

# A New Index of the Business Cycle

Will Kinlaw  
Mark Kritzman  
David Turkington



**STATE STREET**

3511711.1.1.GBL

# Outline

1. Motivation
2. Index construction
3. Empirical results
4. Summary

# Our approach

- We introduce a new index of the business cycle that uses the Mahalanobis distance to measure the relative similarity of current economic conditions to past episodes of recession and robust growth.
- Our approach distinguishes between standard deviations and correlations of economic variables that occur during recessions and those that occur during periods of growth, which allows the weights our approach places on inputs to vary with prevailing economic conditions.

# Common measures

## **NBER**

Business Cycle Dating Committee of approximately 8 members applies judgment to define the peaks and troughs of economic activity in the US.

Recession is “a period of falling economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales.”

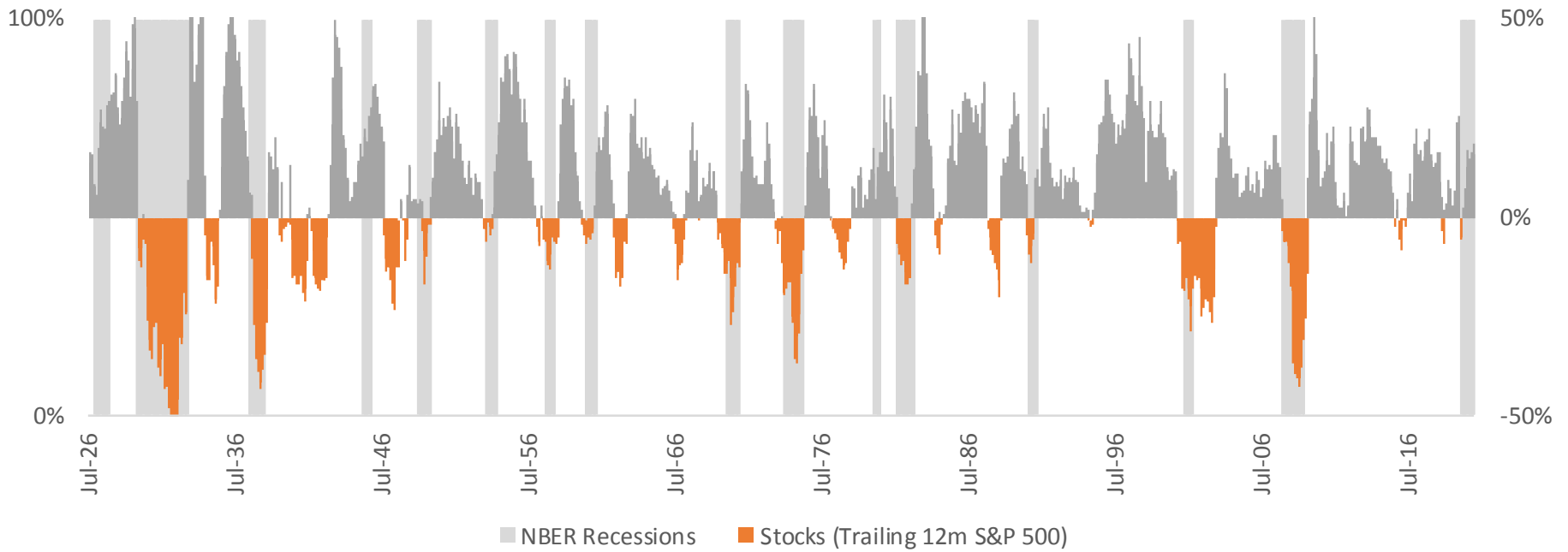
## **Conference Board**

Publishes monthly business cycle indicators, including composite indexes for leading, coincident and lagging economic activity.

Began in 1961 in cooperation with the NBER and the President’s Council of Economic Advisors.

Coincident index averages payrolls, personal income, industrial production, and manufacturing/trade sales.

# Stock market returns

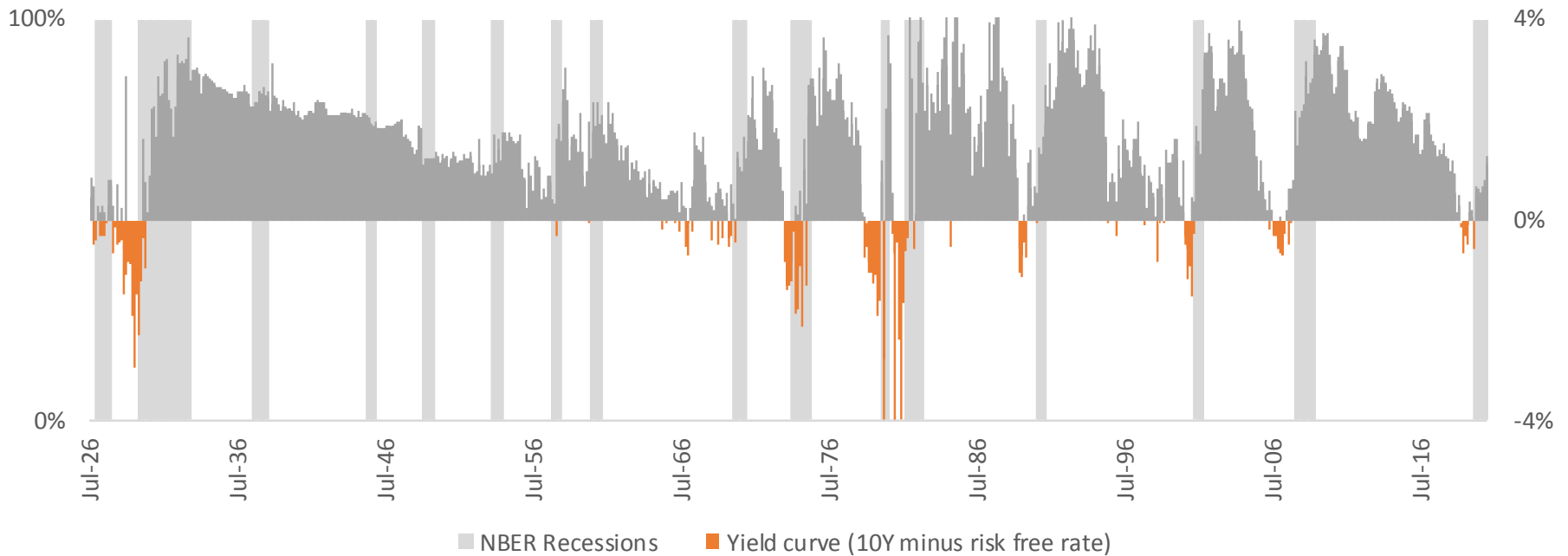


Notes: Time period spans Jul 1926 to Feb 2021.

Source: State Street Global Markets

# Inverted yield curve

- Introduced by Harvey (1986, 1988)



Notes: Time period spans Jul 1926 to Feb 2021.

