotels &
Leisure
J.P. Morgan Securities plc
estelle.weingrod@jpmorgan.com

Fernando Abdalla

Latin American Transportation & Utilities
Banco J.P. Morgan S.A.
fernando.abdalla@jpmorgan.com

Georgina Johanan

Head of European General Retail
J.P. Morgan Securities plc
georgina.s.johanan@jpmorgan.com

Gokul Hariharan

Technology
J.P. Morgan Securities (Asia Pacific)
Limited/
J.P. Morgan Broking (Hong Kong) Limited
gokul.hariharan@jpmorgan.com

Guilherme Grespan

Latin American Financials
Banco J.P. Morgan S.A.
guilherme.grespan@jpmorgan.com

Hisashi Moriyama

Electronics/Industrial & Precision
JPMorgan Securities Japan Co., Ltd.
hisashi.moriyama@jpmorgan.com

James D Gordon

European Healthcare (Pharma, Biotech)
J.P. Morgan Securities plc
james.d.gordon@jpmorgan.com

James R. Sullivan

Head of Asia ex Japan Research and
APAC Telecommunications Research
J.P. Morgan Securities Singapore Private
Limited/
J.P. Morgan Securities (Asia Pacific)
Limited/
J.P. Morgan Broking (Hong Kong) Limited
james.r.sullivan@jpmorgan.com

Jamie Baker

Airlines
J.P. Morgan Securities LLC
jamie.baker@jpmorgan.com

Jason Steed

Australia Equity Strategy
J.P. Morgan Securities Australia Limited
jason.h.steed@jpmorgan.com

Jay Kwon

Technology - Semiconductors
J.P. Morgan Securities (Far East) Limited,
Seoul Branch
jay.h.kwon@jpmorgan.com

Jean-Xavier Hecker

ESG & Sustainability research
J.P. Morgan Securities plc
jean-xavier.hecker@jpmorgan.com

Jessica Fye

SMid Biotechnology
J.P. Morgan Securities LLC
jessica.m.fye@jpmorgan.com

Jimmy S. Bhullar

Insurance - Life & Nonlife
J.P. Morgan Securities LLC
jimmy.s.bhullar@jpmorgan.com

Joanne Cheung

HK Strategy, Conglomerates
J.P. Morgan Securities (Asia Pacific)
Limited/
J.P. Morgan Broking (Hong Kong)
Limited
joanne.cy.cheung@jpmorgan.com

Joseph Giordano

LatAm Retail & Healthcare
Banco J.P. Morgan S.A.
joseph.giordano@jpmorgan.com

Joseph Greff

Gaming & Lodging
J.P. Morgan Securities LLC
joseph.greff@jpmorgan.com

Karen Li

Infrastructure, Industrials & Transport
J.P. Morgan Securities (Asia Pacific)
Limited/
J.P. Morgan Broking (Hong Kong)
Limited
karen.yy.li@jpmorgan.com

Latika Chopra

Consumer, Retail, Media
J.P. Morgan India Private Limited
latika.chopra@jpmorgan.com

Ling Wang

Healthcare and SMID-Caps
J.P. Morgan Securities (Asia Pacific)
Limited/
J.P. Morgan Broking (Hong Kong)
Limited
ling.wang@jpmorgan.com

Lucas Ferreira

LatAm Food & Beverages and
Agribusiness
Banco J.P. Morgan S.A.
lucas.x.ferreira@jpmorgan.com

Marcelo Motta

Latin American Cement &
Construction /
Real Estate and Capital Goods
Banco J.P. Morgan S.A.
marcelo.g.motta@jpmorgan.com

Marcelo Santos

Latin American Education
Banco J.P. Morgan S.A.
marcelo.p.santos@jpmorgan.com

Marcus Diebel

European Media & Internet
J.P. Morgan Securities plc
marcus.diebel@jpmorgan.com

MW Kim

Insurance
J.P. Morgan Securities (Asia Pacific)
Limited/
J.P. Morgan Broking (Hong Kong)
Limited
mw.kim@jpmorgan.com

Berowne Hlavaty
(61-2) 9003-8602
berowne.d.hlavaty@jpmorgan.com

Global Quantitative & Derivatives Strategy
04 February 2021

J.P.Morgan

Rajat Gupta

Autos & Auto Parts
J.P. Morgan Securities LLC
rajat.gupta@jpmorgan.com

Rajiv Batra

Southeast Asia and Emerging Markets Equity
Strategist
J.P. Morgan Securities Singapore Private Limited
rajiv.j.batra@jpmorgan.com

Ranjan Sharma

ASEAN TMT
J.P. Morgan Securities Singapore Private Limited
ranjan.x.sharma@jpmorgan.com

Ricardo Rezende

LatAm Basic Materials
J.P. Morgan Securities plc
ricardo.rezende@jpmorgan.com

Richard Jones

Australian REITs and Infrastructure
J.P. Morgan Securities Australia Limited
richard.b.jones@jpmorgan.com

Richard Vossler

European Healthcare (Pharma, Biotech)
J.P. Morgan Securities plc
richard.vossler@jpmorgan.com

Ritsuko Tsunoda

Food, Toiletry
JPMorgan Securities Japan Co., Ltd.
ritsuko.tsunoda@jpmorgan.com

Rodolfo Angele

LatAm Basic Materials
Banco J.P. Morgan S.A.
rodolfo.r.angele@jpmorgan.com

Samuel Goodacre

CEEMEA Banks
J.P. Morgan Securities plc
samuel.goodacre@jpmorgan.com

Samuel J Bland

European Transport and UK Small & Mid Caps
J.P. Morgan Securities plc
samuel.j.bland@jpmorgan.com

Siddharth Parameswaran

Insurance and Diversified Financials
J.P. Morgan Securities Australia Limited
siddharth.x.parameswaran@jpmorgan.com

SM Kim

Korean Autos
J.P. Morgan Securities (Far East) Limited, Seoul
Branch
sangmyeong.kim@jpmorgan.com

Sofie Peterzens

European Banks
J.P. Morgan Securities plc
sofie.c.peterzens@jpmorgan.com

Sterling Auty

Software - Large Cap / Mid & Small Cap
J.P. Morgan Securities LLC
sterling.auty@jpmorgan.com

Sylvia P Barker

European Business Services
J.P. Morgan Securities plc
sylvia.barker@jpmorgan.com

Tarek Sleiman

MENA Real Estate, Health Care,
Consumer & Petrochemicals
J.P. Morgan Securities plc
tarek.sleiman@jpmorgan.com

Ulises Argote

LatAm Food & Beverage and Mexican
Retailers
J.P. Morgan Casa de Bolsa, S.A. de C.V.,
J.P. Morgan Grupo Financiero
ulises.argote@jpmorgan.com

Yuri R Fernandes

Latin American Financials
J.P. Morgan Securities LLC
yuri.r.fernandes@jpmorgan.com

Economic Research

Jesse Edgerton

Economic and Policy Research
JPMorgan Chase Bank NA
jesse.edgerton@jpmchase.com

Joseph Lupton

Economic & Policy Research
JPMorgan Chase Bank NA
joseph.p.lupton@jpmorgan.com

Fixed Income Strategy

Joshua Younger

US Fixed Income Strategy
J.P. Morgan Securities LLC
joshua.d.younger@jpmorgan.com

Veronica Mejia Bustamante

US Fixed Income Strategy
J.P. Morgan Securities LLC
veronica.mejiabustamante@jpmorgan.com

FX Strategy

Ladislav Jankovic

Global FX Strategy
J.P. Morgan Securities LLC
ladislav.jankovic@jpmchase.com

Markets Strategy

Joyce Chang

Chair of Global Research
J.P. Morgan Securities LLC
joyce.chang@jpmorgan.com

DataQuery

For Client Enquiries:

Data.Query@jpmorgan.com

Executive Summary

At J.P. Morgan, the use of Big/Alt-Data, Machine Learning and Artificial Intelligence is an ever-increasing area of importance for our research teams. The unprecedented events brought about by the COVID-19 pandemic have helped make it clear just how important alternative sources of data are when trying to interpret the impacts of an unknown event, and how to forecast a path forward. The pandemic highlighted the need for high-frequency granular daily or weekly data points to monitor health trends, mobility trends, consumer spending patterns and demand indicators. Across equity research over 20 different [high frequency data trackers](#) were launched. In the second half of 2020, we continued to [embrace AI](#), leveraging these new techniques and datasets to enhance our reports across all research departments. We also review the most significant academic and industry events and developments over the past six months.

We highlight reports published by the Quantitative & Derivatives Strategy, Equity Research, Equity Strategy, Cross-Asset Global Markets Strategy as well as ESG & Sustainable Research teams in 2H20. A full listing of past reports on Alt-Data, Machine Learning and Artificial Intelligence can be found in the [1H20](#), [2H19](#), [1H19](#), [2H18](#), [1H18](#) and [2017](#) summaries. These summaries follow the 280-page book [Big Data and AI Strategies: Machine Learning and Alternative Data](#), which introduced these concepts when it was published in mid-2017. All of our Machine Learning reports are available on the [BigData](#) portal page of the [J.P. Morgan Markets](#) website.

Beyond the Quantitative and Derivatives Strategy team, J.P. Morgan's Global Research team for Equities, Strategy, and ESG have explored Machine Learning techniques for financial analysis and experimented with new, alternative, or big datasets to provide higher frequency updates on macro forecasts and investment recommendations. The combined research teams across J.P. Morgan have deployed a wide and diverse range of data sources and analysis techniques, outlined in 300 reports that utilize alternative data or machine learning to support ratings (or changes) and sector views.

A summary of the reports across the global J.P. Morgan Research teams is grouped into the following categories: COVID-19, Alternative Data, Machine Learning (ML), Natural Language Processing (NLP). Following the discussion of research products, we include highlights from investor conferences. The final section includes an update on broad industry and academic developments over the past six months.

Figure 1: Big Data and AI Strategies: ML and Alternative Data Approach to Investing – May/2017



Source: J.P. Morgan QDS

Super-Human AI



Source: iStockPhoto

While truly [General Artificial Intelligence](#) (GAI) is a while away, over the past six months to a year we have seen measurable progress such as Natural Language Processing (NLP) and Understanding (NLU) models now considered 'Super Human', according to the [SuperGlue](#) leaderboard. There has also been progress made in other areas of AI such as in gaming, which is an important development 'sandbox' for teaching systems on how to [plan for future success](#). But while these advances are technically very interesting, a lot of ethical issues in AI have also been raised in 2020.

Despite being focused on games (for now), the development of MuZero (aka GoZero, first introduced in a [preliminary paper in 2019](#)) was perhaps under-appreciated at first. Recently [DeepMind](#) has explained some of the important features and abilities of this system, and how it learned to play at super-human levels, despite *not being told the rules* of Go, Chess, Shogi and Atari games. To plan an effective strategy the system had to build its own models, as explained in [Nature](#) and commented on in [Medium](#). It is this ability to plan is what some argue has been lacking in previous AI systems, leaving us excited for the potential of this model outside of gaming environments.

Taking another approach, Facebook has built a probabilistic model called [ReBeL](#) that is capable of playing imperfect-information 'zero-sum games' (such as poker) and converging on an optimal policy, performing at super-human levels.

The performance of various computer models at different tasks such as gaming, natural language understanding, natural language generation (NLG) as well as object detection and recognition has made the definition of GAI and Super-Human performance contestable. While [DeBERTa](#) (Microsoft) and Zirui Wang (T5, Meena, Google) can beat humans on the [SuperGlue](#) leaderboard on the average score, they still fall short on a few tasks such as Context, WinoGrad and WinoGender scores.

To address the topic of intelligence, Francois Collet (the creator of [Keras](#)) challenges some of the best-established principles of AI systems in terms of how to measure intelligence. In his paper, [On the Measure of Intelligence](#), Collet suggests for AI systems to reach their full potential, we need quantitative and actionable methods that measure intelligence in a way that shows similarities with human cognition.

In an attempt to define a testable level for NLU, Microsoft and Google released a new set of Benchmarks for Cross-Language Understanding ([XLU](#)) AI Tasks. Google's [XTREME](#) covers 40 languages and includes nine tasks, while Microsoft's [XGLUE](#) covers 27 languages and eleven tasks. The Google Language [Research](#) team released a new dataset for training and [evaluating](#) question-answering systems called Typologically Diverse Question Answering to Benchmark Natural Language Understanding [TyDi QA](#). Meanwhile, Facebook and Stanford are pushing a [dynamic](#) approach to benchmarking.

Through the year we have also seen a lot of developments in the ethical-AI space. At OpenAI efforts are being made to strengthen [communities](#), while at Google ethical issues lead to a bitter [dispute](#) and [public resignations](#) and [response](#).

The widespread attention to deep-fakes and fake-news escalated with dramatic effects on recommender systems like Facebook, who are actively addressing the issues by detecting [hate speech](#) and [misinformation](#).

While most of us were in lockdown for much of 2020, consumption of online content has [skyrocketed](#), leaving us unwittingly at the mercy of social media platforms, also referred to with the unflattering title: "[vectors for disinformation](#)".

AI-generated fakes ("DeepFakes") have the potential to [undermine trust](#) in public institutions by sowing confusion over what is and isn't real. DeepFakes showed up in hundreds of beneficial applications, including mainstream [entertainment](#), [commercials](#), [political campaigns](#), and even a [documentary film](#) where they were used to protect onscreen witnesses as reported in [The Batch's](#) recap of 2020 by Andrew Ng.

Even DeepFake tools designed to help have been found to be biased. For example, [Zoom's](#) background tool struggles with people of colour.

One of the other concerns about AI is the prohibitive cost of these large models. It has been estimated that to train GPT-3, OpenAI & Microsoft may have consumed compute resources worth \$5 to \$10 million, according to this [analysis](#). Or in other words, GPT-3 has been trained on over [50 billion times more words](#) than an educated human would read in a lifetime. Despite these costs, model size keeps getting larger, from GPT-3 with 175Bn parameters to Microsoft's [DeepSpeed ZeRO](#) with support for 1Tn parameters.

To grant academics access to this unaffordable style of AI the [Stanford Institute for Human-Centered Artificial Intelligence](#) (HAI) has proposed a [National Research Cloud](#) to work on public issues such as COVID, climate change and other areas of public benefit.

But perhaps of even more concern is information coming to light that [GPT-3](#) and systems like it *passively absorb information*, including patterns and [bias](#) and may even [leak private information](#).

