BlackRock®

Augmented Investment Management

A systematic framework for designing alpha models

BSYSM0224E/S-3386148-1/14

Raffaele Savi
Global Head of BlackRock Systematic and Co-CIO and Co-Head of Systematic Active Equity

Jeff Shen, PhD
Co-CIO and Co-Head of Systematic Active Equity

Ronald Kahn, PhD
Global Head of Systematic Equity Research

Kevin Franklin
Global Equity Portfolio Manager, Systematic Active Equity

Yaki Tsaig
Research Scientist, Systematic Active Equity

Summary

- **The challenge:** In our data-rich world, active investment managers face an increasing challenge of distilling a wide range of information sources into a holistic investment view. For systematic investors, the growing number of predictive investment signals requires a novel solution for combining these insights into alpha models that can be used in portfolios.

- **Our approach:** Advances in machine learning offer powerful tools to address the challenge of signal combination. This led BlackRock's Systematic Investment Team to develop a system for designing alpha models called Augmented Investment Management ("AIM").

- **Our framework:** AIM brings customization, scalability, and transparency to the process of building alpha models. At the core of AIM is a modular machine learning pipeline that can be configured and fine-tuned by portfolio managers for specific purposes — bringing together human expertise and proprietary technology to enhance active management capabilities.

The challenge

Successful active management as we see it relies on the premise that investors can gain an informational advantage over other market participants to generate excess returns. Today's investors, regardless of approach, are synthesizing a growing volume of data and information to form their investment views. Fundamental managers tend to employ intuition and judgment to distill this information into a set of investment decisions. In contrast, systematic investors codify information sources into predictive investment signals that serve as building blocks in an investment strategy.

Systematic investment signals offer the opportunity to uncover potentially valuable patterns and relationships in financial markets. Insights gleaned from a wider breadth of data can offer a level of analysis simply not possible for an individual or even a team of individuals to compute on their own. Signals can be designed to analyze traditional financial indicators, like enterprise value-to-sales ("EV/ sales"), a measure of a company's total value. A low EV/ sales value may suggest that the security is priced attractively relative to the firm's future revenues. Signals can also be constructed to capture non-traditional measures of companies, such as company sentiment. For example, applying text analysis algorithms to analyst reports can provide better insight into whether analysts have positive or negative views of the firm. Alternative measures of corporate value can also be captured by signals, such as the number of web searches for a specific company's products. This signal can help to evaluate consumer interest and potentially forecast future sales.

These are just a few examples of the signals developed within BlackRock's Systematic Investment Team over more than 35 years of alpha research and innovation.[1] In an increasingly data-rich world, there are now potentially hundreds or even thousands of signals available to investors. This raises a new challenge for systematic investors, which is how to optimally combine investment signals. Traditionally, signal combination has been solved through a discretionary approach where portfolio managers assign weights to a subset of signals to form an alpha model.

In making these allocation decisions, managers have to account for a multitude of complexities:

Signals derived from different data sources can be correlated. For example, a signal derived from price-to-earnings ratios may be correlated with another signal based on price-to-sales ratios. Ignoring the correlation between these signals could lead to overexposure to a particular market factor or risk.

The predictive value of signals often varies across sectors or regions. For example, traditional valuation measures are less relevant for biotech firms, many of which report little or no revenues.

The predictive power of signals can vary over different investment horizons. A signal based on recent price moves might have forecasting power over the next few days, whereas a signal derived from fundamental measures of firm performance may have greater predictive power over the next few months. Investment managers may want to consider a mix of signals that is tailored to the capacity of the fund and associated trading frictions in the market it operates in.

The predictive power of signals can decay over time. As market environments change or information gets priced into markets, the ability of investment signals to harness alpha opportunities can diminish. A systematic approach requires continuous innovation.

These complexities, coupled with the growing arsenal of signals available, make building alpha models using a purely discretionary approach a formidable task. These considerations motivated our Systematic Investment Team to search for algorithmic solutions to this problem.

1 Timeline includes predecessor firms.

Our approach

Advances in machine learning offer powerful tools to help address the challenges faced by investment managers in designing alpha models. Machine learning algorithms, such as decision trees or deep neural networks, have demonstrated remarkable capabilities in extracting patterns and relationships from complex, large-scale data sets.[2,3] For this reason, machine learning tools offer a dynamic alternative to designing alpha models through a discretionary approach.