Source: State Street Global Markets

# Desirable features for our index

- Multivariate
- Summarized in one number, easy to interpret
- Adapt to changing conditions

# Mahalanobis distance

- Mahalanobis (1927, 1936) used distance to compare skull samples.

$$d = (x - \mu)\Omega^{-1}(x - \mu)'$$

$x$  is a vector of values for an observation

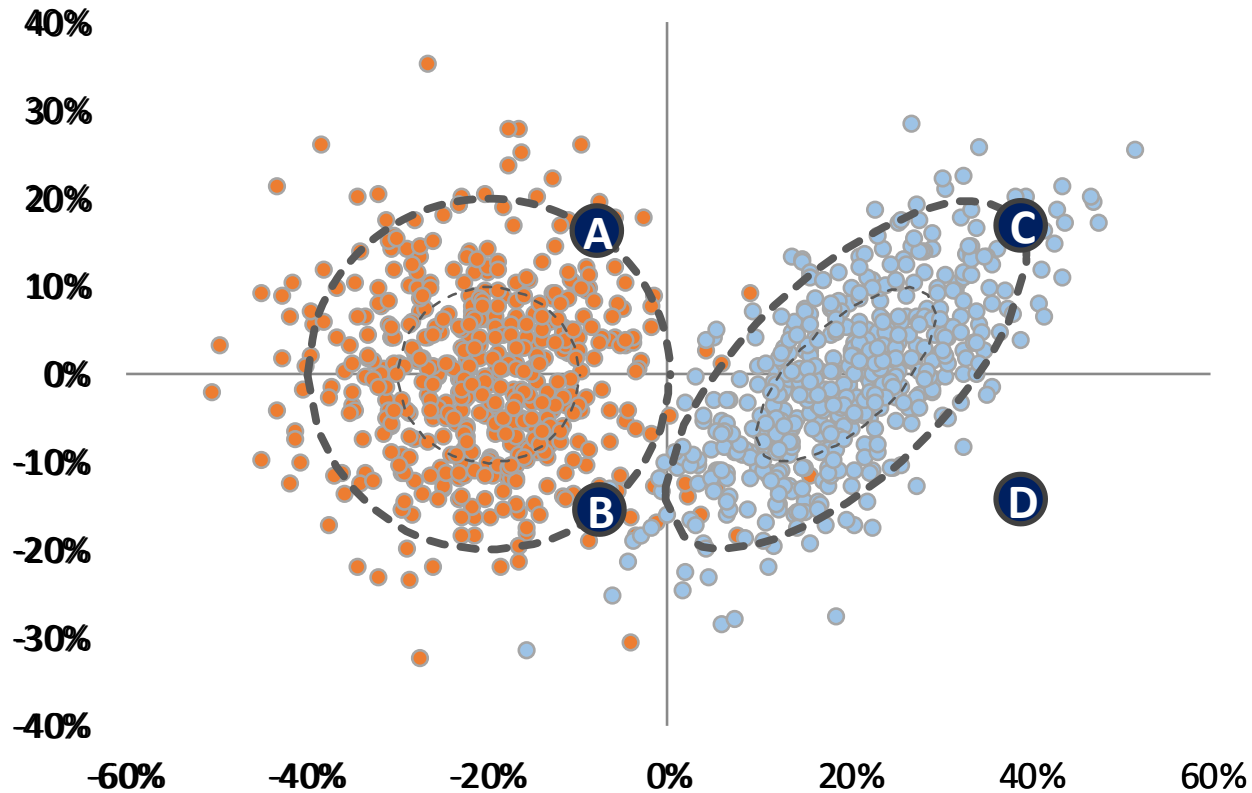
$\mu$  is a vector of mean values within a group

$\Omega$  is the covariance matrix of values within a group



# Mahalanobis distance

Scatter plot of two hypothetical skull dimensions



For illustrative purposes only.

Source: State Street Global Markets

# Mahalanobis distance

## Why it is not arbitrary

- Defines the normal distribution
- Consistent with information theory
- Defines relevance with equivalence to linear regression
  - Czasonis, Kritzman and Turkington (2020a, 2020b, 2021)

# Constructing the index

- **Data inputs (measured monthly, starting in January 1916)**
  - Industrial production (one-year percentage change)
  - Nonfarm payrolls (one-year percentage change)
  - Stock market (one-year return)
  - Yield curve (10-year rate minus Federal Funds rate, one-year average)
- **Since 1956 (when point-in-time data are available)**
  - Identify historical recessions and periods of robust growth
  - Measure the Mahalanobis distance from both, and transform into a “probability”

# Constructing the index

1. Compute the Mahalanobis distance from recession and growth subsamples.

$$d_{rec}(x) = (x - \mu_{rec})\Omega_{rec}^{-1}(x - \mu_{rec})'$$

$$d_{gr}(x) = (x - \mu_{gr})\Omega_{gr}^{-1}(x - \mu_{gr})'$$

2. Convert to a likelihood (normal distribution).

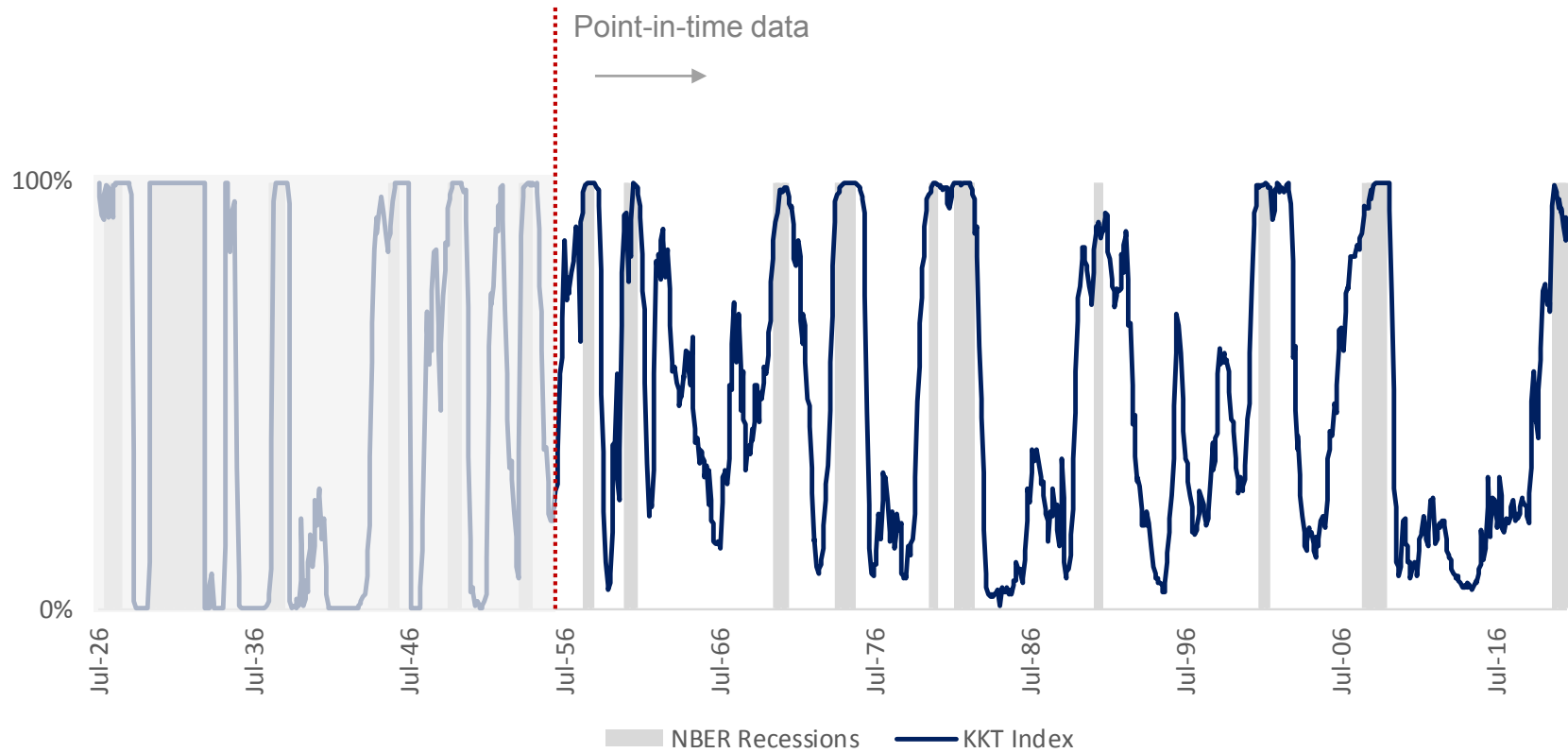
$$\xi_{rec}(d_{rec}) = \det(2\pi\Omega_{rec})^{-1/2} e^{-d_{rec}/2}$$