A team from the Berkeley AI Research Lab ([BAIR](#)) published on the [security vulnerabilities](#) created by the memorization of language and [facts](#) by pre-trained models. Meanwhile, Apple looked into [what NNs memorize and why](#).

Research is being conducted to provide these models with human feedback, which can compel the model to exhibit a great variety of behaviors, and human judges provide [feedback](#) on whether a given behavior was desirable or undesirable. This feedback is proving to be powerful, allowing researchers at OpenAI to shape the model's behaviors quickly and precisely using a relatively modest number of human interactions. GoogleAI have proposed it is possible to mitigate unfair bias in ML models with the [MinDiff Framework](#).

But not everyone is convinced these Transformer models are the right path to natural language understanding. For example, [Walid Saba](#) argues that NLP currently works by *compressing* information, but human conversation embeds prior knowledge that is not necessarily in the data, such that conversation understanding is actually a *decompression* function.

Further criticism of utilitarian AI is directed at the lack of a core set of values for models that are instead trained for a specific set of outcomes. In [The Key to Successful A.I.](#) it is argued that continual human intervention is required to guide AI. While in [Evolution and impact of bias in human and machine learning algorithm interaction](#) the authors argue that iterative training is required.

A new database is Cataloging AI Gone Wrong. The Partnership on AI, a nonprofit consortium of businesses and institutions, launched the [AI Incident Database](#), a searchable collection of reports on the technology's missteps. Examples include a gender-biased [recruiting system](#), a concerning [recommender algorithm](#) for children, and [face recognition](#) that led to wrongful arrests. The UK Dept. of Education had to discard grades generated by an [algorithm](#) designed to predict performance on the annual "A-Level" tests if they were lower than teachers' assessments.

In a scene straight out of the [Minority Report](#), the LAPD had to stop using (or redesign) systems designed to forecast crimes after determining that they were [flawed](#) (e.g. identifying people with no apparent history of violent crime as high-risk offenders).

At one of the DeepFin Investor Workshop events this year we hosted an IBM talk on [Ethical AI - Fair & Explainable Machine Learning](#) where they explained how to remove unfair bias in AI and how to engender trust through explainable AI models. The "Ethical Issues of AI" are addressed further in a dedicated section of this report.

For a review of the major vendors innovations in 2020 see the links for: [Apple](#), [Baidu](#), [FaceBook](#), [Google](#), [IBM](#), [Microsoft](#), [NetFlix](#), [Uber](#)

2021 Forecasts

For 2021 we expect further acceleration in artificial intelligence along multiple fronts; hardware, software, multi-discipline (cross) learning with an increased focus on ethics and security.

We have already seen a great focus on smarter, more efficient algorithms, such as lower memory attention mechanisms, and higher complexity neural net node types

(DNN > RNN > GRU > LSTM > CAPS > GNN), acknowledging that human neurons are more complex than a simple sigmoid function.

Simultaneously we expect the development of [much] larger models (to 1Tn parameters), running on increasingly powerful hardware, some with single chips the size of an entire silicon [wafer](#), or on ‘traditional’ TPUs with more onboard [memory](#).

Taking advantage of all this processing power, the expansion of models to [multi-goal](#) training and [multi-discipline](#) learning while gaining deeper understanding via the use of [context](#). The design of these networks will increasingly rely on [Neural Architecture Search](#).

An example would be the [ViLBERT](#), model that combines ‘Vision and Language with BERT’. Like humans, this model is exposed to more than one medium while developing that should help the model to gain a deeper understanding of both modes of learning.

The [3rd wave of AI](#) is said to comprise ‘[neurosymbolic](#)’ systems that combine the power of neural networks with [symbolic](#) AI methods and [reasoning](#), which looks interesting for advancing AI with less training examples. There will also be a refinement of [causal computing](#) and [transdisciplinary](#) AI systems.

While waiting for (sentient) General AI, we also expect more efficient ML and AI tools to augment human endeavors, including performance enhancements like [Kite](#) (an AI for your IDE) and further progress of auto-ML, auto-MLOps tools, as well as business ‘[hyperautomation](#)’.

Security will also be a focus affecting areas such as Confidential Computing, Quantum-Safe and Fully Homomorphic Encryption. Advances should make even the most regulated industries shift at least some of their process to the [cloud](#).

Finally with the advances made affecting more of humanity, public acceptance (or outrage) will require politicians (and [corporations](#)) to formulate some guiding principles that some data scientists and engineers seem reluctant to build into their models (until bias or other issue causes a problem, as captured in [AIID](#)). These [new rules for AI, updated](#) for the times, perhaps from the [Organization for Economic Cooperation and Development](#), should be agreed to and implemented by all rather than disparate rules developed by narrow focus groups, but this might be a lofty goal, harder to achieve than agreement on climate change principles.

2021 is set to be another transformational year, with continuing advances to these exciting technologies.

2H20: J.P. Morgan Equity Research

We use the following categories to highlight our Global Research approaches: COVID-19 Trackers, Alternative Data, Machine Learning (ML), Natural Language Processing (NLP) and related reports. For 2H20, a total of 300 reports from Quantitative & Derivatives Strategy, Equity, Economics and Cross-Asset Global Markets Strategy were produced. We have included repeated periodicals and trackers as a single entry reference point.

With the evolution of COVID-19 defining economic and market activity in 2020 it is worth highlighting the [Global Research Digest, Summing it up: The road ahead from the COVID-19 pandemic](#). Across JPM we also produced more than 20 [periodic trackers](#) and [indices](#), developed by the insurance, health care, biotech, consumer products, retail, transportation and macro strategy teams across equity research from all regions. We continued our focus on surveys to gain an information edge, and expanded on our “[SmartBuzz](#)” approach to Thematic Investing.

Alt-Data is becoming more widely accepted, a phenomenon that accelerated throughout the year, perhaps aided by the current pandemic as demand for short-term, high frequency information has become vital in understanding 2020.

Most of the J.P. Morgan research teams have adopted widespread use of specialist data series across all sectors, highlighted in the ‘[Data-Driven](#)’ Equity team reports, such as the [Show and Tell Spotlight](#) on China’s golden week, the [Asia Insurance Strategy](#) report that used insights from alt-data and our use of Twitter to gauge the interest levels in new [video game](#) titles. We also used [Social Media Analytics](#) to examine the [US Election](#) campaign response and to measure support for privatization of [Eletrobras](#).

Geospatial data also played an important part of our analysis of [US REITs](#), LaTam’s [Fuel Recovery](#) and single stocks such as [RADL3 BZ](#).

With the focus on ESG issues strengthening across Europe, the US & Asia Pacific we are seeing much more interest in this area that can be helped with a data-driven map of [Double Materiality](#) of ESG topics, allowing the ESG [numbers to talk](#).

We used ML techniques to track [retail trading behaviour](#) and continue our series of [Machine Learning Based Trade Recommendations](#). Weather and Geolocation data combined with some ML techniques was used in the [China Wind Power](#) and [Shipping Insights](#) reports. AI powered trend & sentiment analysis also features in the regular [ESG Wire](#).

We have made numerous advances in Natural Language Processing (NLP) across the research franchise, coinciding with increased adoption by our clients as well as academia and industry. Our [AI and Big Data Approach to Thematic Investing](#) used the ‘SmartBuzz’ framework also seen in the “[COVID-19](#)” and “[Vaccine](#)” portfolios.

The efforts of the J.P. Morgan analysts are detailed below, followed by the academic and industry highlights.

COVID-19 Trackers and Reports



2020 has been defined by the evolution of the [COVID-19](#) pandemic, which has been the key driver for economic, policy, social and market activity since February/March last year. Our research activity grew and adapted to this new challenge with a number of special reports in the second half, including the [Global Research Digest](#), [Summing it up: The road ahead from the COVID-19 pandemic](#) report curated by Joyce Chang.

We continued to produce various periodic trackers such as the [Tracking activity impact of COVID-19 through high frequency data](#), by Mislav Matejka and the [Global COVID-19 Recovery Index](#) by Berowne Hlavaty & Robert Smith.

In 2H20 have continued our focus with a number of surveys looking into specific expectations within the Australian [Consumer](#), Australian [Healthcare](#), [HVAC](#) and [Insurance](#) spaces.

The QDS team expanded on our “[SmartBuzz](#)” approach to Thematic Investing with a number of tradeable portfolio ideas, such as “[COVID-19](#)” and “[Vaccine](#)”.

Table 1: COVID-19 related Alt-Data Reports

Team	Lead AC	Title	Subtitle
QDS	Joyce Chang	J.P. Morgan Perspectives	Pandemic Accelerates Paradigm Shifts
Equity	C. Stephen Tusa	2020 HVAC Survey	COVID-19 and Weather Break The Macro Model: Raising Resi Industry Forecast
Equity	Tarek Sleiman	Almarai	Healthy Q2-20 supported by COVID-19 and Ramadan - Rich valuation captures the defensiveness attributes
Equity	Jimmy S. Bhullar	Arch Capital	COVID Losses Mask Improving Re/insurance Trends, but Economy a Major Headwind for MI
Equity	Richard Jones	A-REIT June Monthly	COVID-19 weighs on distributions and Retail valuations
Equity	MW Kim	Asia Insurance Strategy	Data Driven: Understanding Pandemic Shifts from Big Data
Equity	Siddharth Parameswaran	Australia COVID-19 update	Vaccine news almost the best case outcome
Equity	David Low	Australian Healthcare Survey	COVID-19 patient survey: What are Australian patients saying?
Equity	Ritsuko Tsunoda	Beer Industry	Beer Moves into Cyclical Uptrend, Post COVID-19 and Alcohol Tax Revisions
Equity	Lucas Ferreira	Brazil Retail	Asking Consumers – Findings from “COVID-voucher” Spending Survey
Equity	Karen Li	China Airports and Airlines	Data-driven re-open tracker: Domestic flight activity to see first +ve growth since COVID-19
Economic	Marvin M Chen	COVID-19 China Monitoring	Golden Week tourist numbers 78% normalized, tourism spending trailing at 69%
Equity	Joanne Cheung	COVID-19 China Monitoring	Notable pickup in November exports; local infections center on Inner Mongolia
Equity	Jason Steed	COVID-19 Consumer Survey	A hint of apprehension... vaccine, savings, fiscal and monetary the antidote
Equity	Rajiv Batra	COVID-19 EM Asia Year Ahead 2021	Applying Covid-19 data to inform portfolio choices; Reiterate OW on Indonesia, Thailand
Equity	Richard Vosser	COVID-19 Europe	Infections continue to fall fast in EU5 except for Germany and hospitalisations peaking
Equity	Ling Wang	COVID-19 Update	Vaccines, Drugs & Masks: All of the above?
Equity	Ling Wang	Global COVID-19 Recovery	
QDS	Berowne Hlavaty	Index	Retracing lost-ground, the CRI shows strong improvements over past 4 weeks
Equity	Andrew C. Steiner	Information Services Data Book	JPM's Global Info Services Data Book: Thinking Through COVID-19 Recession/Recovery and the Return of Compounding Growth
Equity	Cory Kasimov	MRNA & BNTX	**Updated** Ph3 COVID-19 Stats Simulator - October Came and Went, but We're Still Comfortable with a Nov First Look
Equity	Tycho W. Peterson	Renalytix AI	F1Q21 Model Update
Equity	Rajiv Batra	Show and Tell	Bumpy ride ahead, follow the data
Equity	MW Kim	Show and Tell	2020-21 Vision: Same Same, but Different?
Equity	Karen Li	ST Engineering	Navigating a post-COVID-19 world: Key learnings from Singapore's SAF Day and Australia's plan to raise defense spend
Equity	Tycho W. Peterson	Thermo Fisher Scientific	2Q20 First Take: Massive Beat as Preannounced, while AI Segment (-20% Organic) in Line with Expectations
Equity	Jimmy S. Bhullar	US Insurance COVID-19 Tracker	Let's Bend the Curve

Source: J.P. Morgan.

Alt-Data & Data-Driven Reports



Source: iStockPhoto

The use of Alt-Data is becoming more widely accepted, a phenomenon that accelerated throughout the year, perhaps aided by the current pandemic as demand for short-term, high frequency information has become vital in understanding 2020. Most of the J.P. Morgan research teams have adopted widespread use of specialist data series across all sectors, highlighted in the [‘Data-Driven’](#) Equity team reports.

We also highlight Data-Driven research featured in our [Show and Tell Spotlight](#) which examines activity during China’s golden week through an alt-data lens. This provides a high-level view complementing on-the-ground channel checks.

[Asia Insurance Strategy](#) by MW Kim used insights from alt-data to understand the shift in the Life Insurance market in a post-pandemic environment. Alexia S. Quadrani turned to Twitter to gauge the interest levels in new [video game](#) titles.

Anthony Paolone turned to transit data to get a read on office space utilisation in a [US REITs](#) report, along with Rodolfo Angele who used mobility data to gauge the [Fuel Recovery](#) in LatAm. Joseph Giordano investigated the digital transformation at RADL3 BZ with the help of [Geo-Tagging](#) analysis.

Looking to the ESG space, Celine Pannuti introduced a data-driven map of [Double Materiality](#) of ESG topics. Chetan Udeshi looked at the European Chemicals companies, where the ESG [numbers talk](#).

Jessica Fye combined an event study with survey results in the 2021 [Biotech outlook](#).

Finally from the QDS team, Marko Kolanovic and Peng Cheng conducted a deep dive into [Social Media Analytics](#) for the [US Election](#).