Rather than viewing the challenge of combining signals as a weight allocation problem, we reframe it as a forecasting problem. This approach requires combining signals into a forecast of excess returns, which we call *alpha forecasts* for each asset in the investible universe. These alpha forecasts are fed to a portfolio optimizer that accounts for co-movement of securities, transaction costs, and various portfolio constraints to generate optimal holdings and associated trades. This separation between alpha forecasting and risk-aware portfolio construction is a common approach in systematic investing, leading to a more tractable problem formulation and a more readily interpretable solution.

Starting in 2014, we set out to design a system that can train machine learning models for this purpose. We named the system Augmented Investment Management ("AIM"), drawing an analogy to augmented reality devices that enhance human decision-making by overlaying additional information and insights. AIM is a system for building systematic alpha models from a large collection of signals.

Its core design is guided by the following characteristics:

Systematic. AIM uses machine learning techniques to generate alpha forecasts from a large collection of signals. Portfolio managers assign a user-specified objective function that the model can be designed to solve. Based on the objective function, AIM automatically identifies relevant signal data, applies a series of processing steps, trains the model to forecast alpha, and tunes the model parameters that are learned from historical data which seeks to maximize model performance.

Customizable. AIM models are modular. They consist of several components that are chained together to create a machine learning pipeline, which can be configured using a configuration file to adjust the model. Portfolio managers can customize AIM models by adding or removing components from the pipeline, modifying the parameters, and tailoring the objective function to target a desired outcome based on the investment objective.

Scalable. Combining the first two principles of being systematic and customizable, AIM facilitates scalable model building. For example, portfolio managers have the ability to use the same set of signals to produce different investment models for a series of strategies with different risk and return mandates without having to manually build and manage separate models. To train models at scale, the underlying infrastructure makes frequent use of distributed computing resources.

Transparent. To improve the transparency of machine learning models, AIM offers an explanation model to provide an interpretable view of the contribution of each signal to model prediction. These analytics can be useful during model development as a diagnosis tool, as well as for live monitoring during trading.

2 Hastie, T., Tibshirani, R., & Friedman, J. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Springer Series in Statistics. **3** Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.

Our framework

AIM relies on two key ingredients. The first is a comprehensive signal library with substantial historical data available for model training. BlackRock's systematic signal library has been built upon 35 years of alpha research. The library includes a wide range of signals from different sources, including financial statements, market indicators, news and analyst reports, and an array of alternative data sources. We devote considerable resources to maintaining accurate point-in-time historical data, employ various data preprocessing techniques to clean and normalize the data, and associate it with assets in our investible universe. Figure 1 illustrates the growth in the number of stock-selection signals developed by our team over the past decade.

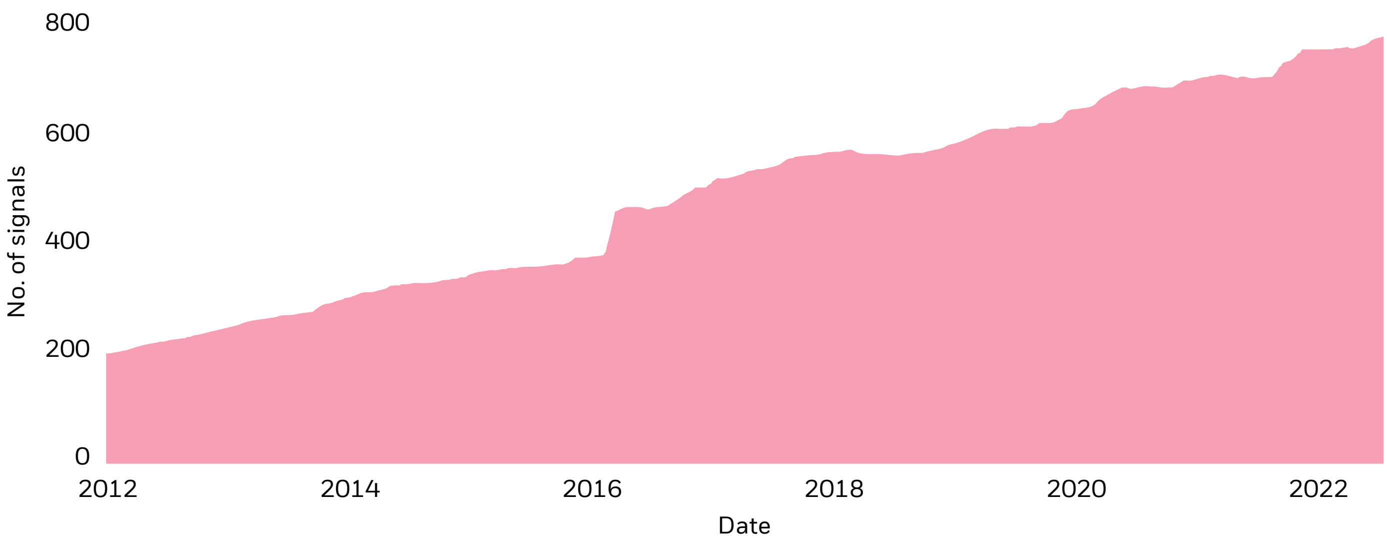
The second ingredient is a high-fidelity, high-performance portfolio optimizer and performance simulator. The portfolio optimizer is used to transform forecasts into portfolio positions by solving a constrained optimization problem accounting for portfolio risk. The performance simulator is then used to evaluate portfolio holdings over a historical backtest period, and model parameters are adjusted with the aim of maximizing a specific performance metric, e.g., the Information Ratio (IR) of the portfolio. The simulator accounts for transaction costs, borrow costs, and fund constraints to produce evaluation results that approximate realized portfolio performance with high fidelity.[4]