$$\xi_{gr}(d_{gr}) = \det(2\pi\Omega_{gr})^{-1/2} e^{-d_{gr}/2}$$

3. Normalize to a value between zero and one.

$$p_{rec}(\xi_{rec}, \xi_{gr}) = \frac{\xi_{rec}}{\xi_{rec} + \xi_{gr}}$$

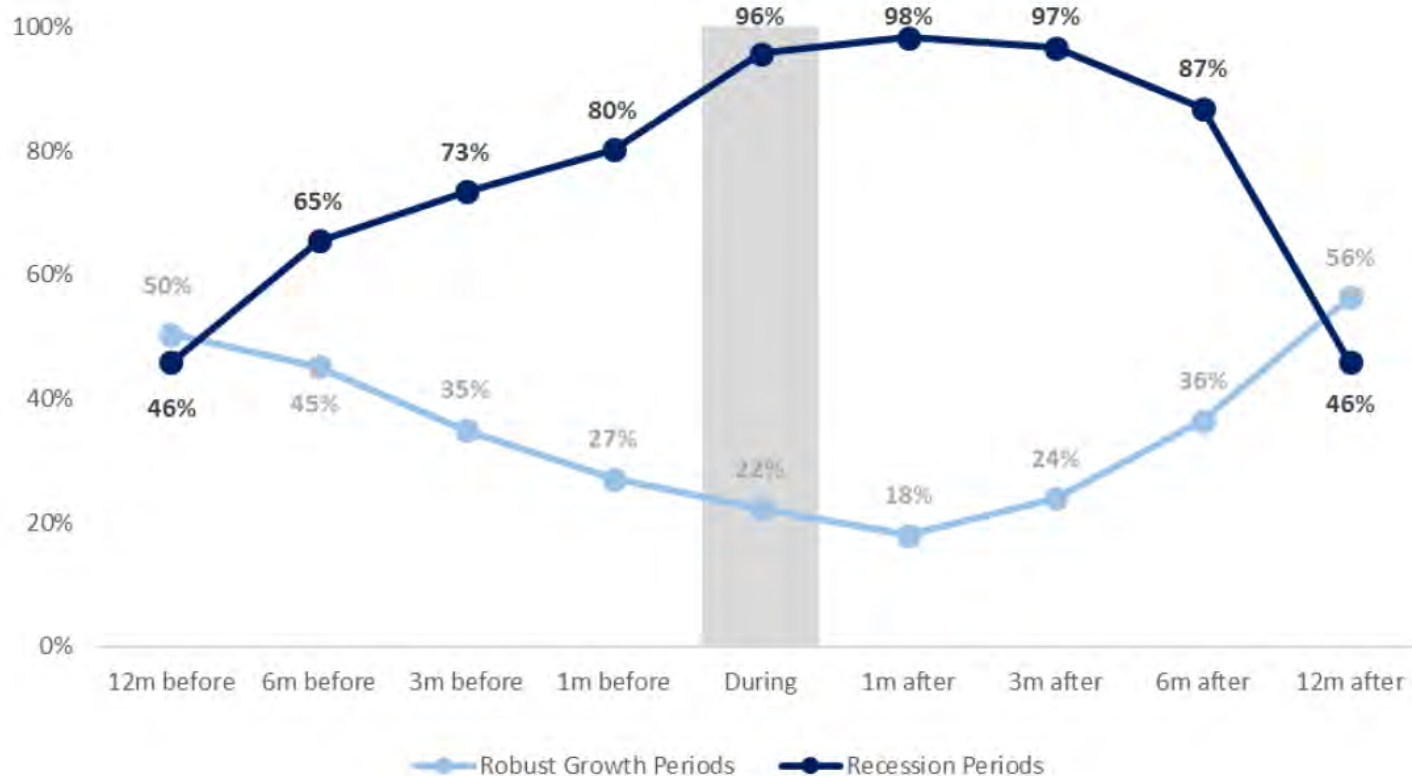
# Historical values



Notes: Time period spans Jul 1926 to Feb 2021.

Source: State Street Global Markets

# Event study for recession and robust growth



Notes: Time period spans Jan 1956 to Jun 2020.

Source: State Street Global Markets

# Conditional probability of recession

Rising and above threshold:	50%	60%	70%	80%	90%	Unconditional Frequency
This month	36%	43%	53%	62%	87%	14%
Next 1m	40%	48%	57%	66%	91%	14%
Next 3m	47%	55%	64%	73%	96%	16%
Next 6m	59%	66%	77%	82%	96%	20%
Next 12m	73%	78%	87%	89%	96%	28%
Next 18m	78%	82%	87%	89%	96%	34%

Note: Rising is defined as a standardized shift greater than 1. The standardized shift is the current value minus the prior year average divided by the standard deviation of values in that prior year.

Notes: Time period spans Jan 1956 to Jun 2020.