Table 2: Alt-Data Reports

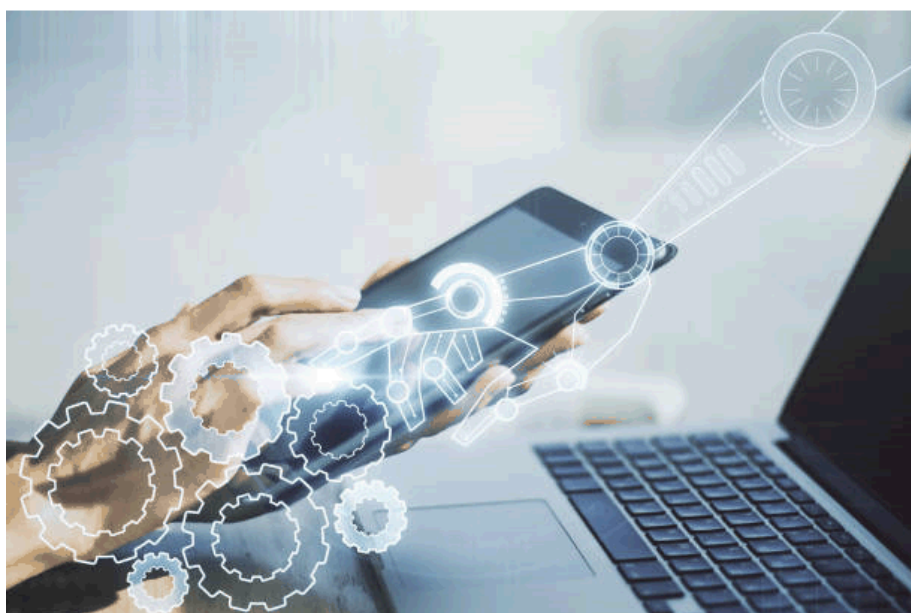
Team	Lead AC	Title	Subtitle
Equity	Jessica Fye	2021 US Biotech Outlook	Now That Biotech Is Saving the World, What Comes Next?
Equity	Marcelo Motta	ANFAVEA Monitor	Nov. Data: Monthly Production Up YoY for the First Time Since Oct-19, But Yellow Flag on Raw Materials
Equity	Ranjan Sharma	ASEAN Ecommerce	A high-level overview of the Indonesian ecommerce industry
Equity	Karen Li	Asia Airlines and Airports	The darkest hour is just before the dawn; who's in better shape to take off?
Equity	Harsh Wardhan Modi	Asia Banks	Fact-checking the digital hype - Vol 1
Equity	SM Kim	Auto Sector	EV proliferation begins now, but so does the competition
Equity	Domingos Falavina	B3	October Data - Small Improvement in Equities ADTV; Derivatives Rev Remains Strong
Equity	Ankur Rudra	Bharti Airtel Limited	Sharp correction creates opportunity - gains on n/w quality, digital metrics and upgrade potential ignored
QDS	Peng Cheng	Big Data and AI Strategies	Social Media Analytics for US Election
Equity	Domingos Falavina	Bolsa Mexicana	November Operational Figures
Equity	Rodolfo Angele	Brave New World	#1: Mobility Data Supports Fuel Recovery in LatAm. But Watch Out for Lockdowns
Equity	Lucas Ferreira	Brazil Beer	Data Driven Price Check #6 Sep-20: Ambev's Portfolio More Affordable After Heineken Hikes, Implying Strong Volumes
Equity	Lucas Ferreira	Brazil Beer	Data Driven Price Check #8: Heineken and Petropolis Keep Leading Hikes
Equity	Joseph Giordano	Brazil E-commerce	Revisiting Estimates After Preliminary Black Friday Data. MGLU Remains the Preferred Vehicle
Equity	Lucas Ferreira	Brazil Grains and Food	Dec-20 Conab 20/21 Estimates: Slashing Corn 1st Crop Yields, Cutting Cotton Area
Equity	Rodolfo Angele	Brazil Iron Ore & Steel	Iron Ore Exports Down Flat y/y (-6.4% m/m)
Equity	Rodolfo Angele	Brazil O&G	Production Down 10.1% y/y in November; PBR Crude Production Down 13.7% y/y
Equity	Lucas Ferreira	Brazil Protein Exports	4th Week of December: Volumes Continue Trending Down M/M, with Relatively Stable Prices
Equity	Domingos Falavina	Brazilian Banks	November Data – Loan Growth at 7-Year Peak Levels
Equity	Marcelo Motta	Brazilian Capital Goods	Dec. Heat Map: Figures Reiterate a Rebound, But There Are Concerns on Temporary Shutdowns in BZ
Equity	Marcelo Santos	Brazilian Education	3Q20 Scorecard: COVID-19 Takes a Toll on Campus Intakes and Delinquency; DL Outperforms
Equity	Marcelo Motta	Brazilian Homebuilders	Dec. Heat Map: Presales Figures Remain Strong, Mortgage Growth Supporting Positive Momentum
Equity	Domingos Falavina	Brazilian Payments	Market Share Tracker - 3Q20: Stone Main Winner But Boosted By Government Aid TPV
Equity	Marcelo Motta	Brazilian Shopping Malls	Dec. Heat Map: Foot Traffic Still Rebounding, but Divergence on Retail Data Between Cielo and IBGE
Equity	Andrew C. Steinerman	Business Services	Global Flex Staffing Database: Global Staffing Revenue Declines Narrow, but Still Large
Equity	Samuel Goodacre	CEEMEA Banks	Data-Driven: App usage trends indicate a possible paradigm shift; digital banking here to stay?
Equity	Joseph Giordano	Chile E-Commerce	Digging into '20 Cyber Day Trends
Equity	Joseph Giordano	Chile Retail	Digging Into Apps and Revisiting Views Ahead of 2Q20E. Preference Remains for Cencosud
Equity	Domingos Falavina	Chilean Banks	November Figures Pointing to a Good 4Q20 for BSAC and BCH
Equity	Karen Li	China airports and airlines	What does high-frequency and alternative data tell us about impact from YRD's extreme weather and Beijing's second wave
Equity	Alan Hon	China wind power - Blowing in the wind	Applying AI to identify wind power stock opportunities - a rebound in wind power generation in October
Equity	Rodolfo Angele	Colombia Oil & Gas	Production Up 2.5% m/m in August (Oil +1.0% m/m, Gas +9.4% m/m)
Equity	Yuri R Fernandes	Colombian Banks	October Data – NPL Up, Loan Growth Down, and System EPS Shrinking ~90% Y-o-Y
Equity	Ankur Rudra	Coming back to life	Indian Telcos look into the shining sun; assume coverage on BHARTI/BHIN at OW, and VIL at UW
Equity	Alberto Lopez Rueda	Compass & Sodexo	DATA-Driven: Tracking real-time activity - Recovery has stagnated over the last c10 days
Equity	Karen Li	Container Shipping Insights	Raising Evergreen PT, spot freight rates reached new high, while LA ports seeing notable volume pickup in coming weeks
Equity	Brandt Montour	Cruise Lines Monthly Pricing Trends	Cruise Pricing Stable Overall Month-over-Month; Dispersion Continues Between Brands and Regions
Equity	James R. Sullivan	Data-Driven Investing: Telecommunications	Updated 3Q20 Operational Factors and Conclusions
Equity	Rajat Gupta	Digital Used Vehicle Retail	Tracking DAU and Download Data: Carvana Continues to Outperform Peers
Equity	Jean-Xavier Hecker	ESG Integration - Double Materiality Mapping	DATA-Driven - Oil & Gas
Equity	Celine Pannuti	ESG Integration- Introducing Double Materiality	DATA-Driven: Showcasing a framework - Consumer Staples

Team	Lead AC	Title	Subtitle
Equity	David H Perry	European Airlines & Aerospace	DATA-Driven: "Express Check In" (Jan 4, 2021)
Equity	Elodie Rall	European Airports	DATA-Driven: JPM AMT & FBI traffic trackers show bleak Q4/Q1; recent bookings show small uptick since vaccine news
Equity	Alberto Lopez Rueda	European Airports	DATA-Driven: Real-time traffic monitors AMT & FBI suggest Aug/Sept peak and Q4 rolling over; implies estimates downside
Equity	Chetan Udeshi	European Chemicals	Number talks: cross sector benchmarking on growth, quality and ESG metrics
Equity	Sylvia P Barker	European Employment Services	DATA-Driven: December monthly data and valuation: limited impact from second lockdowns, RAND to OW
Equity	Georgina Johanan	European General Retail	DATA DRIVEN: App activity growing steadily; Asos activity remains strong while B&Q shows some moderation
Equity	Alberto Lopez Rueda	European Internet Data Handbook - September 2020	DATA-Driven - Tracking high frequency data for our space
Equity	Jay Kwon	EV battery & material sector	Extended EU economic recovery plan and policy stimulus raise EV battery growth prospects
Equity	Sylvia P Barker	Experian plc	DATA-Driven: TOP IDEA: recent trends in mobile app data for Consumer Services remain positive
Equity	Elodie Rall	Ferrovial	Premium valuation with congestion ahead; Downgrade to Neutral
Equity	Samuel J Bland	Freight forwarding monthly	DATA-Driven: Update on industry data and valuations
Equity	Ricardo Rezende	Fuel Distribution Monthly	Monitoring the Brazilian Fuel Distribution Market
Equity	Joseph Greff	Gaming	Revisiting the recovery trajectory in Las Vegas, Louisiana, Mississippi, Missouri, and Iowa; Part IV
Equity	Marcus Diebel	Global Food Delivery Tracker	DATA Driven - Current traffic data underpins the JET investment case as strong momentum continues
Equity	Christopher Brown	Hipgnosis Songs Fund: TOP IDEA: All I Want For Christmas Is	An analysis of the enduring popularity of Christmas classics using Spotify data
Equity	Gokul Hariharan	Hon Hai Precision	Margins on an uptrend from 2Q, iPhone 12 and servers to drive YoY growth in 2H, OW
Equity	Latika Chopra	India Consumer - The Digital Barometer	Domino's & DMART Ready App tracking healthy DAU growth though moderating m/m; Netflix & Hotstar do well in OTT
Equity	Gunjan Prithyani	India Motown Beat	Strong demand trends holding up for PVs/tractors; 2W recovery remains vague
Equity	Rajiv Batra	Indonesia Equity Strategy	HFA shows mild activity improvement; risks remain
Equity	Deepika Mundra	InterGlobe Aviation Ltd	Valuation vs Vaccine: Flying towards a non-COVID world rather quickly
Equity	Jamie Baker	J.P. Morgan Global Airlines	Valuation Dashboard - December Edition
Equity	Ankur Rudra	JioNation	Deep dive into RIL's digital assets - One ecosystem to rule them all?
Equity	Adrian E Huerta	Latam Cement Data Points	MX: Oct Cement Vols +11.2% m/m and Could Mean Up 8-13% y/y in 4Q and Likely Stronger for CX
Equity	Marcelo Motta	LatAm Infrastructure	August Heat Map: HV Sales Recovering Faster Than LV; Production Still Weak
Equity	Marcelo Motta	LatAm Real Estate	Housing Trends Post-Pandemic: Data and Homebuyer Preferences Support Our Bullish View
Equity	Tycho W. Peterson	Life Science Tools & Diagnostics	Back to School, But Back to the Lab? Our Latest Pulse Check on the Academic Research Markets & Outlook for the Fall
Equity	Melanie Flouquet	Luxurious Thoughts	DATA-Driven - App activity improves in China and the US & LV leads
Equity	Marcus Diebel	M&A in Food Delivery	DATA-Driven: More markets, more opportunities for Delivery Hero - a detailed view on LatAm and Japan
Equity	Domingos Falavina	Mexican Banks	October Data - Some Banks Reducing Provisions While Others Are Building It Now
Equity	Joseph Giordano	Mexico Retail	Data-Driven First Read from "El Buen Fin". Walmex and Liverpool Likely Benefitting
Equity	Alexia S. Quadrani	Outdoor	Adjusting Estimates for OUT and LAMR; Mobility Data Update
Equity	Alexia S. Quadrani	Outdoor	Mobility Data Update; Outdoor Audience Grows but Transit Recovery Lags
Equity	James R. Sullivan	Politics by Numbers	Quantifying populism: India > China
Equity	Guilherme Grespan	Porto Seguro	Theft and Robbery for October
Equity	Joseph Giordano	RD	DATA DRIVEN - Digging into Footprint Overlaps - Proprietary Geo-Tagging Analysis. Remain OW
Equity	Anthony Paolone	REITs	Transit data unsurprisingly shows recovery stalling around key real estate locations
Equity	Doug Anmuth	Rideshare Roadmap, 10/15/20	Recovery Remains Slow as Engagement Data Mixed, w/Int'l Ahead of US; Heavy Focus Remains on Prop 22
Equity	Jay Kwon	Samsung SDS	In the middle of the IT spending cut cycle, rich cash position supports downside risk
Equity	Fernando Abdalla	Santos Brasil	Tecon Monthly Volumes: Flattish Performance After Eight Months of Negative Results
Equity	Don Carducci	Seek Ltd	Zhaopin Pricing and Competitive Environment Analysis
Equity	Karen Li	Shipping insights	Container rates climb further, with Asia-US WC seeing biggest gains since end-August; bulk shipping continues to recover
Equity	Karen Li	Shipping Insights	Data-Driven - Navigating sailing tides and currents via Big Data Analytics
Equity	Rajiv Batra	Show and Tell Spotlight	China Golden Week through alt-data lens
Equity	Sofie Peterzens	Spanish Banks	DATA-Driven: The future is here, M&A the catalyst for long awaited slim-fast diet, analyzing the opportunities
Equity	Estelle Weingrod	SSP	DATA-Driven: Tracking real-time volumes - Not a straight line to recovery, PT down

Team	Lead AC	Title	Subtitle
Equity	Karen Li	Techtronic Industries (0669)	to 400p (450p) Raising PT, our data-driven analysis sheds light; +ve read-throughs from SWK's 3Q20 post-call
Economic	Joseph Lupton	Tracking global employment using alt-data, cautiously	
Equity	Samuel Goodacre	Turkish Banks	DATA-Driven: Shallower yet longer cycle; AI-model predicts 80% rise in NPLs in base case
Equity	Alberto Lopez Rueda	Ubisoft	DATA-Driven: Immortals Fenyx Rising - Twitch data, social media sentiment & reviews; Outlook for 2021
Equity	Adrian E Huerta	US Construction Data Points	Nov Housing Starts +1.2% m/m on top of strong Oct while permits were even stronger at +6.2%
Equity	Samuel J Bland	Vesuvius	DATA-Driven: Monthly note - global steel production
Equity	David Karnovsky	Video Games	Examining Social Media Data and Q3 Preview
Equity	Marcelo Motta	Weg	Growing in the Industry 4.0. Acquisition of 51% of AI Startup Called BirminD

Source: J.P. Morgan.

Machine Learning Reports



Source: iStockPhoto

The QDS team is actively applying Machine Learning techniques to analyse investment trends and patterns across equities and multi-asset classes. The Big Data and AI Strategies team reports are featured on the QDS [Big Data & AI](#) portal on [JPMorganMarkets](#). For example, we used ML techniques to track [retail trading behaviour](#) without relying on Robinhood trade data. We also continue our series of [Machine Learning Based Trade Recommendations](#).