At its core, AIM is designed as a modular machine learning pipeline that can be configured and customized by portfolio managers. Figure 2 (on the following page) illustrates the key components in the pipeline used to process raw signal data, train a machine learning model, and evaluate the model's performance.

In the initial step, raw signal data is processed to form a feature matrix.[5] This step involves handling outliers, imputing missing values, applying time-series transformations, and (optionally) neutralizing the effect of risk factors. The feature matrix is coupled with a target variable, which represents the measure that we're trying to predict and is typically generated based on forward-looking returns over a specified time horizon. The feature matrix and target variable are constructed over a long historical period, typically in the range of 10 to 20 years, and used as training data in the next step.

Next, a model is initialized according to the configuration supplied by the portfolio manager and fits to the training data constructed in the previous step. The choice of

Figure 1: The number of stock selection signals in BlackRock's systematic signal library continues to grow over time



Source: BlackRock Systematic, as of June 2023.

4 The back-testing done by the performance simulator is described for illustrative purposes only and is not meant to be representative of any account, portfolio or strategy. No representation is being made that any account, portfolio or strategy will or is likely to achieve certain results based on the back test. There is no guarantee that any forecasts will come to pass. **5** In the machine learning literature, independent variables used as predictions are referred to as features. We adopt this terminology throughout this work.

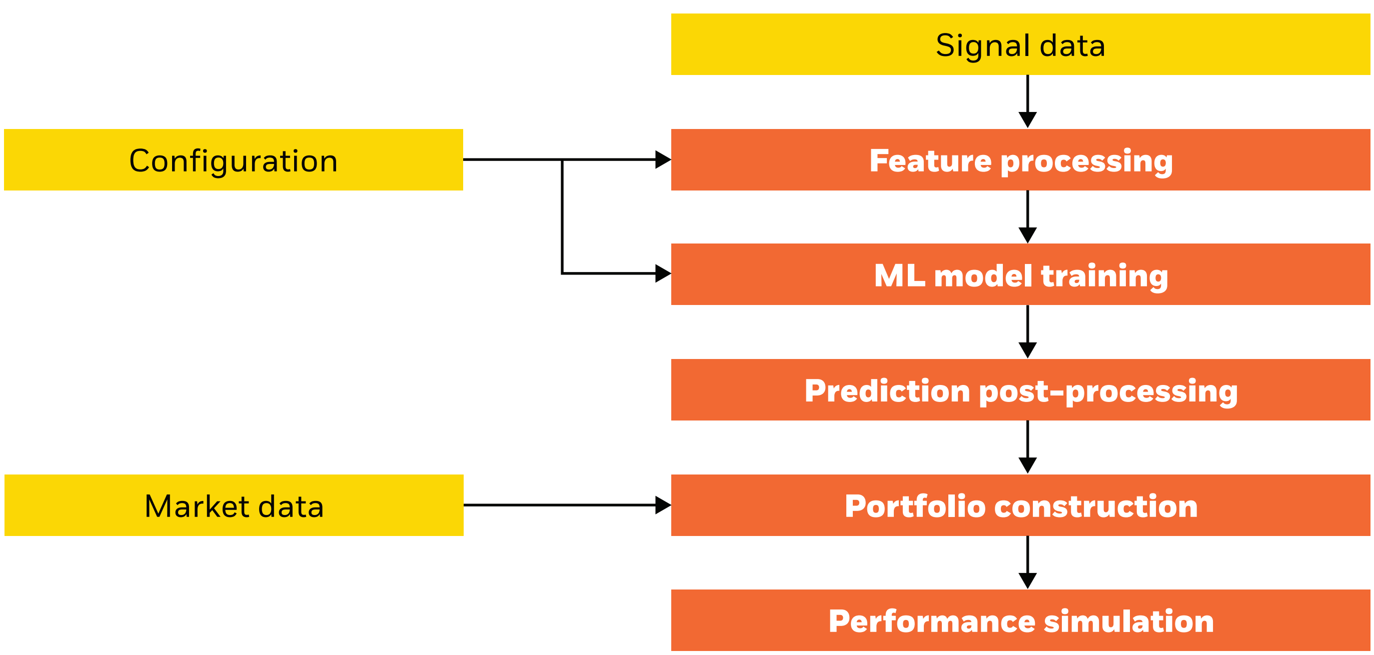
machine learning model and its parameters is guided by a large-scale search over possible configurations. AIM supports a variety of machine learning models, including regularized linear models, gradient boosting ensembles, neural network architectures, and proprietary variants. The machine learning model uses the available historical data to identify associations between input features (signals) and the target variable (excess returns). For linear models, this involves assigning higher weights to signals that have historically demonstrated positive predictive power. More complex models like neutral networks learn a non-linear transformation of the input features that can best predict the target variable. Although these more complex models can facilitate a better understanding of data relationships, they also increase the likelihood of overfitting. Overfitting is a common pitfall in machine learning, where a model is excessively tuned to the training data, diminishing its predictive performance on new, unseen data.