Source: State Street Global Markets

# Yield curve

Falling and below threshold:	0%	Unconditional Frequency
This month	10%	14%
Next 1m	15%	14%
Next 3m	21%	16%
Next 6m	39%	20%
Next 12m	60%	28%
Next 18m	82%	34%

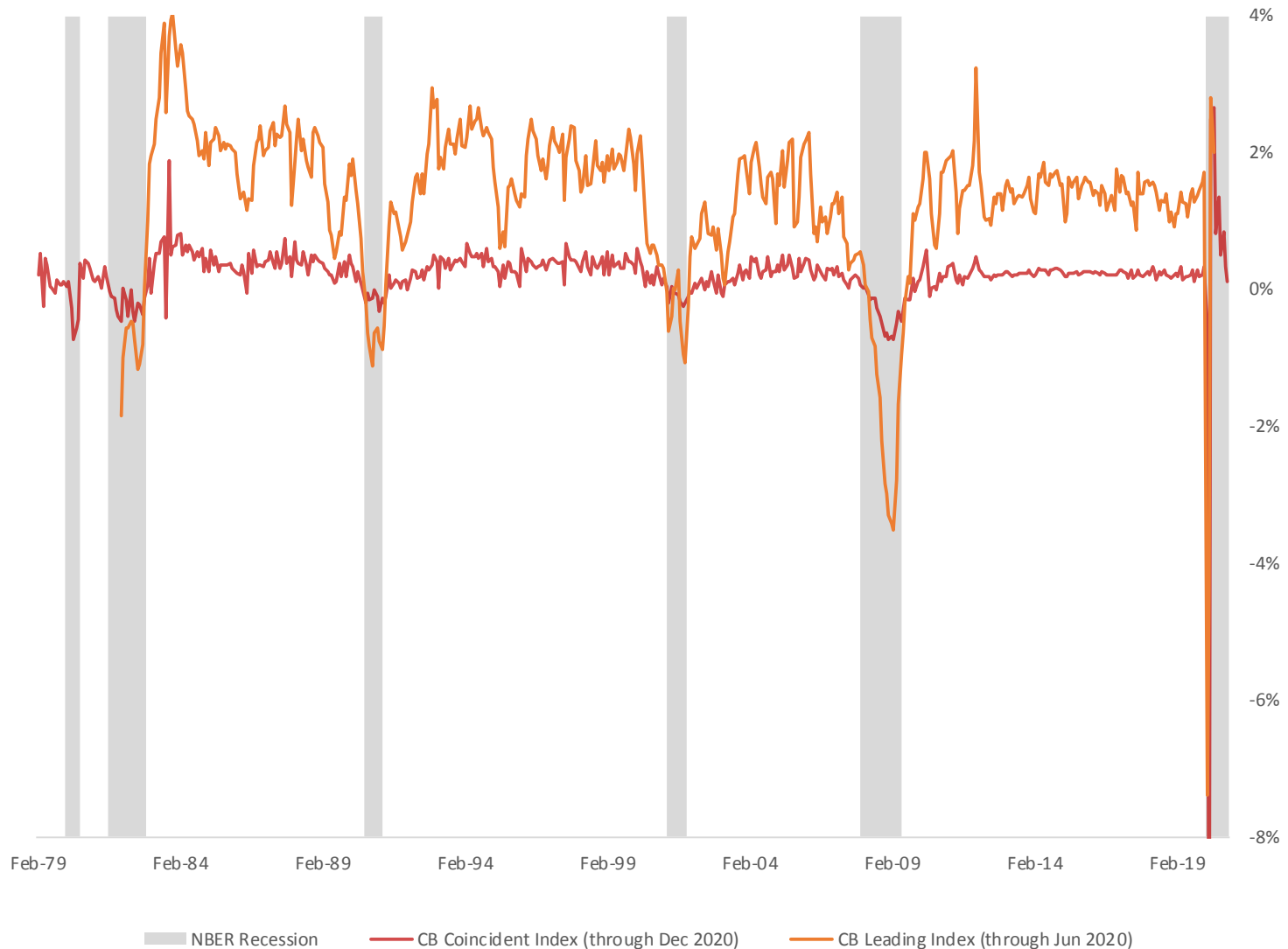
Note: Falling is defined as a standardized shift less than -1. The standardized shift is the current value minus the prior year average divided by the standard deviation of values in that prior year.

Notes: Time period spans Jan 1956 to Jun 2020.

Source: State Street Global Markets



# Conference Board indicator history

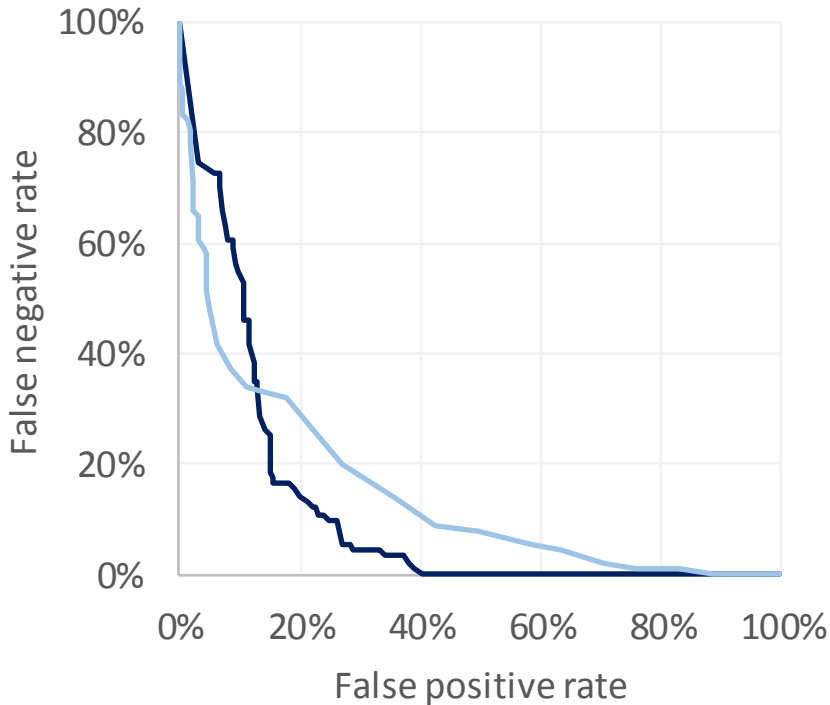


Notes: Time period spans Feb 1979 to Dec 2020.