The Data-Driven report on [Shipping Insights](#) by Karen Li launched J.P. Morgan BIDS I Shipping All-Weather Barometer (an extension of JPM BIDS I), a proprietary tool to track real-time global containerized and bulk shipping activity via the use of alternative data along with ML techniques to clean the raw AIS signals and create indices that are highly correlated to traditional (but lagged) data sources.

At one of the DeepFin Investor Workshop events this year we hosted an IBM talk on [Ethical AI - Fair & Explainable Machine Learning](#) where they explained how to remove unfair bias in AI and how to engender trust through explainable AI models.

We also flag the [China Wind Power](#) report by Alan Hon that looks at applying machine learning to predict wind power generation for China wind farms using weather data.

Jean-Xavier Hecker & Hugo Dubourg used AI powered trend & sentiment analysis in the regular [ESG Wire](#).

Table 3: Machine Learning Reports

Team	Lead AC	Title	Subtitle
Equity	Bob Chen	Appen Limited	Short-term blip in AI leveraged growth story
QDS	Ladislav Jankovic	Audio Presentation - FX Derivatives	RVs and vol ratio spreads still the game
Equity	Don Carducci	Australia Media Weekly	Media Listings + OML takeaways: Real Estate New Listings +16.8% y/y; SEK -3.0% y/y; CAR -28.1% y/y
Equity	Sterling Auty	Autodesk	Pype Acquisition Adds AI Functionality to Construction Solutions
Equity	Ulises Argote	Bachoco	November Price Tracker: Good Trends Remain Across the Industry; Remain N on Profitability
QDS	Marko Kolanovic	Big Data and AI Strategies	Social Media Analytics for US Election
Equity	Rodolfo Angele	Brazil Steel	Brazil Steel Demand Remains Strong at +16% y/y in November
Equity	Fernando Abdalla	Brazilian Airlines	Fare Monitor 4Q20: Sequential Improvements on Yields, but Still Down on a Yearly Basis
Equity	Alan Hon	China wind power - Blowing in the wind	Applying AI to identify wind power stock opportunities - decelerating growth for August generation
Equity	Karen Li	Chinese Airlines	How high will cruising altitude be? Yield risks balance recovery optimism: CEA Top Pick, CSA Top UW
QDS	Peng Cheng	Cross Asset Volatility	Machine Learning Based Trade Recommendations
Equity	Jean-Xavier Hecker / Hugo Dubourg	ESG Wire	Will 2021 be the year of biodiversity? Results from an AI powered trend & sentiment analysis
QDS	Ayub Hanif	Ethical AI - Fair & Explainable Machine Learning	DeepFin Investor Workshop Summary with IBM
QDS	Peng Cheng	Global Equity Derivatives	Tech Stocks: Protective and Tactical Strategies to Navigate Potential Risks Ahead
Equity	Ulises Argote	Grupo Lala	MX Price Check #1: Price Pass-Through On Track And Should Bode Well For Margins. Remain OW
QDS	Marko Kolanovic	Hedging Long-Term Risks for Multi-Asset Portfolios	Yields, Crowding, and Correlation Shocks
FICC	Joshua Younger	Interest Rate Derivatives	A machine learning approach to classifying feature importance in short-term spread models
Equity	Alan Hon	Longyuan (0916)	Step-up in June wind power generation in-line with our predictions using AI
Equity	Doug Anmuth	Netflix Inc	NFLX Trending, 11/23/20: Tweaking Estimates for US Price Increase & Raising PT to \$628
QDS	Robert Smith, PhD	News Sentiment in China	Using ChinaScope NLP for Trade Timing A-Shares
QDS	Ada Lau	Quantitative Perspectives on Cross-Asset Risk Premia	Value/Momentum rotation broadly supported by macro backdrop, and latest model views
QDS	Ada Lau	Quantitative Perspectives on Cross-Asset Risk Premia	Value's exposures to yield curve; Mimicking portfolios to rates and Trend-following on equity factors
Equity	Tycho W. Peterson	Renalytix AI	F4Q20 Model Update: Mount Sinai Rollout Live with FDA & CMS Coverage Expected Soon, As 2021 Sets Up to Be a Pivotal Year
Equity	Fernando Abdalla	Rumo	Grains Deep Dive: Understanding the Dynamics of Soy and Corn in Brazil and the Implications for RAIL
QDS	Ada Lau	Quantitative Perspectives on Cross-Asset Risk Premia	Equity value factors review, Defensive overlay on Short-vol strategies and Latest Model Views
QDS	Ayub Hanif	Spatial Data Science	DeepFin Investor Workshop Summary with CARTO
QDS	Peng Cheng	VIX Technical Update	Position for a transition into a lower vol regime
FICC	Veronica Mejia Bustamante	When prophecy fails	A cautionary tale for machine learning

Source: J.P. Morgan

NLP Reports



Source: iStockPhoto

We have made numerous advances in Natural Language Processing (NLP) across the research franchise, coinciding with increased adoption by our clients as well as academia and industry. Note we have categorized some NLP-related reports under Alt-Data if they are predominantly based on vendor provided sentiment scores.

In our [AI and Big Data Approach to Thematic Investing](#) report led by Haoshun Liu, we highlight the usefulness of using NLP to structural digitalization trends in cloud computing, telehealth, video gaming and cybersecurity. This Thematic Investing report uses ‘Smart Buzz’ which was also used for the “[COVID-19](#)” and “[Vaccine](#)” exposure reports tabled earlier.

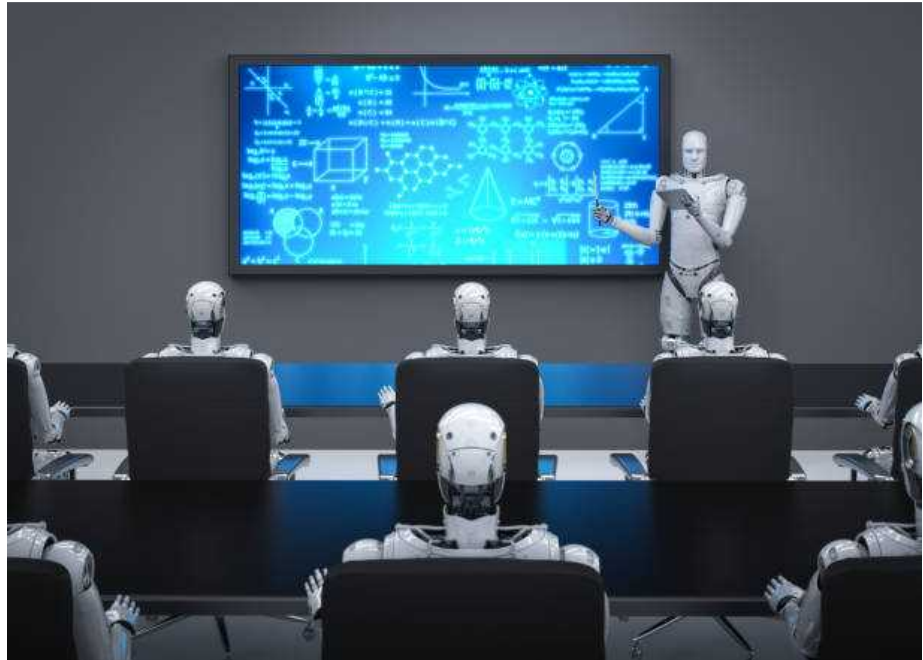
Fernando Abdalla used Sentiment analysis to measure the support for privatization of [Eletrobras](#).

Table 4: NLP Reports

Team	Lead AC	Title	Subtitle
Equity	Fernando Abdalla	Eletrobras	Sentiment analysis shows light improvement in support for privatization
QDS	Haoshun Liu	AI and Big Data Approach to Thematic Investing	Structural digitalization trends in cloud computing, telehealth, video gaming and cybersecurity

Source: J.P. Morgan.

Conferences, Forums and Tutorials



Source: iStockPhoto

The JPM Quantitative & Derivatives Strategy and other teams have hosted a series of global conferences in different regions to a growing audience of portfolio managers, asset owners and analysts keen to understand the investment implications for their stocks, sectors, portfolios and asset classes. These events are listed below along with details about some of the leading industry conferences.

DeepFin Machine Learning Tutorials in 2020

We continued our “DeepFin” series of tutorial sessions focusing on financial modeling using Machine Learning and Deep Learning techniques throughout 2020. These sessions are now run on a virtual platform given COVID-19 lockdown restrictions. Further global events are planned for the remainder of 2021 to ensure you are up to date with the core concepts and latest techniques to implement ML/AI and alt-data ideas.

Location	Date	Partner	Topic
NY	27-Jan	EagleAlpha	Data Quality Assessment
AU-APAC	03-Apr	EagleAlpha	Data Quality Assessment
NY	28-Apr	QuantCube	Massive Data Analytics
UK	09-Jul	Carto	Spatial Data Science
AU-APAC	29-Jul	Refinitiv	NLP sentiment scoring and event prediction
NY	6, 13, 20 Aug	nVidia	BERT training on GPUs
UK	4-Sep	IBM	Fair and Explainable AI
AU	7 & 14 Oct	nVidia	BERT training on GPUs

Source: J.P. Morgan.

J.P. Morgan Conferences

14-17 Jan 2020	38th annual Healthcare Conference in San Francisco with 472 presenting companies.
13-15 May 2020	48th annual TMC Conference virtually, with 200 of the leading TMC companies.
10 Jun 2020	21st annual and first virtual Macro Quantitative and Derivatives conference
22-24 Jun 2020	China Investor Conference virtually with theme "Future in Focus".
22 Jul 2020	22nd Indonesia Strategy virtual conference
30 Jul 2020	APAC Macro Quantitative Virtual Conference 2020 - Systematic Investing
13-14 Sep 2020	Tech Stars 2020 European
6-7 Oct 2020	Media & Communications Industry Panel Forum
28 Oct 2020	Technology Innovation Symposium
2-3 Nov 2020	Energy Conference
16-18 Nov 2020	Global Technology, Media and Telecom Conference in Asia – Virtual
10-14 Jan 2021	Healthcare Conference
22 Jan 2021	Macro Quantitative & Derivatives Conference

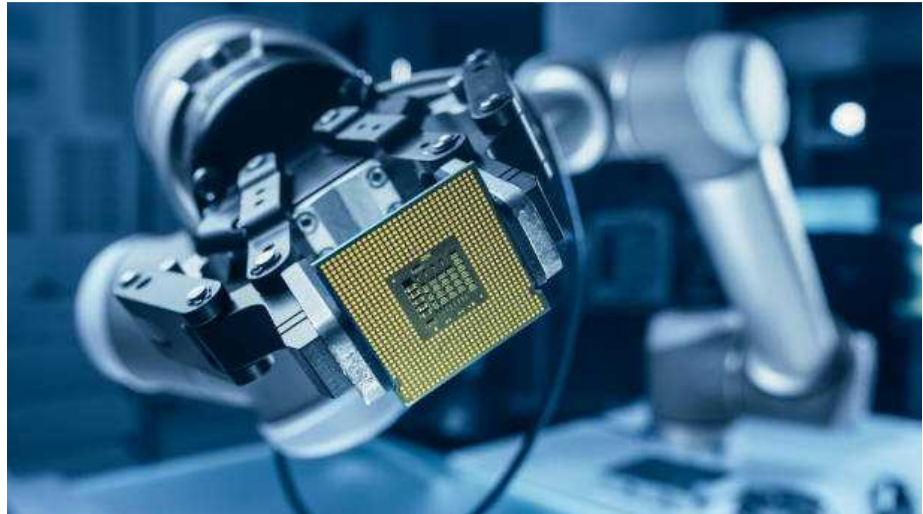
Source: J.P. Morgan.

Major Industry Conferences

8 Mar 2021	Global Women in Data Science (WiDS)
4-7 May 2021	ICLR Ethiopia
27-28 April 2021	Red hat Summit
14-18 August 2021	ACM SIGKDD Conference on Knowledge Discovery and Data Mining
2-4 March 2021	AI for Business Summit
2-4 Aug 2021	Association for Computational Linguistics (ACL 2021)
14-17 Aug 2021	Knowledge Discovery in Databases (KDD)
2-3 Sept 2021	Intelligent Systems Conference
22-26 Feb 2021	Global Artificial Intelligence Conference
8-10 June 2021	Open Data Science Conference
16-18 Oct 2020	International Conference on AI in Finance (ICAIF 2021)
22-23 Sept 2021	AI & Big Data Expo
11-13 Nov 2021	Supercomputing 2021 (SC21)
27 Nov-5 Dec 2021	NeurIPS 2021
2-9 Feb 2021	Association of Artificial Intelligence Conference (AAAI21)

Source: J.P. Morgan.

Industry Developments and News



Source: iStockPhoto

Beyond J.P. Morgan Global Research, we have curated key developments from academic and industry research, highlighting progress and major discoveries introduced over the second half of the year, especially within the AI, NLP, software, wetware and hardware systems as well as in quantum mechanics. A tectonic shift is underway from the use of traditional CPU chips to purpose-built GPU, TPU, IPU, chips as well as analogue RPU chips. Quantum computing has advanced, with a refined focus on effective quantum volume rather than just counting qubits. State of the art advances have been achieved in GPT-3 with 175B trainable parameters and various BERT derivatives achieving super-human performance at language modeling tasks. Here we share some identified noteworthy contributions from [Facebook](#), [Neuralink](#), [Google](#), [Amazon](#), [Microsoft](#), [IBM](#), [DeepMind](#), [OpenAI](#), [Intel](#), [nVidia](#), and prominent academics.

ML&AI Developments



Source: iStockPhoto

IPOs, Funding and Acquisitions within the ML/AI space continues with some very large deals taking place.

- Nvidia offered to [purchase](#) chip designer ARM for \$4Bn, subject to approvals.
- [Second Measure](#) was [acquired](#) by Bloomberg. The startup analyzes anonymized consumer purchases.
- [C3.ai](#). traded above \$100, well over the IPO price of \$42, a strong result for the first public offering of a standalone AI platform company.
- AutoML platform startup [DataRobot](#) raised \$270 million in series funding.
- Apple made a number of acquisitions like [Xnor.ai](#), [Voysis](#), [Camerai](#), [Scout FM](#).
- Microsoft acquired [ADRM Software](#) and [Orions Systems](#).
- Amazon [acquired](#) Zoox.
- Google [acquired](#) AppSheet.
- ServiceNow [acquired](#) ElementAI.
- Goldman Sachs' acquired [WhiteOps](#), ClearSky Security, and NightDragon under [undisclosed](#) terms to combat automated bot-based attacks and fraud.
- Salesforce acquired Slack for \$27.7Bn, an [about-face for Slack](#). Read the [FastCo](#) article for more.
- OpenAI, which started as a nonprofit, has turned into a [for-profit](#) company by granting Microsoft an exclusive license for its GPT-3 NLP model.
- [Google](#) partners with an investment bank, modernizing the bank's operations and services such as their electronic trading platform.