To mitigate the risks of overfitting, AIM incorporates stringent validation protocols, relying on cross-validation. In detail, the dataset is partitioned into subsets, and the model is trained on a portion of the data — called the training set — and then tested on the remaining 'held-out' data to validate its performance. This process can be repeated multiple times, rotating the data used for training and validation. The advantage of cross-validation is that it provides a more reliable estimate of the model's ability to generalize to new data by evaluating its performance on data that the model has not seen during training.

During validation, it is important to calculate historical performance measures using a realistic portfolio simulation that accounts for market frictions. To that end, model predictions are post-processed into alpha forecasts, and fed to a portfolio optimizer. The optimizer is responsible for transforming the alpha forecasts into portfolio holdings — accounting for fund specifications, estimated transaction costs, and portfolio constraints. This ensures that the portfolio is optimized in line with the investor's goals and risk tolerance, while also considering market dynamics and potential costs associated with trading. In the final component of the AIM pipeline, portfolio performance is evaluated over a historical period, using a realistic simulation environment. The portfolio simulator produces an array of performance measures that are used to evaluate the performance of the machine learning model over the validation period and tune the pipeline configuration.

In summary, AIM allows portfolio managers to create models that are sophisticated enough to capture complex signal interactions yet general enough to perform well on unseen data, balancing model capacity with versatility.