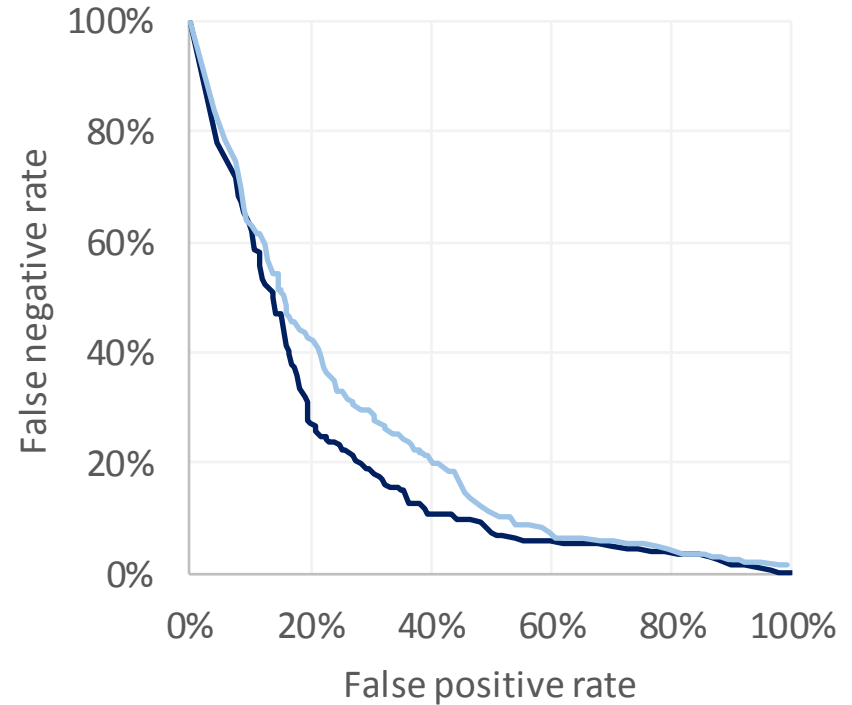
Source: State Street Global Markets

# Accuracy (NBER recession within next 12 months)

KKT Index (dark) versus Conference Board Leading Index (light), 1982 – 2020



KKT Index (dark) versus logistic regression (light), 1956 – 2020



Notes: Time period spans Jan 1956 to Jun 2020.

Source: State Street Global Markets

# Attribution of variable importance

- We take the derivative of nested functions for our index with respect to  $x$ . It depends on both the distance to growth and the distance to recession.

$$\frac{\partial p_{rec}}{\partial x} = p_{rec} p_{gr} \left( \Omega_{gr}^{-1} (x - \mu_{gr})' - \Omega_{rec}^{-1} (x - \mu_{rec})' \right)$$

- A variable's importance is the element-wise multiple of its derivative and its full-sample standard deviation, normalized to sum to one across variables.

$$\text{Variable importance} = \frac{\frac{\partial p_{rec}}{\partial x} \circ \sigma}{\left| \frac{\partial p_{rec}}{\partial x} \circ \sigma \right|}$$

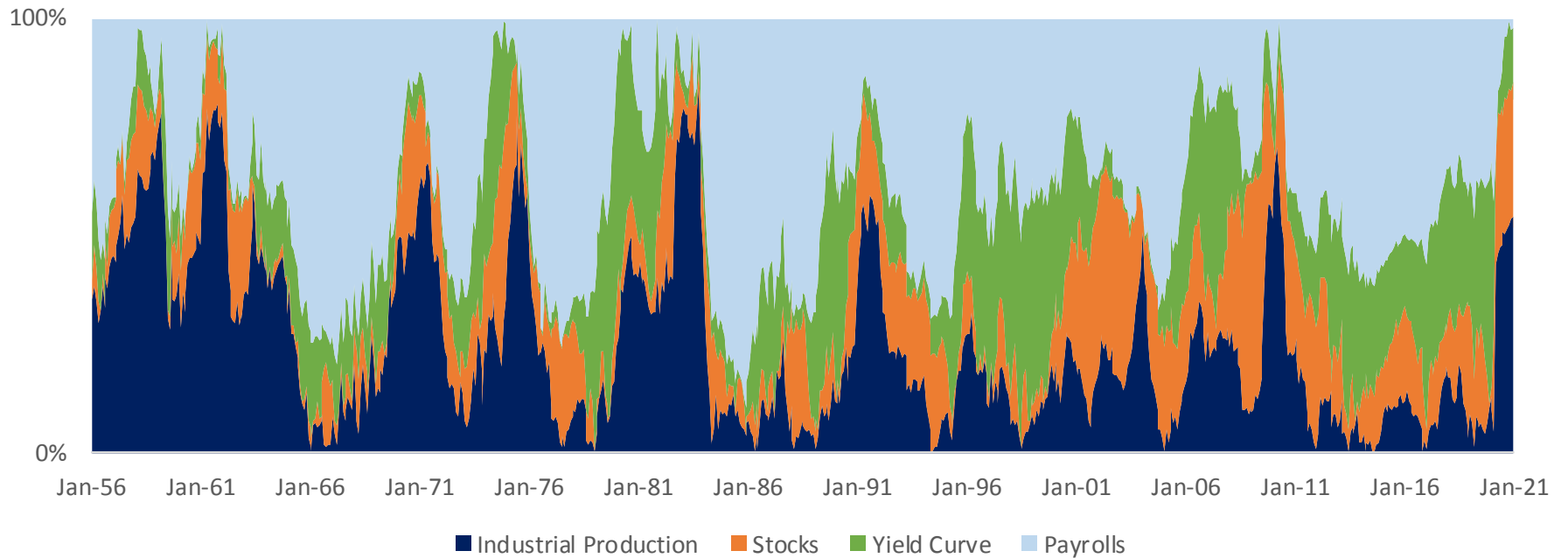
# Comparing to linear regression

- In logistic regression, the relative contribution of each variable is constant with respect to  $x$ .

$$p_{rec,logistic}(\hat{y}^{linear}) = \frac{1}{(1 + e^{-\hat{y}^{linear}})} = \frac{1}{(1 + e^{-\beta x})}$$