Natural Language Processing (NLP)



Source: iStockPhoto

GPT-3 News

For more details on GPT-3 (and a discussion of NLP in general) see this [special](#) in The Batch.

BERT + XLNet = MPNet

[MPNet](#) is a hybrid of Masked Language Modeling (MLM – BERT style) and autoregressive Permuted Language Modeling (PLM – think XLNet), adding additional masks up to the end of the sentence so that prediction at any position would attend to N number of tokens.

Flexible NLP

[CoreNLP](#) is Stanford's NLP framework for Java based on pipelines, updated to v4.2.

Top2Vec New Topic Modelling Tool

[Top2Vec](#) performs topic modelling. This article on [Medium](#) describes how UMAP and HDBSCAN are used across distributed Doc2Vecs to identify clusters, where the centroid vector represents the topic.

FactSet on Sentiment

FactSet have released an [eBook](#) discussing the main method of using NLP with portfolio management, via sentiment.

Natural Language Understanding (NLU)



Source: iStockPhoto

DeBERTa Breaks SuperGlue Records

Microsoft Research published a paper outlining [DeBERTa](#), a transformer-based model that surpasses the [SuperGlue](#) leaderboard for natural language understanding tasks using Disentangled Attention. Microsoft has also worked on Data Augmentation for [Multi-Document Summarisation](#).

Typologically Diverse Question Answering to Benchmark Natural Language Understanding

The Google Language [Research](#) team presents a new dataset for training and [evaluating](#) question-answering systems called [TyDi QA](#)

DeepPavlov answers your questions

[DeepPavlov](#) is an open-source framework for advanced NLU methods, including question-answering.

PEGASUS for text summaries

[PEGASUS](#) is Google's new research tool for abstractive text summarization

TLDR Concise Summaries

Allen Institute researchers have created [TLDR](#) using [BART](#) which can generate concise summaries of papers.

DALL-E and CLIP connect text and images

OpenAI announced [DALL·E](#) which can generate images from text instructions while [CLIP](#) can learn visual concepts using language supervision.

Natural Language Generation (NLG)



Source: iStockPhoto

Flexible NLG

[Turing-NLG](#) is a new Language Generation model from Microsoft with a [range of applications](#).

Polite Conversation

Uber and Carnegie Mellon University published a co-authored paper proposing a model for injecting [polite language](#) into conversational agents.

Big Bird: Transformers for Longer Sequences

[Big Bird](#) uses sparse attention where a node only attends to a few randomly selected tokens and some neighboring tokens, as well as CLS tokens that are fully connected, which provide relevant context, dependencies, etc for the self-attention layers to learn.

Fast Transformers with Clustered Attention

[Fast Transformers](#) approximate the standard self-attention to make it linear (rather than quadratic) for dependency. Attention is clustered and the attention values are calculated only for the centroids (and top members within a cluster).

Chat Bots



Source: iStockPhoto

Plato: A Framework for Building Conversational Agents at Scale

Uber built the [Plato Research Dialogue System \(PRDS\)](#) to address the challenges of building large scale conversational applications.

Code Free ChatBots

IBM announced Actions in [Watson Assistant](#) in beta, to be released 2021.

Rasa 2 Chatbots

[Rasa](#) 2.0 allows easier creation of [chatbots](#).

NeMo ChatBots

[NeMo](#) (Neural Modules) from NVIDIA allows you to [build](#), train and manipulating SotA conversational AI models capable of speech recognition.

Meena ChatBots

[Google Meena](#) is an open-domain chatbot that is scored on Sensibleness and Specificity Averages, aiming for more human-like responses.

XiaoIce Chatbots

[XiaoIce.ai](#), a spin-out from Microsoft provides a chatbot that has shown human-like performance in generating poems, paintings and music.

English Language Dialogue Data Released

The Microsoft Semantic Machines research team introduced [a new framework for conversational AI](#) in which dialogues represented as dataflow graphs make AI more flexible in its ability to adapt to the natural flow of conversation. Along with this, they released [the largest, most complex task-oriented dialogue dataset](#) to help advance conversational AI research more broadly.

Ethical Issues of AI



Source: iStockPhoto

A growing concern within the AI Community is centered around [ethics](#), and the lack of rules being embedded in autonomous systems. This is an issue the author Isaac Asimov addressed in [I, Robot](#) with the “[3 Laws of Robotics](#)” with [4 rules](#). There are people calling for [new rules for AI, updated](#) for the times since we are currently building technology that affects billions of people without a coherent set of guiding principles such as those advanced by the [Organization for Economic Cooperation and Development](#), agreed to and implemented by all rather than disparate rules developed by narrow focus groups, individual teams and private rules. Various reports suggest the problem is exacerbated by a [lack of training](#) and ambivalence amongst AI developers, many of whom may not consider it their [responsibility](#) to address potential negative consequences as a part of this work, not even [thinking](#) about how to [build ethical AI](#).

Representing the Underrepresented

Some of deep learning’s core datasets came under scrutiny as researchers combed them for [built-in biases](#) against socially marginalized groups.

The Right To Work

With [widespread unease](#) among British workers, the Trades Union Congress (TUC) in the UK [launched](#) a task force to lobby for legal protections related to AI in the workplace, suggesting the importance of a collaborative approach to the introduction of new technology.

Governance Issues with AI in Government

Many government efforts to exploit AI have not lived up to scrutiny, according to a new [report](#) that found many implementations of ML by US federal agencies are “uneven at best, and problematic and perhaps dangerous at worst”.

Model Bias

There are many [examples](#) of [researchers](#) & [skeptics](#) finding [flaws](#) in COVID-19 related machine learning models, finding bias in many systems for analyzing hospital admissions, diagnosis, imaging, and prognosis.

The UK Home Office has abandoned a [visa algorithm](#) designed to streamline visa applications after human rights activists sued, arguing that the model discriminated against people from countries with large non-white populations.

In a case of life mimicking [art](#), the LAPD had to stop using (or redesign) systems designed to forecast crimes after determining that they were [flawed](#) (e.g. identifying people with no apparent history of violent crime as high-risk offenders).

Biased Training Data Sets

Popular ML training datasets impart [biases against socially marginalized groups](#) which some are trying to [correct](#), or remove (such as the [Tiny Images](#) dataset after outside researchers found that it was rife with disparaging labels).

The Batch offers courses and information on bias mitigation techniques including [Double-Hard Debias](#) and [Deep Representation Learning on Long-Tailed Data](#).

Smaller Models, Bigger Biases

Google found that compression methods like parameter pruning and quantization designed to shrink neural networks while maintaining accuracy also [exacerbate a neural network's bias](#).

Social Media vs. Disinformation

- [Facebook](#) cracked down on misleading/manipulated media and banned DeepFake videos while continuing to develop deep learning tools to detect hate speech, memes that promote bigotry, and misinformation.
- [YouTube](#) developed a classifier to identify 'borderline content': videos that comply with its rules against hate speech but promote conspiracy theories, medical misinformation, and other fringe ideas.
- Facebook and Twitter [shut down thousands of accounts](#) deemed to be fronts for state-backed propaganda.
- Twitter [added disclaimers](#) to some content and [flagged](#) falsehoods from Trump.
- Unfortunately, the [WSJ](#) & [NYT](#) reported some efforts have been watered down, or are misfiring. See additional stories from The Batch [here](#), [here](#), [here](#) and [here](#).

Discrimination for Sale

[Ethnicity](#) and even [attractiveness](#) classification tools are available from: [Face++](#), [Spectrico](#), [Cognitec Systems](#) & [Facewatch](#), helping business understand sales patterns along questionable 'features'.

Responsible AI

Google continued to invest in [responsible AI research](#) and [tools](#), releasing a [blog post](#) and [report](#) on progress. They also did a lot of work on model bias and information (privacy) leakage in transformer models [summarized here](#) including a tool to measure [privacy vulnerability](#) as a function of model accuracy.

DeepFakes



Source: iStockPhoto

Deep Fakes (using GAN's) Proliferate

The Batch's [GAN special issue](#) features stories about detecting deepfakes, making GANs more inclusive, and an interview with GAN inventor Ian Goodfellow.

Protected By DeepFakes

Censor Veil is a technique that uses deepfakes to protect the privacy of at-risk subjects in documentaries as seen in "[Welcome to Chechnya](#)".

Deepfakes for Good

A Tencent paper argues that "[deepfake synthesis](#)" (of realistic human faces, voices, and bodies, as well as other objects) is of benefit, such as producing body doubles of dead actors to syncing lips to voiceovers in different languages, with many other potential commercial applications, but acknowledges the tools need effective regulation.

Machine Learning (ML) Techniques & Tools



Source: iStockPhoto

Reformers and Linear Attention offers 4000x improvement

Kernel trick for [transformers](#) helps reduce memory requirement from quadratic to linear. The neat [kernel trick](#) detailed in the research converts transformers into functional RNNs for a major speed boost.

Sequence-to-Sequence Models for TensorFlow

[tf-seq2seq](#) is an encoder-decoder framework developed for TensorFlow by Google for tasks such as machine translation services.

GANs for Good

“GANs for Good” was an online discussion hosted by Andrew Ng with Anima Anandkumar, Alexei Efros, Ian Goodfellow, and Sharon Zhou which was summarized in the [GAN Special Issue](#) of [The Batch](#).

GANs for Causal Modeling

Microsoft Research published an insightful blog that discusses techniques for uncovering [causal relationships](#) in datasets.

Time-Series Forecasting

[Neural Prophet](#) is inspired by [AR-Net](#) from Facebook AI Research (FAIR), which is an Autoregressive Neural Network for Time-Series Forecasting, complementing their well known [Prophet](#) model.

[PyTorch Forecasting](#) enables deep learning models for time-series forecasting with a simplified workflow.

Decentralized AI

[SingularityNET's](#) decentralized AI platform could reduce (the apparent) cost of AI models by exploiting blockchain runtimes.

Deep Sharpe

[Deep Learning for Portfolio Optimization](#) utilizes deep learning models to directly optimize a portfolio's Sharpe ratio.

Visual NN

[Uber Manifold](#) is a framework to help visually analyse and debug neural networks

Google blogged on the [Fairness Indicators](#) in TF that could become a key component of any [ethical] ML model.

Shrinking Bidirectional Long-Short Term Memory Networks

Attention-based [BDLSTM](#) Networks distill BERT for smaller models with faster inference time at relation classification tasks.

Temporal Convolutional Networks

[TCN's](#) are a new tool for Sequence Modeling, set to replace RNNs for tasks such as Market Trend Prediction, upgraded to Temporal Convolutional Attention-based Network ([TCAN](#)) recently.

Pyro: A Native Probabilistic Programming Language

[Pyro](#) is a deep probabilistic programming language (PPL) released by Uber AI Labs. Pyro is built on top of PyTorch

Debugging ML Models

[Manifold](#) is Uber's tool for debugging and interpreting machine learning models at scale.

Unadversarial Examples

Microsoft published an interesting paper about how to use "[unadversarial examples](#)" to increase the robustness of image classification models

Limits to Depth Efficiencies of Self-Attention

[Depth Efficiency](#) describes how Transformers can be scaled up to the '**depth threshold**' which is the **base 3 logarithm of the width**. If the depth is below this depth threshold increasing depth is more efficient than increasing the width.

[Double descent](#) is a phenomenon where, as model size increases, performance first gets worse and then gets better. OpenAI studied how many modern deep learning models are vulnerable to the double-descent phenomenon. Google took this one step further finding models can be susceptible to [triple-descent](#) and can be explained by a novel bias-variance decomposition.

Toward 1 Trillion Parameters

[DeepSpeed](#) accelerates the PyTorch deep learning framework thanks to Microsoft. DeepSpeed can now support trillion-parameter neural networks and help small-time developers build big-league models, such as the 17Bn parameter language model Turing-NLG.

Infinitely Wide Neural Net

At the limit of *infinite* width, neural networks take on a surprisingly simple form, and are described by a Neural Network Gaussian Process (NNGP) or Neural Tangent

Kernel (NTK). Google studied this phenomenon [theoretically](#) and [experimentally](#), and released [Neural Tangents](#), an [open-source software library](#) (for JAX).

Dropout with a Difference

[SliceOut](#) boosts NN speed with minimal impact on accuracy and runs faster on GPUs and TPUs than regular dropout.

Lap2D for RL

DeepMind open-sourced [Lab2D](#), a system for advancing research in multi-agent RL

RL Lookback

Reinforcement Learning benefits from the right amount of history via a refined [Experience Replay](#) parameter representing the ratio of stored observations to updates of the agent's strategy.

MuZero – Reinforcement Learning

DeepMind published a paper in [Nature](#) on [MuZero](#), an RL agent that can master games *without knowing the rules*, with good [forward planning](#) abilities.

ReBeL – Plays Games Too

Facebook built a probabilistic model called [ReBeL](#) that can play many different two-player zero-sum games, treating the imperfect knowledge state as factored probability distributions of the different beliefs of each player and using this feeding this through RL.

Zero Shot Learning

[Polygames](#) can become an important component of the toolset of researchers evaluating the training of zero-learning models.

Accelerating Training of Transformer-Based Language Models with Progressive Layer Dropping

2.5x faster pre-training with [Switchable Transformers](#) (ST) compared to standard and the same validation error as the baselines with 53% fewer training samples.

Coresets for Robust Training of Neural Networks against Noisy Labels

NEURIPS talk that creates sets of mostly clean data ([Coresets](#)) to train a model with and show a significant increase in performance on noisy datasets.

Sparse NNs

There exists a **sub-network that exhibits performance comparable to the original complete network**. These sub-networks are called [lottery tickets](#) and are defined by masks that tell which weight is zeroed out in the original network, with sparsity between **40% to 90%** for a range of downstream tasks.

Mathematical Proofs

[GPT-f](#) can generate mathematical proofs.