Figure 2: The machine learning pipeline used in AIM



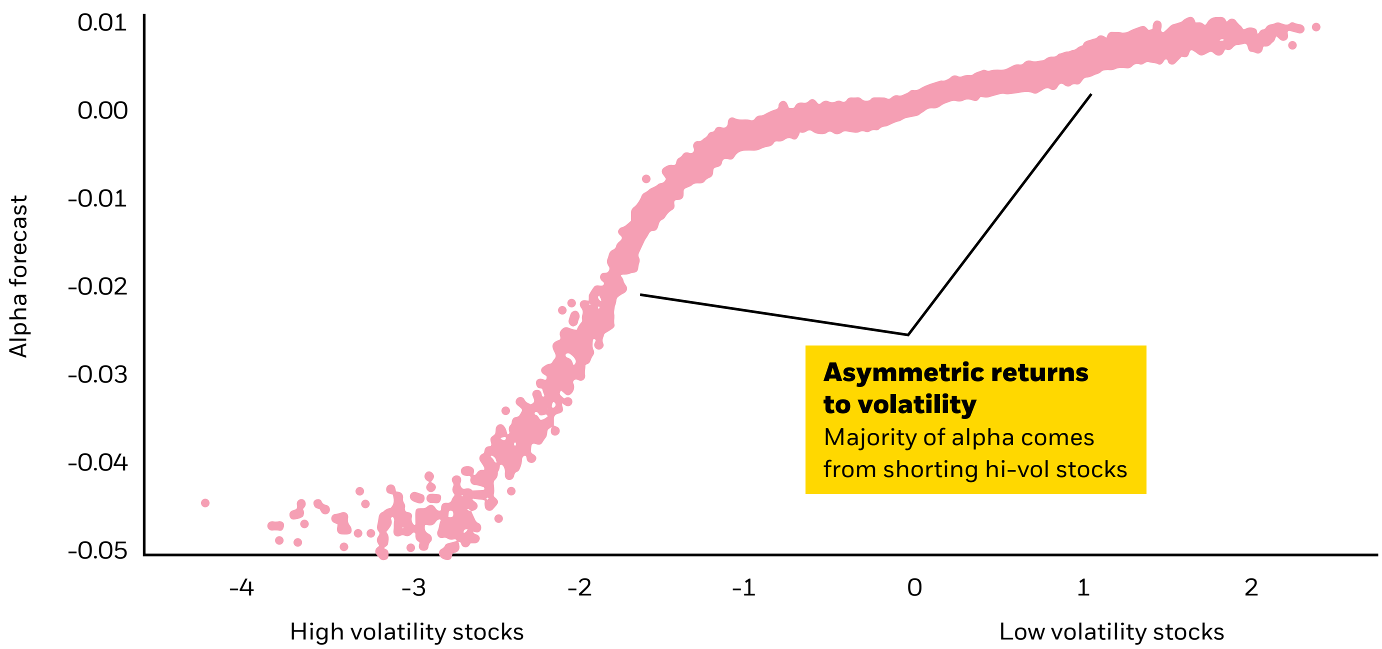
Source: BlackRock Systematic, as of July 2023. Model construction process provided for illustrative purposes only and is subject to change without notice.

Looking under the hood

The machine learning pipeline described on the previous page involves non-linear transformations of the input signals, making it difficult to link model predictions with corresponding input signals. Model interpretability is important not only for performance attribution, but also to guide model development (diagnosing data issues, identifying appropriate feature transformations, etc.). To solve for this challenge, machine learning researchers often turn to explanation models, which are interpretable approximations of the original model. In AIM, we have adopted an additive attribution approach based on Shapley regressions,[6] which produces a decomposition of the prediction value into a sum of individual signal contributions.

Figure 3 illustrates the model's view of one signal in the library that measures stock-specific volatility. The horizontal axis of the scatter plot corresponds to signal values, representing the level of stock volatility. The vertical axis shows the corresponding contribution to the alpha forecast, i.e., how much of the overall model forecast is attributed to this signal value. Individual points on the graph represent assets in the investible universe of about 3,000 large and mid-cap stocks in developed market countries. If we were to fit a linear model, the points in the graph would lie on a straight line, i.e., the contribution of the signal would be linearly proportional to the value of the signal for each asset. However, as evident in the figure, the model discovers a non-linear, asymmetric relationship between volatility and stock returns. This model discovery is consistent with evidence in the economic literature, namely that the empirical relationship between historical volatility and expected returns is negative.[7,8]

Figure 3: The model discovers an asymmetric relationship between volatility and stock returns
Model view of stock-specific volatility



Source: BlackRock Systematic, as of June 2023. For illustrative purposes only. There is no guarantee that any forecasts will come to pass.

6 Lundberg, S. M., & Lee, S. I. (2017), A unified approach to interpreting model predictions, *Advances in neural information processing systems, 30.* **7** Van Vliet, Blitz, van der Grient, Is the Relation between Volatility and Expected Stock Returns Positive, Flat or Negative? **8** Ang, Hodrick, Xing, Zhang, The Cross-Section of Volatility and Expected Returns.

Customizing alpha models

Predicting inflection points in global financial markets or the outcomes of macroeconomic shocks is a very difficult task, and portfolio managers are often guided by judgement and intuition when assessing regime changes and repositioning portfolios. By combining this human expertise with machine learning, we can enhance our approach for preparing for shifts in market regimes. A key benefit of machine learning systems is the low marginal cost of designing custom alpha models. Thus, portfolio managers can use AIM to design regime-aware models that are trained to be more resilient during negative regimes. This approach is analogous to earthquake management, where, due to the lack of reliable earthquake forecasting models, earthquake-resilient structures and contingency plans are developed to handle seismic events.