$$\frac{\partial p_{rec,logistic}}{\partial x} = p_{rec} p_{gr} \beta$$

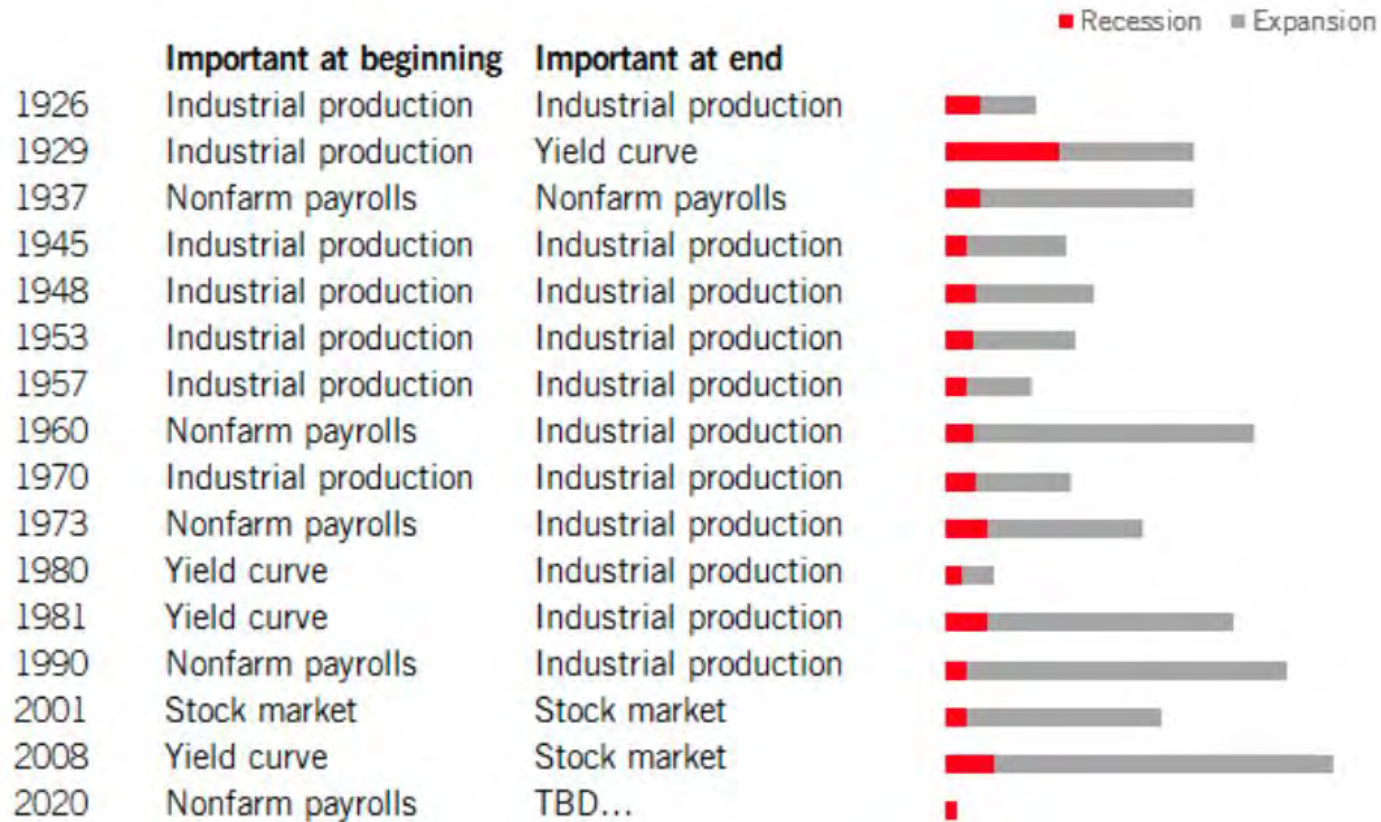
# Attribution of variable importance



Notes: Time period spans Jan 1956 to Feb 2021.

Source: State Street Global Markets

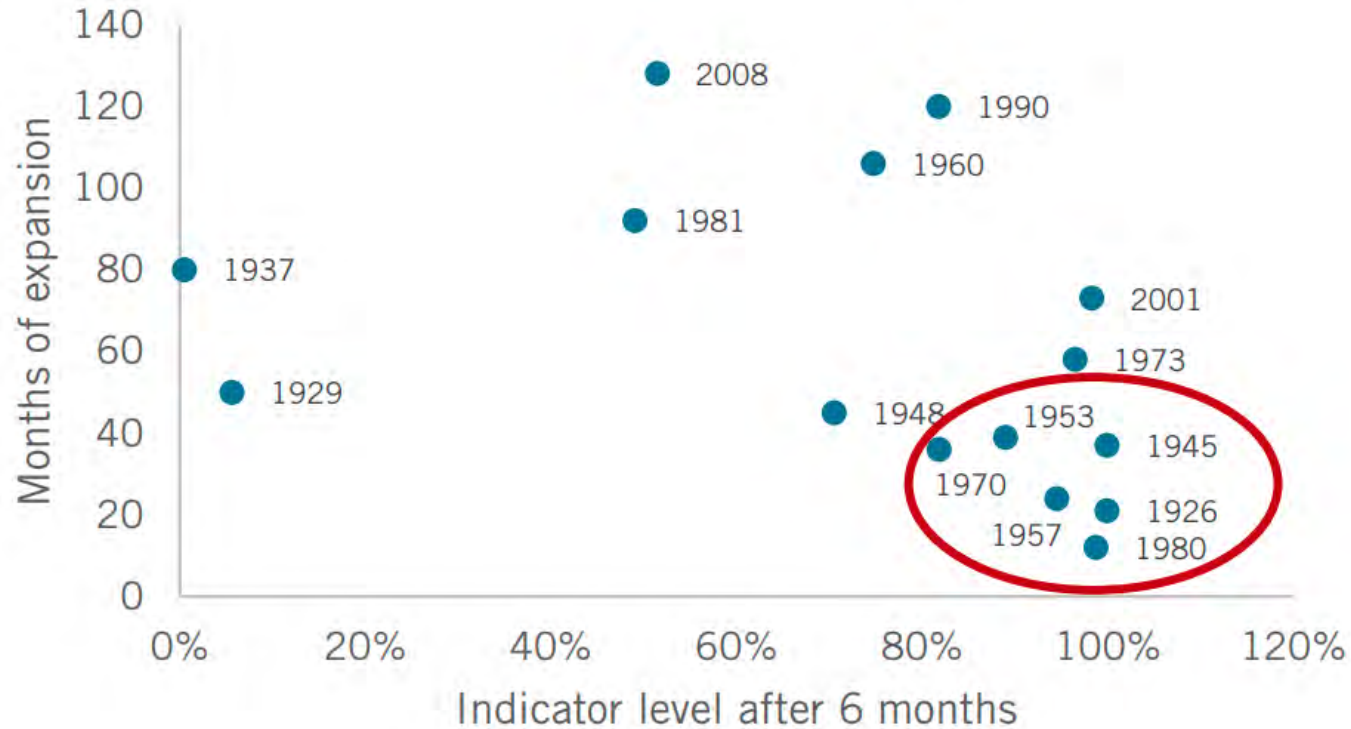
# Variable importance for specific recessions



Notes: Time period spans Jul 1926 to Feb 2021.

Source: State Street Global Markets

# Length of expansion following recession



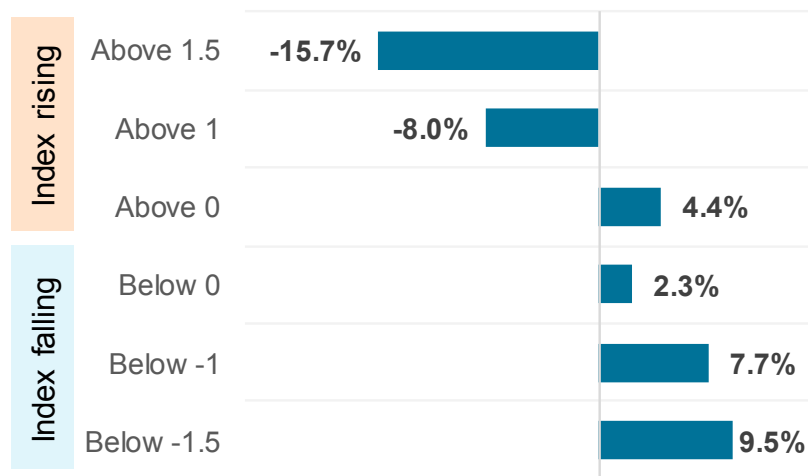
Notes: Time period spans Jul 1926 to Feb 2021.