TAPAS – Tabular NLP

Googles [TAPAS](#) is a model to query tabular data using NLP, and is based on BERT

Causal Inference for continuous (rather than binary) problems

Uber published on [Learning Continuous Treatment Policy and Bipartite Embeddings for Matching with Heterogeneous Causal Effects](#)

Transformers for Image Classification

Facebook + Sorbonne University published a method to optimize the training of [image classification transformer](#) models, which are notoriously data hungry.

Logic Neural Networks

IBM are trying to get AI to Reason by using [Neuro-Symbolic AI](#) for Knowledge-Based Question Answering.

HiPlot for PyTorch

[HiPlot](#) is a library for exploring and visualizing high-dimensional datasets, which are common in deep learning problems.

Computational Causal Inference from Netflix

[Computational causal inference](#) is a new interdisciplinary field which Netflix are seeking to collaborate in.

Alternative Notebooks

[Polynote](#) is a multi-language notebook environment from NetFlix with support for Python, SQL, Vega (visualizations), & Scala.

Object Detection Advances

Baidu publishes [PP-YOLO](#) (PaddlePaddle) and pushes the [state of the art](#) in object detection research beyond YOLOv4

Visualize Neural Networks

The [Lucid Library](#) is a framework to improve the interpretation of deep neural networks. The current release includes all the visualizations included in [OpenAI's Microscope](#).

FastIngest Data Pipeline

[LinkedIn](#) released [FastIngest](#), a data ingestion pipeline based on Apache Gobblin

Probabilistic Time Series Modeling

[Gluon](#) was released by AWS with a focus on deep learning-based models

Excel with Embedded Python

[PyXLL-Jupyter](#) package allows Python to be embedded in Excel, potentially replacing VBA

Mac M1 Optimized TensorFlow

[Apple](#) released a version of the TensorFlow deep learning framework optimized for the new Mac M1 hardware

The Language Interpretability Tool (LIT)

Google open-sourced the [LIT](#), an interactive toolkit that addresses challenges specific to NLP models.

Massively Scalable Deep Reinforcement Learning (DRL)

[SEEDRL](#) is a new architecture for DRL with massive levels of scalability, superceding [IMPALA](#)

ML for the Common Good

The [MLCommons](#) consortium is building open data and tools for next-generation machine learning and includes representatives of Alibaba, Facebook, Google, Intel, and Landing AI. Releasing [People's Speech](#) contains 87,000 hours of spoken-word examples in 59 languages and [MLCube](#), an interface for sharing models, including data and parameters, via containers.

AI Explainability

The AI Explainability 360 Toolkit ([AIX360](#)) from IBM simplifies the interpretability of ML models and datasets.

Performers accelerate SoftMax

[Performers](#) approximate the slow softmax function via the gaussian kernel to speed up transformers by approximating attention as documented in [Rethinking Attention with Performers](#) which will benefit long attention models most with a linear model instead of a quadratic.

Halve Your Memory Requirements with Shards

[FairScale](#) and [PyTorch Lightning](#) bring you 50% memory reduction across all your models via [Sharded Training](#).

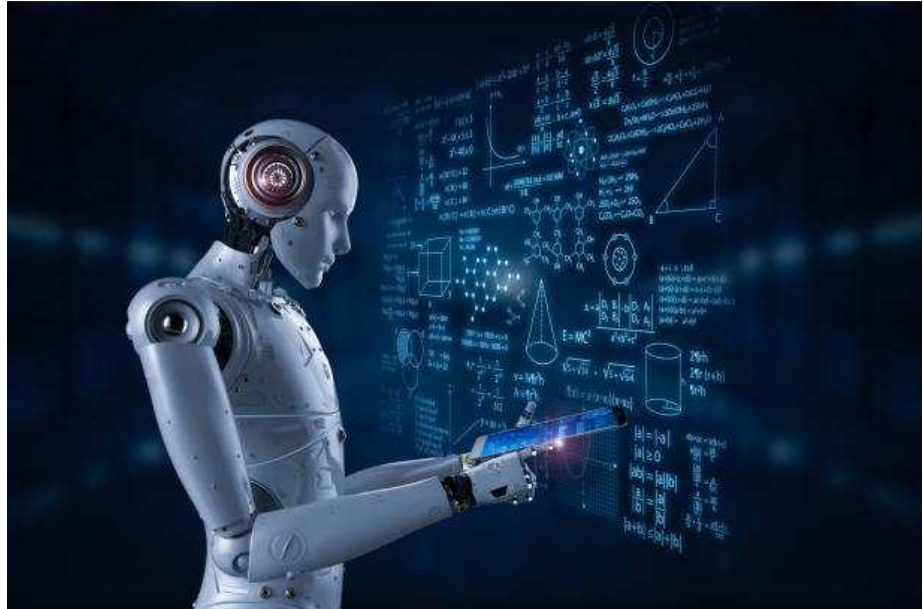
Graph Neural Nets solved with PageRank

[Grapple](#) is a framework from Google used to design ML Graphs. To solve [scalable graph neural network models](#), Google uses [PageRank](#) to accelerate inference in GNNs.

CorrGAN: Realistic Financial Correlation Matrices

The new CorrGAN model (part of [MIFinLab](#) – with restricted licenses) is designed to generate [realistic correlation matrices](#) closely aligned to empirical ones across a range of statistical measures.

Automated Machine Learning



Source: iStockPhoto

Overview

AutoML.org has a good [archive](#) of relevant research that is constantly updated.

Low-Code Auto-ML

Uber's [Ludwig](#) is a low-code machine learning platform.

[AutoML-Zero](#) proposed a method to expand the frontiers of AutoML models.

NN Designer

[Neural Architecture Search \(NAS\)](#) might outperform hand designed NN architectures.

Scala-ble AI

[TransmogriAI](#) an open-source framework that Salesforce.com used to build Einstein, running on Apache Spark & written in Scala.

Meta-Learning

[Comet.ml](#), often called the GitHub of machine learning, are advancing the famous paper about an algorithm for **Model-Agnostic Meta-Learning (MAML)**.

Evolution

Google gave an [evolutionary algorithm](#) a search space consisting of primitive operations (like addition, subtraction, variable assignment, and matrix multiplication) in order to see if it was possible to evolve modern ML algorithms from scratch.

Time-Series Modeling

IBM's [AutoAI](#) platform now supports time series feature selection, model selection and optimization.

Data & Labels



Source: Pexels

Fewer Labels, More Learning

Andrew Ng ([the Batch](#)) reminds us of the importance of correctly labelled data, especially for small sized training sets.

[SimCLRv2](#) uses a training method for image recognition that outperformed the state of the art in self-supervised learning and beat fully supervised models while using a small fraction of the labels.

[Ordered Temporal Alignment Module](#) (OTAM) is a model that classifies videos with limited training data.

All Examples Are Not Equal

Semi-supervised learning typically treats all unlabeled examples the same while this [algorithm](#) weighs the most significant examples more heavily.

Improved Crowd Counts

[DM-Count](#) trains NNs to count crowd size using [optimal transport](#) cost function.

Identifying Mislabeled Data

[Mislabeled data](#) can be identified using the Area Under the Margin (AUM) Ranking, and removed, resulting in a more accurately trained model.

Improving Class-Imbalanced Learning

Avoid [Label Bias](#) with self-training or self-supervised pretraining can be used when you have an imbalanced training set and larger un-labelled dataset.

Consistent Training with Few Labels

[Unsupervised Data Augmentation for Consistency Training](#) uses remarkably few (~20) true labels to learn a good classifier.

Recurrence vs. Attention

[Untangling tradeoffs between recurrence and self-attention in neural networks](#) with attention *sparsity* and gradient flow *depth* bounding the computational complexity and the information flow in these types of networks.

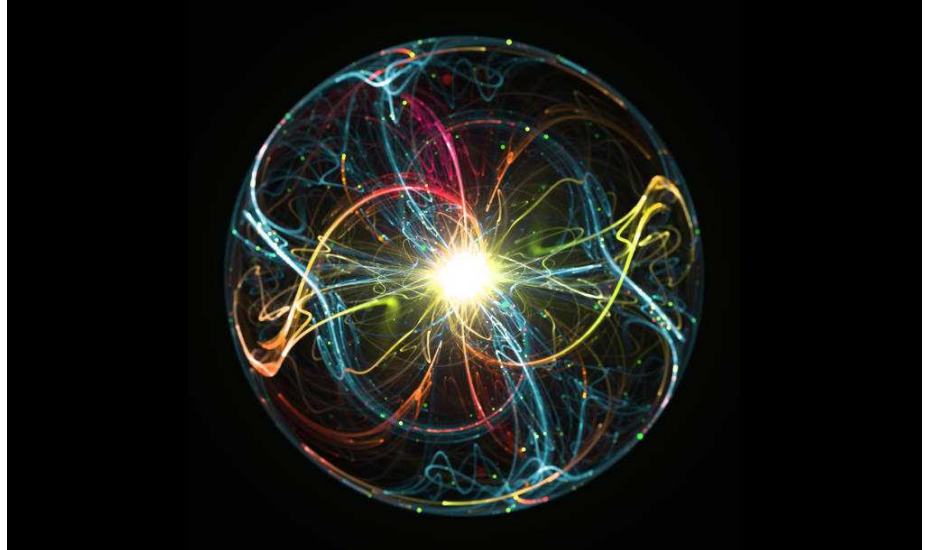
Retrieval based Question Answering

[Retrieval-Augmented Generation for Knowledge-Intensive NLP tasks](#) can answer questions for which it wasn't trained on by swapping the collection of documents it gets knowledge from (without any re-training). But beware as factual accuracy still falls.

Classifying More Classes than Data

'[Less Than One](#)'-Shot Learning or detecting N classes from $M < N$ Samples, is an interesting idea for [training with less data](#).

Quantum Computing



Source: iStockPhoto

The quest for “[Quantum Supremacy](#)” between Google and IBM that started in 1H20 continues with a [new entrant](#) “[Jiuzhang](#)” from a group of institutions based in China.

Meanwhile, scientists at the University of Chicago announced a new [technique](#) that allows quantum systems to stay operational—or “coherent”—[10,000 times longer](#) than before.

[J.P. Morgan](#) continues to [investigate](#) Quantum Computing for such tasks as risk management, portfolio allocation, fraud detection & [Quantum Oracles](#).

IBM and Goldman Sachs provide an estimate of the quantum computing resources needed to achieve quantum advantage for derivative pricing in “[A Threshold for Quantum Advantage in Derivative Pricing](#)”.

Quantum computing can also help with QRNN’s ([Quantum Recurrent Neural Networks](#)) and regular ML tasks ([Learning with Optimized Random Features: Exponential Speedup by Quantum Machine Learning without Sparsity and Low-Rank Assumptions](#)) as presented at NeurIPS 2020.

Baidu Quantum Computing Institute announced [Paddle Quantum](#), a quantum machine learning development toolkit based on PaddlePaddle, named [Quantum Leaf](#).

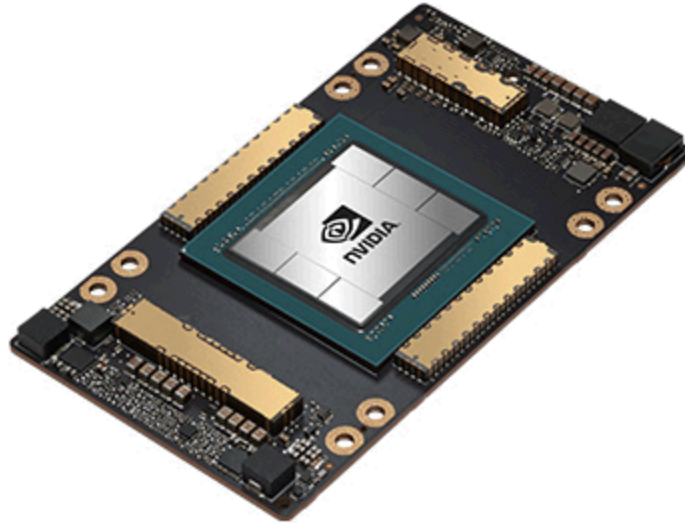
Microsoft is also actively researching [Quantum-safe cryptography](#)

Google continued to progress their roadmap towards building a [universal error-corrected](#) quantum computer.

IBM worked on determining when a Quantum Computer has a “[Quantum Advantage](#)” over classical (binary) algorithm.

CPU, GPU, TPU, IPU, RPU & Other Hardware Developments

Figure 2: The nVidia A100 GPU



Source: nVidia (with permission).

TinyML for IoT

[Tiny Machine Learning](#) is pushing *ultra-low-power embedded devices* such as Arduino Nano (USD \$2 for clones) into new uses, coupled with the introduction of embedded machine learning frameworks like TensorFlow Lite for Microcontrollers which often run at reduced bit depth (8-bit instead of 64) to enable the proliferation of AI-powered IoT devices.

Embedded AI

The [Jetson Nano](#) is a cheap (USD \$59) compact, powerful (128-core NVIDIA Maxwell cores) embedded platform for AI/ML/Robotics.

Large Chips

NVIDIA upgraded the [A100](#) GPU, now with 80GB of memory.

For a single system that replaces racks of graphics processing units try [Cerebras' CS-1 SYSTEM](#) with 400,000 Sparse Linear Algebra Compute (SLAC) cores and 1.2Tn transistors. Or perhaps you could wait for the new version with 2.6Tn transistors and 850,000 cores using Temasec's 7nm process.

[Graphcore's](#) IPU-Machine M2000, each hosting four Mk2 Colossus chips which combine to deliver a computational punch of 1 petaflop, or to 16 ExaFlops for the IPU-POD64 rack.

Built with NVIDIA A100 GPUs, [Selene](#) achieved 63.4 petaflops on HPL (a test on the [TOP500 list](#)) and nearly 2.8 exaflops of peak AI performance.

[Googles new TPU](#) shifts the work of scheduling and logic control to the CPU host so the TPU acts as a simple coprocessor. TPU v3 doubles the number of cores than v2, and the coming TPU v4 will double in performance again (2.7x) per [Medium](#) article.

Taking a different approach, Intel have updated the [FPGA for faster ML](#).

Apple's new M1 is very capable ML tool

M1 Mac Mini scores higher than an NVIDIA RTX 2080Ti in ([some](#)) TensorFlow speed tests, thanks in part to a new customised fork of TensorFlow.

Alexa, Read My Lips

Amazon's digital assistant is using its eyes as well as its ears to figure out who's talking with a new Alexa [skill](#).

Holographic Storage

In search for the future of large, stable, read-only storage, Microsoft look to [holographic storage](#) solutions.