A simple and intuitive approach to training resilient models is to overstate the likelihood of negative regimes in the historical data used to train the model. This is akin to training the model on an alternate history where the prevalence of negative states (e.g., bear markets) is significantly higher. As a result, the model learns that to do well on its training data, it needs to find investment patterns that perform well during negative regimes.

Besides facilitating customization, these methods also help to safeguard against the pitfall of over-reliance on a dominant market regime in the training data. Through a training regime that emphasizes a higher frequency of negative states, the model explores diverse investment patterns for robust performance across market variations. This technique insulates AIM models against over-fitting to a particular market regime, leading to more stable and resilient portfolio strategies.

As a concrete example, we used AIM to train an alpha model that is more resilient to drawdowns of a broad equity index, in this case the MSCI World index. Starting with index returns, we resampled periods where the index return was consistently negative to overstate the likelihood of drawdowns, and trained a model on resampled historical data. Figure 4 (on the following page) summarizes the hypothetical historical performance of this defensive model relative to a baseline model trained on the same historical data without resampling. We find that the defensive model picks up many of the characteristics that we would expect a defensive strategy to have, including better risk-adjusted performance during market drawdowns relative to the benchmark, and lower overall drawdowns, particularly around periods of market stress like the Great Financial Crisis ("GFC"). This more resilient performance comes at a cost. Compared with the baseline model, the defensive model incurs a 20% performance haircut overall. We further found that the model intuitively discovers investment patterns that are consistent with a defensive strategy, by avoiding leveraged, high growth, high volatility names, and realizing an overall negative exposure to these risk factors (Figure 5, on the following page).

Figure 4: The defensive model demonstrates better risk-adjusted performance during historical drawdowns, but weaker performance than the baseline model overall

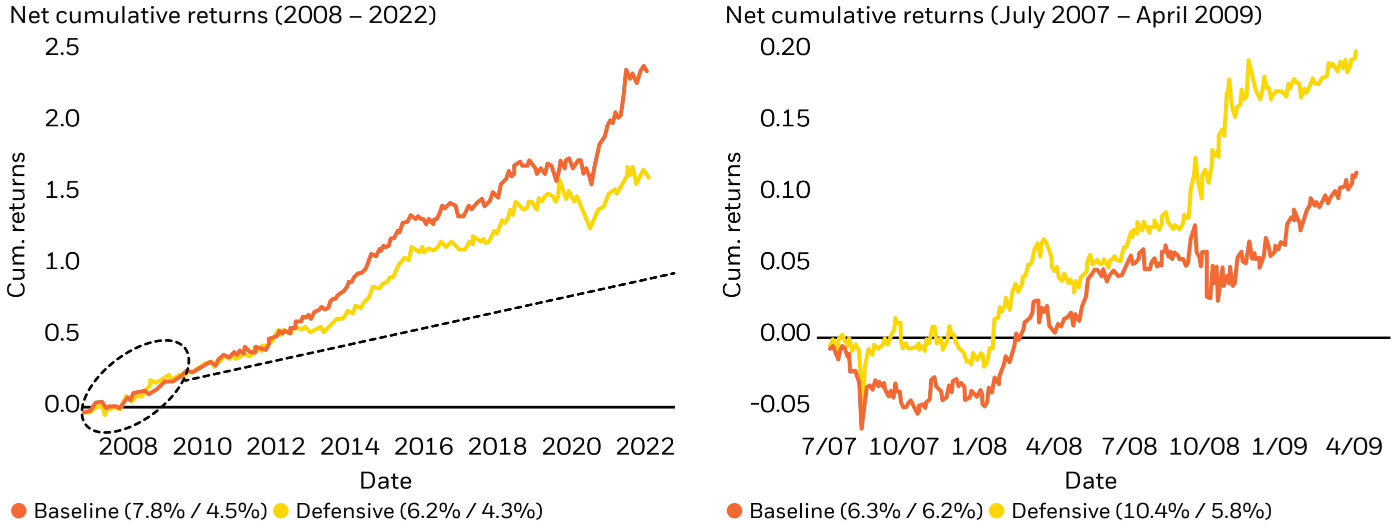
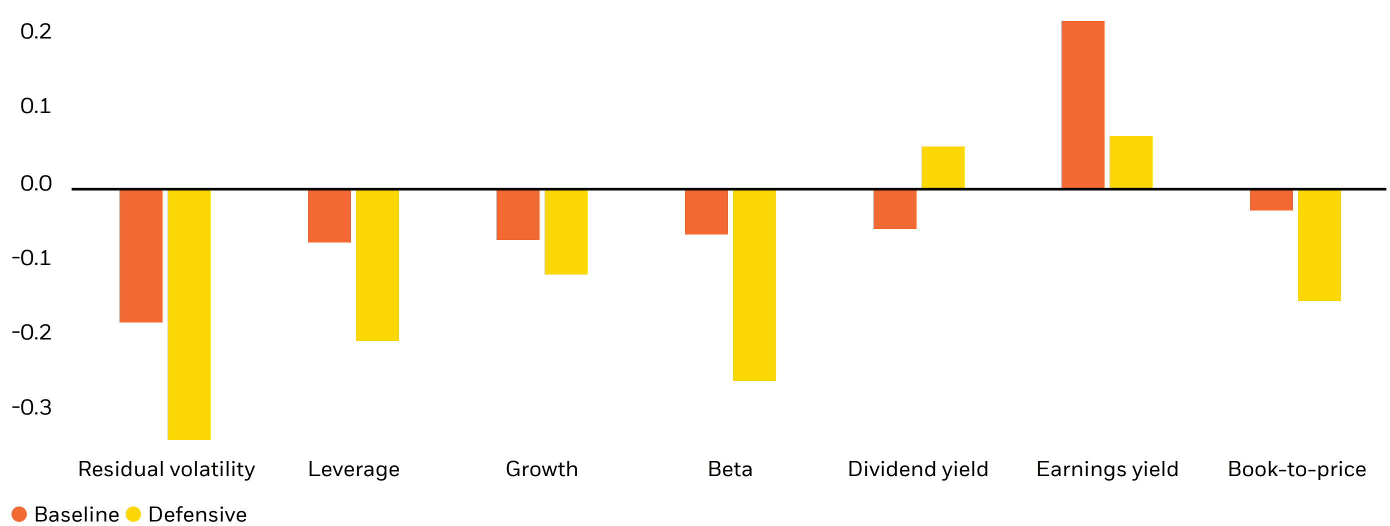