Source: State Street Global Markets

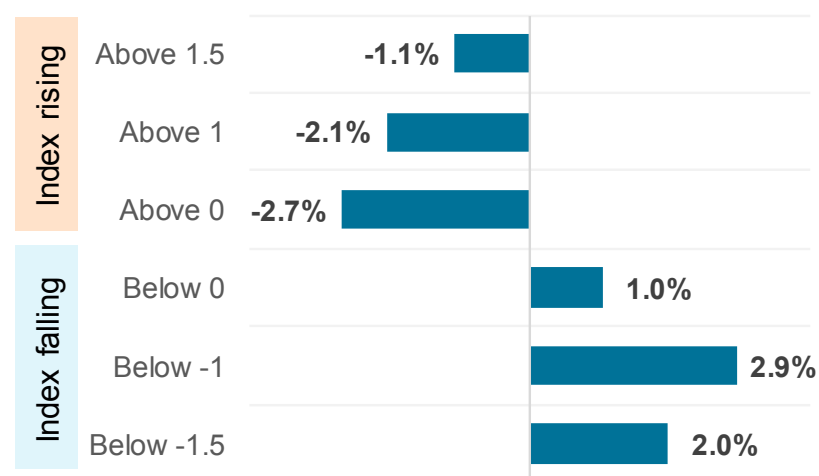
# Inflection points and asset returns

- Measure inflection points using standardized shifts
- Compute the next 6 month performance of stocks versus bonds

Stock minus bond returns after inflection points (index above 90%)



Stock minus bond returns after inflection points (index below 10%)



Notes: Time period spans Jan 1956 to Aug 2020.

Source: State Street Global Markets



# Summary

- There are advantages to combining multiple indicators.
- The Mahalanobis distance combines information in a non-arbitrary, user-friendly way.
- Our composite index is more effective than many other quantitative measures, and it avoids the bias and persuasion that may affect discretionary methods.
- We can observe changing variable importance over time, an intuitive and distinguishing feature of our approach.

# Disclaimers and Important Risk Information

State Street Global Markets® is the business name and a registered trademark of State Street Corporation® and is used for its financial markets business and that of its affiliates. State Street Associates® is a registered trademark of State Street Corporation, and the analytics and research arm of State Street Global Markets.

The products and services outlined herein are only offered to professional clients or eligible counterparties through State Street Bank and Trust Company, authorized and regulated by the Federal Reserve Board. State Street Bank and Trust Company is registered with the Commodity Futures Trading Commission as a Swap Dealer and is a member of the National Futures Association. Please note that certain foreign exchange business, including spot and certain forward transactions, are not regulated.

This document is a communication intended for general marketing purposes, and the information contained herein has not been prepared in accordance with legal requirements designed to promote the independence of investment research. It is for clients to determine whether they are permitted to receive research of any nature. It is not intended to suggest or recommend any transaction, investment, or investment strategy, does not constitute investment research, nor does it purport to be comprehensive or intended to replace the exercise of an investor's own careful independent review and judgment regarding any investment decision.

This communication is not intended for retail clients, nor for distribution to, and may not be relied upon by, any person or entity in any jurisdiction or country where such distribution or use would be contrary to applicable law or regulation. This communication and the information herein does not constitute investment, legal, or tax advice and is not a solicitation to buy or sell securities or any financial instrument nor is it intended to constitute a binding contractual arrangement or commitment by State Street of any kind. The information provided does not take into account any particular investment objectives, strategies, investment horizon or tax status. This communication or any portion hereof may not be reprinted, sold or redistributed without the prior written consent of State Street Global Markets.

The views expressed herein are the views of State Street Global Markets as of the date specified and are subject to change, without notice, based on market and other conditions. The information provided herein has been obtained from sources believed to be reliable at the time of publication, nonetheless, we make no representations or assurances that the information is complete or accurate, and you should not place any reliance on said information. State Street Global Markets hereby disclaims any warranty and all liability, whether arising from contract, tort or otherwise, for any losses, liabilities, damages, expenses or costs, either direct, indirect, consequential, special, or punitive, arising from or in connection with any use of this document and/or the information herein.

State Street Global Markets may from time to time, as principal or agent, for its own account or for those of its clients, have positions in and/or actively trade in financial instruments or other products identical to or economically related to those discussed in this communication. State Street Global Markets may have a commercial relationship with issuers of financial instruments or other products discussed in this communication.

This document may contain statements deemed to be forward-looking statements. These statements are based on assumptions, analyses and expectations of State Street Global Markets in light of its experience and perception of historical trends, current conditions, expected future developments and other factors it believes appropriate under the circumstances. All information is subject to change without notice. Clients should be aware of the risks trading foreign exchange, equities, fixed income or derivative instruments or in investments in non-liquid or emerging markets. Derivatives generally involve leverage and are therefore more volatile than their underlying cash investments. Past performance is no guarantee of future results.

The products and services outlined in this document are generally offered in the **United States and Latin America** by State Street Bank and Trust Company. This communication is made available in **Japan** by State Street Bank and Trust Company, Tokyo Branch, which is regulated by the Financial Services Agency of Japan and is licensed under Article 47 of the Banking Act. **EMEA:** (i) State Street Bank and Trust Company, London Branch, authorized and regulated by the Prudential Regulation Authority, subject to regulation by the Financial Conduct Authority and limited regulation by the Prudential Regulation Authority. Details about the extent of regulation by the Prudential Regulation Authority are available upon request; and/or (ii) State Street Bank International GmbH, authorized by Deutsche Bundesbank and the German Federal Financial Supervisory Authority and, in respect of State Street Bank International GmbH, London Branch, subject to limited regulation by the Financial Conduct Authority and Prudential Regulation Authority. Details about the extent of regulation by the Financial Conduct Authority and Prudential Regulation Authority are available upon request. **Brazil:** The products in this marketing material have not been and will not be registered with the Comissão de Valores Mobiliários - the Brazilian Securities and Exchange Commission ("CVM"), and any offer of such products is not directed to the general public within the Federative Republic of Brazil ("Brazil"). The information contained in this marketing material is not provided for the purpose of soliciting investments from investors residing in Brazil and no information in this marketing material should be construed as a public offering or unauthorized distribution of the products within Brazil, pursuant to applicable Brazilian law and regulations. The products and services outlined in this document are generally offered in **Canada** by State Street Bank and Trust Company. This communication is made available in **Hong Kong** by State Street Bank and Trust Company which accepts responsibility for its contents, and is intended for distribution to professional investors only (as defined in the Securities and Futures Ordinance). Information provided is of a general nature only and has not been reviewed by any regulatory authority in Hong Kong. This communication is made available in