Spinning Storage

IBM announced a "Spin State" memory chip that uses the spin-state of electrons to store information in L2-Cache's. The 14nm [STT-MRAM](#) chips operate at 3ns for fast memory transfer.

Analog Chips

IBM developed an "[Unassisted True Analog Neural Network Training Chip](#)," the first analog neural network training chip based on a resistive processing unit, or RPU which stores data and performs compute on the same chip.

End of Moore's Law?

[Huang's Law](#) of AI ([GPU] chips that power AI more than double in performance every two years) has been [proposed](#) and [contested](#) as a replacement Moore's Law as we approach the physical limits of atomic-scale circuitry.

Wetware – Human Computer Interfaces



Source: iStockPhoto

For more detail on the major advances in Brain Implants for 2020 see [this](#) article.

Running Blind

Lane Departure Warnings for Runners via a Google smartphone [app](#) translates camera images into audio signals. Guidelines produces sounds that indicate deviations from lines painted on a path, enabling people to correct their course without using their eyes.

Neuralink Brain Implants

[Neuralink demonstrated](#) a brain implant in a Pig that could solve brain problems.

Brain Scan

[Paradromics](#) has achieved the largest-ever electrical recording of neural activity from the cerebral cortex, using 65,000 electrodes.

[Aurora 21](#) will map an entire human brain using their ExaFlop scale Supercomputer. The human “connectome” contains 100Mn neurons and the connections.

A [Stentrode](#) inserted in a [jugular vein](#) allows paralyzed people to type with their minds (via a second device embedded in the chest, which wirelessly transmits that data to a computer or phone and converts it into computer commands).

Deep brain stimulation alters human behaviour

A scientist is using a brain implant to cure his alcoholism with [Deep Brain Stimulation](#)

Artificial Vision

Scientists used a brain-stimulating implant in monkeys that allowed them to “see” shapes via a high-resolution [neuroprosthesis](#) device that contains more than 1,000 electrodes and sits on top of the visual cortex. Second Sight is conducting human trials to restore people’s vision with an interview [here](#).

Healthcare and COVID-19



Source: iStockPhoto

The Batch featured regular [AI-Against-COVID-19](#) news reports throughout the year.

Crowdsourcing Coronavirus Cures

IEEE [Spectrum](#) reported on 4 antiviral drugs identified (in part) by an ML project “[Covid Moonshot](#)” as having potential to treat people who are already infected.

Advanced Warning

[BlueDot](#) analyzed news reports for significant events, [detected the COVID pandemic](#) days ahead of the global health monitors.

Mask Compliance

Some cities in France evaluated [compliance](#) with mask wearing regulations using computer assisted vision in public areas.

Regional Relief

The government of Togo used a computer model based on satellite imagery to [identify regions](#) of extreme poverty which helped guide the distribution of relief funds.

Zoom your PJ's into a suit

Videoconferencing tools such as Microsoft Teams can filter background noises (like [eating](#)) and [virtually transform pajamas](#) into something more business appropriate.

Highlight active *sign-language* speaker

Google developed [Real-Time, Automatic Sign Language Detection for Video Conferencing](#) because often sign-ing people are not recognized as ‘active’ speakers in multi-participant rooms.

CT Scan for COVID-19

A model that can [detect Covid-19 in CT scans](#) was developed in China.

Software (S/W) & Tool Developments



Source: iStockPhoto

Python 3.9

[Python](#) updates continue with the latest stable release in October with many enhancements including some to CPython (that will need testing).

Julia 1.5

[Julia 1.5](#) released with new features, improved stability and performance

TensorFlow 2.4

[TensorFlow](#) has released its new update with many requested features and enhancements focused on performance and scaling

HTTP 3

[HTTP3](#) is being developed to help ensure streaming media, games and 5G have the technical mechanisms to provide the immediate response, always connected experience we are becoming accustomed to.

Baidu Brain 6 + PaddlePaddle 2.0

[Baidu Brain](#) covers 6 layers of AI and was recently updated including support for Baidu Kunlun 2, a home grow AI Chip that uses 7 nm process technology ready for 2021.

Horovod 0.2

UBER have updated [Horovod](#) with optimized Network Utilisation via Local Gradient Aggregation. Horovod supports scaling NN's across 100's of GPU's.

Recommended Reading

- [What Machine Learning Will Mean for Asset Managers](#)
- Max Kuhn's [Applied Predictive Modeling](#) book.
- Andrew Ng's [AI Transformation Playbook](#)
- [SOTA](#)
- [DeepLearning.ai](#)
- [Fast.ai](#)
- [Open.ai](#)
- [Google AI Blog](#)
- [Microsoft AI Research](#)
- [Uber AI Research](#)
- [FaceBook AI Research](#)
- [Baidu Research](#)
- [Medium.com](#)
- [Towards Data Science](#)
- [blog.acolyer.org](#)
- [Twiml AI](#)
- [neurohive.io](#)
- [Ma & Musk on AI](#)
- [The Sequence](#)
- [JP Morgan Markets](#)

J.P. Morgan Alternative Data Tools & APIs

The www.jpmm.com website offers a wealth of services to clients including screening tools and the DataQuery portal. All of our reports are available in HTML and PDF format or via data feeds in PDF and RIXML format. A suite of APIs is available on [J.P. Morgan Developer](#). J.P. Morgan's research can now be accessed through Amazon's virtual voice assistant, [Alexa](#), creating the start of a new delivery channel for the firm. Clients can request Alexa to email them information such as a stock's tear sheet or the latest research from a specific analyst.

DataQuery

[DataQuery](#) now allows users to view market movers in real-time. As part of our continuing strategy to evolve DataQuery into a unified and best-in-class Pre-Trade Analytics hub, we have launched DataQuery Market Monitor, which provides a real-time view of market data. We also released DataQuery Market Impacting Events, to allow users to overlay and analyze the impact of macroeconomic indicators, as well as geopolitical events, on queries and charts.

J.P. Morgan Developer

[Developer](#) provides direct access to data and functionality that allow our clients to seamlessly integrate J.P. Morgan's data with the way they work. The various APIs provide access to J.P. Morgan's range of solutions across Research and Analytics (including DataQuery), Pricing and Structuring, Execution, Post-Trade and Banking.

Data feeds

All J.P. Morgan Global Research reports are distributed through data feeds in PDF format with accompanying RIXML files. The RIXML file provides sufficient metadata (tagging) to allow for searching, sorting, parsing and filtering our research. Examples of such metadata include tagging of coverage actions (e.g., initiations), rating actions (e.g., downgrade), price target actions and Global Industry Classification Standard (GICS) industry (e.g., Financials).

We are excited to announce the launch of the new DataQuery application with an extended navigation and an enhanced experience to create, save, and manage your queries. The latest upgrade allows us to integrate additional data and analytics services and offer you more capabilities on the platform in the coming months and for years to come. Please [Contact DataQuery](#) today to learn more and schedule a demo.

Analyst Certification: The Research Analyst(s) denoted by an “AC” on the cover of this report certifies (or, where multiple Research Analysts are primarily responsible for this report, the Research Analyst denoted by an “AC” on the cover or within the document individually certifies, with respect to each security or issuer that the Research Analyst covers in this research) that: (1) all of the views expressed in this report accurately reflect the Research Analyst’s personal views about any and all of the subject securities or issuers; and (2) no part of any of the Research Analyst’s compensation was, is, or will be directly or indirectly related to the specific recommendations or views expressed by the Research Analyst(s) in this report. For all Korea-based Research Analysts listed on the front cover, if applicable, they also certify, as per KOFIA requirements, that the Research Analyst’s analysis was made in good faith and that the views reflect the Research Analyst’s own opinion, without undue influence or intervention.

All authors named within this report are Research Analysts unless otherwise specified. In Europe, Sector Specialists (Sales and Trading) may be shown on this report as contacts but are not authors of the report or part of the Research Department.

Research excerpts: This note includes excerpts from previously published research. For access to the full reports, including analyst certification and important disclosures, investment thesis, valuation methodology, and risks to rating and price targets, please contact your salesperson or the covering analyst’s team or visit www.jpmorganmarkets.com.

Important Disclosures

This report is a product of the research department’s Global Quantitative and Derivatives Strategy group. Views expressed may differ from the views of the research analysts covering stocks or sectors mentioned in this report. Structured securities, options, futures and other derivatives are complex instruments, may involve a high degree of risk, and may be appropriate investments only for sophisticated investors who are capable of understanding and assuming the risks involved. Because of the importance of tax considerations to many option transactions, the investor considering options should consult with his/her tax advisor as to how taxes affect the outcome of contemplated option transactions.

Company-Specific Disclosures: Important disclosures, including price charts and credit opinion history tables, are available for compendium reports and all J.P. Morgan–covered companies by visiting <https://www.jpmm.com/research/disclosures>, calling 1-800-477-0406, or e-mailing research.disclosure.inquiries@jpmorgan.com with your request. J.P. Morgan’s Strategy, Technical, and Quantitative Research teams may screen companies not covered by J.P. Morgan. For important disclosures for these companies, please call 1-800-477-0406 or e-mail research.disclosure.inquiries@jpmorgan.com.

Explanation of Equity Research Ratings, Designations and Analyst(s) Coverage Universe:

J.P. Morgan uses the following rating system: Overweight [Over the next six to twelve months, we expect this stock will outperform the average total return of the stocks in the analyst’s (or the analyst’s team’s) coverage universe.] Neutral [Over the next six to twelve months, we expect this stock will perform in line with the average total return of the stocks in the analyst’s (or the analyst’s team’s) coverage universe.] Underweight [Over the next six to twelve months, we expect this stock will underperform the average total return of the stocks in the analyst’s (or the analyst’s team’s) coverage universe.] Not Rated (NR): J.P. Morgan has removed the rating and, if applicable, the price target, for this stock because of either a lack of a sufficient fundamental basis or for legal, regulatory or policy reasons. The previous rating and, if applicable, the price target, no longer should be relied upon. An NR designation is not a recommendation or a rating. In our Asia (ex-Australia and ex-India) and U.K. small- and mid-cap equity research, each stock’s expected total return is compared to the expected total return of a benchmark country market index, not to those analysts’ coverage universe. If it does not appear in the Important Disclosures section of this report, the certifying analyst’s coverage universe can be found on J.P. Morgan’s research website, www.jpmorganmarkets.com.

J.P. Morgan Equity Research Ratings Distribution, as of January 01, 2021

	Overweight (buy)	Neutral (hold)	Underweight (sell)
J.P. Morgan Global Equity Research Coverage*	48%	39%	13%
IB clients**	53%	49%	35%
JPMS Equity Research Coverage*	45%	40%	14%
IB clients**	78%	69%	51%

*Please note that the percentages might not add to 100% because of rounding.

**Percentage of subject companies within each of the "buy," "hold" and "sell" categories for which J.P. Morgan has provided investment banking services within the previous 12 months.

For purposes only of FINRA ratings distribution rules, our Overweight rating falls into a buy rating category; our Neutral rating falls into a hold rating category; and our Underweight rating falls into a sell rating category. Please note that stocks with an NR designation are not included in the table above. This information is current as of the end of the most recent calendar quarter.

Equity Valuation and Risks: For valuation methodology and risks associated with covered companies or price targets for covered companies, please see the most recent company-specific research report at <http://www.jpmorganmarkets.com>, contact the primary analyst

or your J.P. Morgan representative, or email research.disclosure.inquiries@jpmorgan.com. For material information about the proprietary models used, please see the Summary of Financials in company-specific research reports and the Company Tearsheets, which are available to download on the company pages of our client website, <http://www.jpmorganmarkets.com>. This report also sets out within it the material underlying assumptions used.

Analysts' Compensation: The research analysts responsible for the preparation of this report receive compensation based upon various factors, including the quality and accuracy of research, client feedback, competitive factors, and overall firm revenues.

Registration of non-US Analysts: Unless otherwise noted, the non-US analysts listed on the front of this report are employees of non-US affiliates of J.P. Morgan Securities LLC, may not be registered as research analysts under FINRA rules, may not be associated persons of J.P. Morgan Securities LLC, and may not be subject to FINRA Rule 2241 or 2242 restrictions on communications with covered companies, public appearances, and trading securities held by a research analyst account.

Other Disclosures

J.P. Morgan is a marketing name for investment banking businesses of JPMorgan Chase & Co. and its subsidiaries and affiliates worldwide.

All research material made available to clients are simultaneously available on our client website, J.P. Morgan Markets, unless specifically permitted by relevant laws. Not all research content is redistributed, e-mailed or made available to third-party aggregators. For all research material available on a particular stock, please contact your sales representative.

Any long form nomenclature for references to China; Hong Kong; Taiwan; and Macau within this research material are Mainland China; Hong Kong SAR (China); Taiwan (China); and Macau SAR (China).

Options and Futures related research: If the information contained herein regards options- or futures-related research, such information is available only to persons who have received the proper options or futures risk disclosure documents. Please contact your J.P. Morgan Representative or visit <https://www.theocc.com/components/docs/riskstoc.pdf> for a copy of the Option Clearing Corporation's Characteristics and Risks of Standardized Options or http://www.finra.org/sites/default/files/Security_Futures_Risk_Disclosure_Statement_2018.pdf for a copy of the Security Futures Risk Disclosure Statement.

Changes to Interbank Offered Rates (IBORs) and other benchmark rates: Certain interest rate benchmarks are, or may in the future become, subject to ongoing international, national and other regulatory guidance, reform and proposals for reform. For more information, please consult: https://www.jpmorgan.com/global/disclosures/interbank_offered_rates

Private Bank Clients: Where you are receiving research as a client of the private banking businesses offered by JPMorgan Chase & Co. and its subsidiaries ("J.P. Morgan Private Bank"), research is provided to you by J.P. Morgan Private Bank and not by any other division of J.P. Morgan, including, but not limited to, the J.P. Morgan Corporate and Investment Bank and its Global Research division.

Legal entity responsible for the production and distribution of research: The legal entity identified below the name of the Reg AC Research Analyst who authored this material is the legal entity responsible for the production of this research. Where multiple Reg AC Research Analysts authored this material with different legal entities identified below their names, these legal entities are jointly responsible for the production of this research. Research Analysts from various J.P. Morgan affiliates may have contributed to the production of this material but may not be licensed to carry out regulated activities in your jurisdiction (and do not hold themselves out as being able to do so). Unless otherwise stated below, this material has been distributed by the legal entity responsible for production. If you have any queries, please contact the relevant Research Analyst in your jurisdiction or the entity in your jurisdiction that has distributed this research material.