Figure 5: The defensive model reflects investment patterns that are consistent with expectations of a defensive strategy

Baseline and defensive model risk exposures



Source (Figure 4 and Figure 5): BlackRock Systematic, as of June 2023. Past performance is not an indicator of future results. The model is shown for informational purposes only. It is not meant to be a prediction or projection of the defensive model. It is provided to illustrate the characteristics and historical performance of the defensive alpha model through different market regimes. Actual returns may vary. The model is based purely on assumptions using available data, based on past and current market conditions, and assumptions relating to available investment opportunities, each of which are subject to change. The underlying assumptions in the model do not include all assumptions that may have been applied to a particular model, and the model itself does not factor in every performance factor that can have a significant impact on the performance of the defensive model. Since many potential scenarios exist, it is impossible to show all of the potential circumstances that could yield similar results. Actual events will vary and may differ materially from those assumed. The model is subject to significant limitations. It cannot account for the impact that economic, market, and other factors may have on the implementation of an actual investment. In addition to the variables identified above, the return of any portfolio will vary materially from the returns shown based on numerous factors. The model's simulated performance also has inherent limitations. Back-tested performance is used for illustrative purposes only and is not meant to be representative of any account, portfolio or strategy. There is no guarantee that any forecasts will come to pass. Results do not represent actual trading, and thus do not reflect transaction costs. The results may not reflect material economic and market factors. No representation is made that a client account will achieve results similar to those shown, and performance of actual client accounts may vary significantly from the hypothetical or back-tested results.

Putting it all together

AIM seeks to allow portfolio managers to harness the power of machine learning to design alpha models. Managers can use their expertise to calibrate, customize, and scale alpha models — relying on AIM to automate the complex task of optimally combining and considering non-linear relationships across a large set of individual signals.