**Australia** by State Street Bank and Trust Company ABN 70 062 819 630, AFSL 239679 and is intended only for wholesale clients, as defined in the Corporations Act 2001. This communication is made available in **Singapore** by State Street Bank and Trust Company, Singapore Branch ("SSBTS"), which holds a wholesale bank license by the Monetary Authority of Singapore. In Singapore, this communication is only distributed to accredited, institutional investors as defined in the Singapore Financial Advisers Act ("FAA"). Note that SSBTS is exempt from Sections 27 and 36 of the FAA. When this communication is distributed to overseas investors as defined in the FAA, note that SSBTS is exempt from Sections 26, 27, 29 and 36 of the FAA. This advertisement has not been reviewed by the Monetary Authority of Singapore. The products and services outlined in this document are made available in **South Africa** through State Street Bank and Trust Company, which is authorized in South Africa under the Financial Advisory and Intermediary Services Act, 2002 as a Category I Financial Services Provider; FSP No. 42671. This communication is made available in **Israel** by State Street Bank and Trust Company, which is not licensed under Israel's Regulation of Investment Advice, Investment Marketing and Portfolio Management Law, 1995. This communication may only be distributed to or used by investors in Israel which are "eligible clients" as listed in the First Schedule to Israel's Regulation of Investment Advice, Investment Marketing and Portfolio Management Law 1995. This communication is made available in **Qatar** by State Street Bank and Trust Company and its affiliates. The information in this communication has not been reviewed or approved by the Qatar Central Bank, the Qatar Financial Markets Authority or the Qatar Financial Centre Regulatory Authority, or any other relevant Qatari regulatory body. This communication is made available in **Malaysia** by State Street Bank and Trust Company, which is authorized and regulated by the Federal Reserve Board. State Street Bank and Trust Company is not licensed within or doing business within Malaysia and the activities that are being discussed are carried out off-shore. The written materials do not constitute, and should not be construed as constituting: 1) an offer or invitation to subscribe for or purchase securities or futures in Malaysia or the making available of securities or futures for purchase or subscription in Malaysia; 2) the provision of investment advice concerning securities or futures; or 3) an undertaking by State Street Bank and Trust Company to manage the portfolio of securities or futures contracts on behalf of other persons. This communication is made available in **Turkey** by State Street Bank and Trust Company and its affiliates. The information included herein is not investment advice. Investment advisory services are provided by portfolio management companies, brokers and banks without deposit collection licenses within the scope of the investment advisory agreements to be executed with clients. Any opinions and statements included herein are based on the personal opinions of the commentators and authors. These opinions may not be suitable to your financial status and your risk and return preferences. Therefore, an investment decision based solely on the information herein may not be appropriate to your expectations. This communication is made available in **United Arab Emirates** by State Street Bank and Trust Company and its affiliates. This communication does not, and is not intended to, constitute an offer of securities anywhere in the United Arab Emirates and accordingly should not be construed as such. Nor does the addressing of this communication to you constitute, or is intended to constitute, the carrying on or engagement in banking, financial and/or investment consultation business in the United Arab Emirates under the rules and regulations made by the Central Bank of the United Arab Emirates, the Emirates Securities and Commodities Authority or the United Arab Emirates Ministry of Economy. Any public offer of securities in the United Arab Emirates, if made, will be made pursuant to one or more separate documents and only in accordance with the applicable laws and regulations. Nothing contained in this communication is intended to endorse or recommend a particular course of action or to constitute investment, legal, tax, accounting or other professional advice. Prospective investors should consult with an appropriate professional for specific advice rendered on the basis of their situation. Further, the information contained within this communication is not intended to lead to the conclusion of any contract of whatsoever nature within the territory of the United Arab Emirates. This communication has been forwarded to you solely for your information, and may not be reproduced or passed on, directly or indirectly, to any other person or published, in whole or in part, for any purpose. This communication is addressed only to persons who are professional, institutional or otherwise sophisticated investors. This communication is made available in **Saudi Arabia** by State Street Bank and Trust Company and its affiliates. The information contained in this communication is not intended to invite or induce any person to engage in securities activities nor does it constitute an offer to sell securities or the solicitation of an offer to buy, or recommendation for investment in, any securities within the Kingdom of Saudi Arabia or any other jurisdiction. The information in this communication is not intended as financial advice. Moreover, this communication is not intended as a prospectus within the meaning of the applicable laws and regulations of the Kingdom of Saudi Arabia or any other jurisdiction and this communication is not directed to any person in any country in which the distribution of such communication is unlawful. This communication provides general information only. The information and opinions in this communication are stated as at the date indicated. The information may therefore not be accurate or current. The information and opinions contained in this communication have been compiled or arrived at from sources believed to be reliable in good faith, but no representation or warranty, express or implied, is made by State Street Bank and Trust Company and its affiliates as to their accuracy, completeness or correctness. This communication is made available in **South Korea** by State Street Bank and Trust Company and its affiliates, which accept responsibility for its contents, and is intended for distribution to professional investors only. State Street Bank and Trust Company is not licensed to undertake securities business within South Korea, and any activities related to the content hereof will be carried out off-shore and only in relation to off-shore non-South Korea securities. This communication is made available in **Indonesia** by State Street Bank and Trust Company and its affiliates. Neither this communication nor any copy hereof may be distributed in Indonesia or to any Indonesian citizens wherever they are domiciled or to Indonesian residents except in compliance with applicable Indonesian capital market laws and regulations. This communication is not an offer of securities in Indonesia. Any securities referred to in this communication have not been registered with the Capital Market and Financial Institutions Supervisory Agency (BAPEPAM-LK) pursuant to relevant capital market laws and regulations, and may not be offered or sold within the territory of the Republic of Indonesia or to Indonesian citizens through a public offering or in circumstances which constitute an offer within the meaning of the Indonesian capital market law and regulations. This communication is made available in **Oman** by State Street Bank and Trust Company and its affiliates. The information contained in this communication is for information purposes and does not constitute an offer for the sale of foreign securities in Oman or an invitation to an offer for the sale of foreign securities. State Street Bank and Trust Company is neither a bank nor financial services provider registered to undertake business in Oman and is neither regulated by the Central Bank of Oman nor the Capital Market Authority. Nothing contained in this communication report is intended to constitute Omani investment, legal, tax, accounting, investment or other professional advice. This communication is made available in **Taiwan** by State Street Bank and Trust Company and its affiliates, which accept responsibility for its contents, and is intended for distribution to professional investors only. State Street Bank and Trust Company is not licensed to undertake securities business within Taiwan, and any activities related to the content hereof will be carried out off-shore and only in relation to off-shore non-Taiwan securities. **Peoples Republic of China ("PRC")**. This communication is being distributed by State Street Bank and Trust Company. State Street Bank and Trust Company is not licensed or carrying on business in the PRC in respect of any activities described herein and any such activities it does carry out are conducted outside of the PRC. These written materials do not constitute, and should not be construed as constituting: 1) an offer or invitation to subscribe for or purchase securities or futures in PRC or the making available of securities or futures for purchase or subscription in PRC; 2) the provision of investment advice concerning securities or futures; or 3) an undertaking by State Street Bank and Trust Company to manage the portfolio of securities or futures contracts on behalf of other persons.

Products and services may not be available in all jurisdictions. Please contact your State Street representative for further information. SSA MMD 2021-02

To learn how State Street looks after your personal data, visit: <http://www.statestreet.com/utility/data-processing-and-privacy-notice.html>

© 2021 State Street Corporation – All Rights Reserved