Legal Entities Disclosures and Country-/Region-Specific Disclosures:

Argentina: JPMorgan Chase Bank N.A Sucursal Buenos Aires is regulated by Banco Central de la República Argentina ("BCRA"- Central Bank of Argentina) and Comisión Nacional de Valores ("CNV"- Argentinian Securities Commission" - ALYC y AN Integral N°51). **Australia:** J.P. Morgan Securities Australia Limited ("JPMSAL") (ABN 61 003 245 234/AFS Licence No: 238066) is regulated by the Australian Securities and Investments Commission and is a Market, Clearing and Settlement Participant of ASX Limited and CHIX. This material is issued and distributed in Australia by or on behalf of JPMSAL only to "wholesale clients" (as defined in section 761G of the Corporations Act 2001). A list of all financial products covered can be found by visiting <https://www.jpmm.com/research/disclosures>. J.P. Morgan seeks to cover companies of relevance to the domestic and international investor base across all Global Industry Classification Standard (GICS) sectors, as well as across a range of market capitalisation sizes. If applicable, in the course of conducting public side due diligence on the subject company(ies), the Research Analyst team may at times perform such diligence through corporate engagements such as site visits, discussions with company representatives, management presentations, etc. Research issued by JPMSAL has been prepared in accordance with J.P. Morgan Australia's Research Independence Policy which can be found at the following link: [J.P. Morgan Australia - Research Independence Policy](#). **Brazil:** Banco J.P. Morgan S.A.

is regulated by the Comissao de Valores Mobiliarios (CVM) and by the Central Bank of Brazil. Ombudsman J.P. Morgan: 0800-7700847 / ouvidoria.jp.morgan@jpmorgan.com. **Canada:** J.P. Morgan Securities Canada Inc. is a registered investment dealer, regulated by the Investment Industry Regulatory Organization of Canada and the Ontario Securities Commission and is the participating member on Canadian exchanges. This material is distributed in Canada by or on behalf of J.P.Morgan Securities Canada Inc. **Chile:** Inversiones J.P. Morgan Limitada is an unregulated entity incorporated in Chile. **China:** J.P. Morgan Securities (China) Company Limited has been approved by CSRC to conduct the securities investment consultancy business. **Dubai:** JPMorgan Chase Bank, N.A., Dubai Branch is regulated by the Dubai Financial Services Authority (DFSA) and its registered address is Dubai International Financial Centre - The Gate, West Wing, Level 3 and 9 PO Box 506551, Dubai, UAE. This material has been distributed to persons regarded as professional clients or market counterparties as defined under the DFSA rules. **European Economic Area (EEA):** Unless specified to the contrary, research is distributed in the EEA by J.P. Morgan AG (“JPM AG”), which is a member of the Frankfurt Stock Exchange, is authorised by the European Central Bank (“ECB”) and is regulated by the Federal Financial Supervisory Authority (BaFin). JPM AG is a company incorporated in the Federal Republic of Germany with a registered office at Taunustor 1, 60310 Frankfurt am Main, the Federal Republic of Germany. The material has been distributed in the EEA to persons regarded as professional investors (or equivalent) pursuant to Art. 4 para. 1 no. 10 and Annex II of MiFID II and its respective implementation in their home jurisdictions (“EEA professional investors”). This material must not be acted on or relied on by persons who are not EEA professional investors. Any investment or investment activity to which this material relates is only available to EEA relevant persons and will be engaged in only with EEA relevant persons. **Hong Kong:** J.P. Morgan Securities (Asia Pacific) Limited (CE number AAJ321) is regulated by the Hong Kong Monetary Authority and the Securities and Futures Commission in Hong Kong, and J.P. Morgan Broking (Hong Kong) Limited (CE number AAB027) is regulated by the Securities and Futures Commission in Hong Kong. JP Morgan Chase Bank, N.A., Hong Kong (CE Number AAL996) is regulated by the Hong Kong Monetary Authority and the Securities and Futures Commission, is organized under the laws of the United States with limited liability. **India:** J.P. Morgan India Private Limited (Corporate Identity Number - U67120MH1992FTC068724), having its registered office at J.P. Morgan Tower, Off. C.S.T. Road, Kalina, Santacruz - East, Mumbai – 400098, is registered with the Securities and Exchange Board of India (SEBI) as a ‘Research Analyst’ having registration number INH000001873. J.P. Morgan India Private Limited is also registered with SEBI as a member of the National Stock Exchange of India Limited and the Bombay Stock Exchange Limited (SEBI Registration Number – INZ000239730) and as a Merchant Banker (SEBI Registration Number - MB/INM000002970). Telephone: 91-22-6157 3000, Facsimile: 91-22-6157 3990 and Website: www.jpmini.com. JPMorgan Chase Bank, N.A. - Mumbai Branch is licensed by the Reserve Bank of India (RBI) (Licence No. 53/ Licence No. BY.4/94; SEBI - IN/CUS/014/ CDSL : IN-DP-CDSL-444-2008/ IN-DP-NSDL-285-2008/ INBI00000984/ INE231311239) as a Scheduled Commercial Bank in India, which is its primary license allowing it to carry on Banking business in India and other activities, which a Bank branch in India are permitted to undertake. For non-local research material, this material is not distributed in India by J.P. Morgan India Private Limited. **Indonesia:** PT J.P. Morgan Sekuritas Indonesia is a member of the Indonesia Stock Exchange and is regulated by the OJK a.k.a. BAPEPAM LK. **Korea:** J.P. Morgan Securities (Far East) Limited, Seoul Branch, is a member of the Korea Exchange (KRX). JPMorgan Chase Bank, N.A., Seoul Branch, is licensed as a branch office of foreign bank (JPMorgan Chase Bank, N.A.) in Korea. Both entities are regulated by the Financial Services Commission (FSC) and the Financial Supervisory Service (FSS). For non-macro research material, the material is distributed in Korea by or through J.P. Morgan Securities (Far East) Limited, Seoul Branch. **Japan:** JPMorgan Securities Japan Co., Ltd. and JPMorgan Chase Bank, N.A., Tokyo Branch are regulated by the Financial Services Agency in Japan. **Malaysia:** This material is issued and distributed in Malaysia by JPMorgan Securities (Malaysia) Sdn Bhd (18146-X), which is a Participating Organization of Bursa Malaysia Berhad and holds a Capital Markets Services License issued by the Securities Commission in Malaysia. **Mexico:** J.P. Morgan Casa de Bolsa, S.A. de C.V. and J.P. Morgan Grupo Financiero are members of the Mexican Stock Exchange and are authorized to act as a broker dealer by the National Banking and Securities Exchange Commission. **New Zealand:** This material is issued and distributed by JPMSAL in New Zealand only to “wholesale clients” (as defined in the Financial Advisers Act 2008). JPMSAL is registered as a Financial Service Provider under the Financial Service providers (Registration and Dispute Resolution) Act of 2008. **Pakistan:** J. P. Morgan Pakistan Broking (Pvt.) Ltd is a member of the Karachi Stock Exchange and regulated by the Securities and Exchange Commission of Pakistan. **Philippines:** J.P. Morgan Securities Philippines Inc. is a Trading Participant of the Philippine Stock Exchange and a member of the Securities Clearing Corporation of the Philippines and the Securities Investor Protection Fund. It is regulated by the Securities and Exchange Commission. **Russia:** CB J.P. Morgan Bank International LLC is regulated by the Central Bank of Russia. **Singapore:** This material is issued and distributed in Singapore by or through J.P. Morgan Securities Singapore Private Limited (JPMSS) [MCI (P) 018/04/2020 and Co. Reg. No.: 199405335R], which is a member of the Singapore Exchange Securities Trading Limited, and/or JPMorgan Chase Bank, N.A., Singapore branch (JPMCB Singapore) [MCI (P) 052/09/2020], both of which are regulated by the Monetary Authority of Singapore. This material is issued and distributed in Singapore only to accredited investors, expert investors and institutional investors, as defined in Section 4A of the Securities and Futures Act, Cap. 289 (SFA). This material is not intended to be issued or distributed to any retail investors or any other investors that do not fall into the classes of “accredited investors,” “expert investors” or “institutional investors,” as defined under Section 4A of the SFA. Recipients of this material in Singapore are to contact JPMSS or JPMCB Singapore in respect of any matters arising from, or in connection with, the material. As at the date of this material, JPMSS is a designated market maker for certain structured warrants listed on the Singapore Exchange where the underlying securities may be the securities discussed in this material. Arising from its role as a designated market maker for such structured warrants, JPMSS may conduct hedging activities in respect of such underlying securities and hold or have an interest in such underlying securities as a result. The updated list of structured warrants for which JPMSS acts as designated market maker may be found on the website of the Singapore Exchange Limited: <http://www.sgx.com>. **South Africa:** J.P. Morgan Equities South Africa Proprietary Limited and JPMorgan Chase Bank, N.A., Johannesburg Branch are members of the Johannesburg Securities Exchange and are regulated by the Financial

Services Board. **Taiwan:** J.P. Morgan Securities (Taiwan) Limited is a participant of the Taiwan Stock Exchange (company-type) and regulated by the Taiwan Securities and Futures Bureau. Material relating to equity securities is issued and distributed in Taiwan by J.P. Morgan Securities (Taiwan) Limited, subject to the license scope and the applicable laws and the regulations in Taiwan. According to Paragraph 2, Article 7-1 of Operational Regulations Governing Securities Firms Recommending Trades in Securities to Customers (as amended or supplemented) and/or other applicable laws or regulations, please note that the recipient of this material is not permitted to engage in any activities in connection with the material that may give rise to conflicts of interests, unless otherwise disclosed in the "Important Disclosures" in this material. **Thailand:** This material is issued and distributed in Thailand by JPMorgan Securities (Thailand) Ltd., which is a member of the Stock Exchange of Thailand and is regulated by the Ministry of Finance and the Securities and Exchange Commission, and its registered address is 3rd Floor, 20 North Sathorn Road, Silom, Bangrak, Bangkok 10500. **UK:** Unless specified to the contrary, research is distributed in the UK by J.P. Morgan Securities plc ("JPMS plc") which is a member of the London Stock Exchange and is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. JPMS plc is registered in England & Wales No. 2711006, Registered Office 25 Bank Street, London, E14 5JP. This material is directed in the UK only to: (a) persons having professional experience in matters relating to investments falling within article 19(5) of the Financial Services and Markets Act 2000 (Financial Promotion) (Order) 2005 ("the FPO"); (b) persons outlined in article 49 of the FPO (high net worth companies, unincorporated associations or partnerships, the trustees of high value trusts, etc.); or (c) any persons to whom this communication may otherwise lawfully be made; all such persons being referred to as "UK relevant persons". This material must not be acted on or relied on by persons who are not UK relevant persons. Any investment or investment activity to which this material relates is only available to UK relevant persons and will be engaged in only with UK relevant persons. Research issued by JPMS plc has been prepared in accordance with JPMS plc's policy for prevention and avoidance of conflicts of interest related to the production of Research which can be found at the following link: [J.P. Morgan EMEA - Research Independence Policy](#). **U.S.:** J.P. Morgan Securities LLC ("JPMS") is a member of the NYSE, FINRA, SIPC, and the NFA. JPMorgan Chase Bank, N.A. is a member of the FDIC. Material published by non-U.S. affiliates is distributed in the U.S. by JPMS who accepts responsibility for its content.

General: Additional information is available upon request. The information in this material has been obtained from sources believed to be reliable. While all reasonable care has been taken to ensure that the facts stated in this material are accurate and that the forecasts, opinions and expectations contained herein are fair and reasonable, JPMorgan Chase & Co. or its affiliates and/or subsidiaries (collectively J.P. Morgan) make no representations or warranties whatsoever to the completeness or accuracy of the material provided, except with respect to any disclosures relative to J.P. Morgan and the Research Analyst's involvement with the issuer that is the subject of the material. Accordingly, no reliance should be placed on the accuracy, fairness or completeness of the information contained in this material. Any data discrepancies in this material could be the result of different calculations and/or adjustments. J.P. Morgan accepts no liability whatsoever for any loss arising from any use of this material or its contents, and neither J.P. Morgan nor any of its respective directors, officers or employees, shall be in any way responsible for the contents hereof, apart from the liabilities and responsibilities that may be imposed on them by the relevant regulatory authority in the jurisdiction in question, or the regulatory regime thereunder. Opinions, forecasts or projections contained in this material represent J.P. Morgan's current opinions or judgment as of the date of the material only and are therefore subject to change without notice. Periodic updates may be provided on companies/industries based on company-specific developments or announcements, market conditions or any other publicly available information. There can be no assurance that future results or events will be consistent with any such opinions, forecasts or projections, which represent only one possible outcome. Furthermore, such opinions, forecasts or projections are subject to certain risks, uncertainties and assumptions that have not been verified, and future actual results or events could differ materially. The value of, or income from, any investments referred to in this material may fluctuate and/or be affected by changes in exchange rates. All pricing is indicative as of the close of market for the securities discussed, unless otherwise stated. Past performance is not indicative of future results. Accordingly, investors may receive back less than originally invested. This material is not intended as an offer or solicitation for the purchase or sale of any financial instrument. The opinions and recommendations herein do not take into account individual client circumstances, objectives, or needs and are not intended as recommendations of particular securities, financial instruments or strategies to particular clients. The recipients of this material must make their own independent decisions regarding any securities or financial instruments mentioned herein and should seek advice from such independent financial, legal, tax or other adviser as they deem necessary. J.P. Morgan may trade as a principal on the basis of the Research Analysts' views and research, and it may also engage in transactions for its own account or for its clients' accounts in a manner inconsistent with the views taken in this material, and J.P. Morgan is under no obligation to ensure that such other communication is brought to the attention of any recipient of this material. Others within J.P. Morgan, including Strategists, Sales staff and other Research Analysts, may take views that are inconsistent with those taken in this material. Employees of J.P. Morgan not involved in the preparation of this material may have investments in the securities (or derivatives of such securities) mentioned in this material and may trade them in ways different from those discussed in this material. This material is not an advertisement for or marketing of any issuer, its products or services, or its securities in any jurisdiction.

"Other Disclosures" last revised January 23, 2021.

Copyright 2021 JPMorgan Chase & Co. All rights reserved. This material or any portion hereof may not be reprinted, sold or redistributed without the written consent of J.P. Morgan.