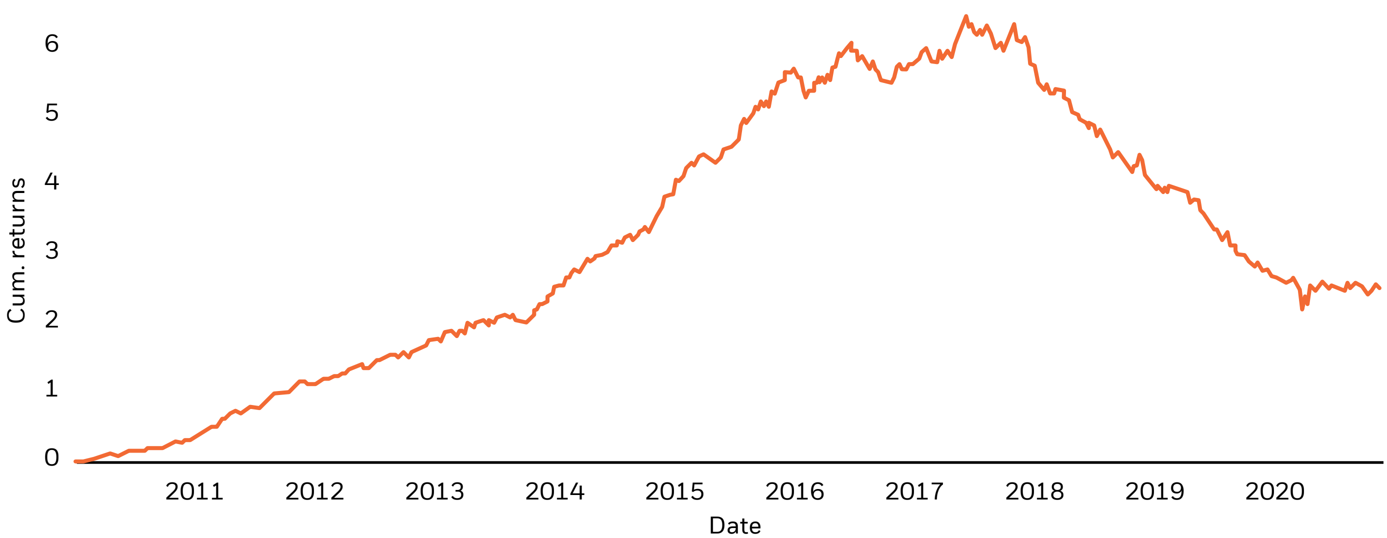
Portfolio managers configure the component pieces of AIM models to fit a specific function or investment mandate using their domain knowledge and historical training data. In the context of the previous example, a defensive alpha model may be used in a strategy with a conservative risk allocation or to limit portfolio drawdowns during periods of market stress. Portfolio managers can tailor models to capture opportunities as they arise, for example to target returns that aren't explained by traditional risk factors. The combination of human expertise and machine learning is what we believe makes AIM such a powerful tool for constructing systematic portfolios while balancing risk and return considerations.

Ongoing research directions

A fundamental assumption common to most machine learning models is that data used for training the model is drawn from the same distribution as live data used for inference. When the two distributions diverge, a phenomenon referred to as non-stationarity or covariate shift, the ability of a machine learning model to generalize from training data to live data is hampered. Non-stationarity is common in financial data and manifests in different forms.

First, signals can lose efficacy over time as sources of data become commoditized or underlying mechanisms become well understood by market participants. Figure 6 illustrates the cumulative returns of a calendar seasonality signal over the past decade, demonstrating a sharp turning point in the predictive ability of the signal. This is a particularly acute example of a change in the predictive power of a signal. More often, signals tend to stagnate or flatline and their predictive power decays over time.

Figure 6: Historical returns of a seasonality signal



Source: BlackRock Systematic, as of November 2020. Past performance is not an indicator of future results. The model is shown for informational purposes only. It is not meant to represent actual returns of, or to be a prediction or projection, of the signal. It is provided to illustrate the cumulative returns of a calendar seasonality signal over the past decade. Actual returns may vary. The model is based purely on assumptions using available data, based on past and current market conditions, and assumptions relating to available investment opportunities, each of which are subject to change. The underlying assumptions in the model do not include all assumptions that may have been applied to a particular model, and the model itself does not factor in every performance factor that can have a significant impact on the signal. Since many potential scenarios exist, it is impossible to show all of the potential circumstances that could yield similar results. Actual events will vary and may differ materially from those assumed. The model is subject to significant limitations. It cannot account for the impact that economic, market, and other factors may have on the implementation of an actual investment. In addition to the variables identified above, the return of any portfolio will vary materially from the return shown based on numerous factors. The model's simulated performance also has inherent limitations. The results do not represent actual trading, and thus do not reflect transaction costs. Returns may not reflect material economic and market factors. No representation is made that a client account will achieve results similar to those shown, and performance of actual client accounts may vary significantly from the hypothetical results due to the customization of advice to each client and other factors.

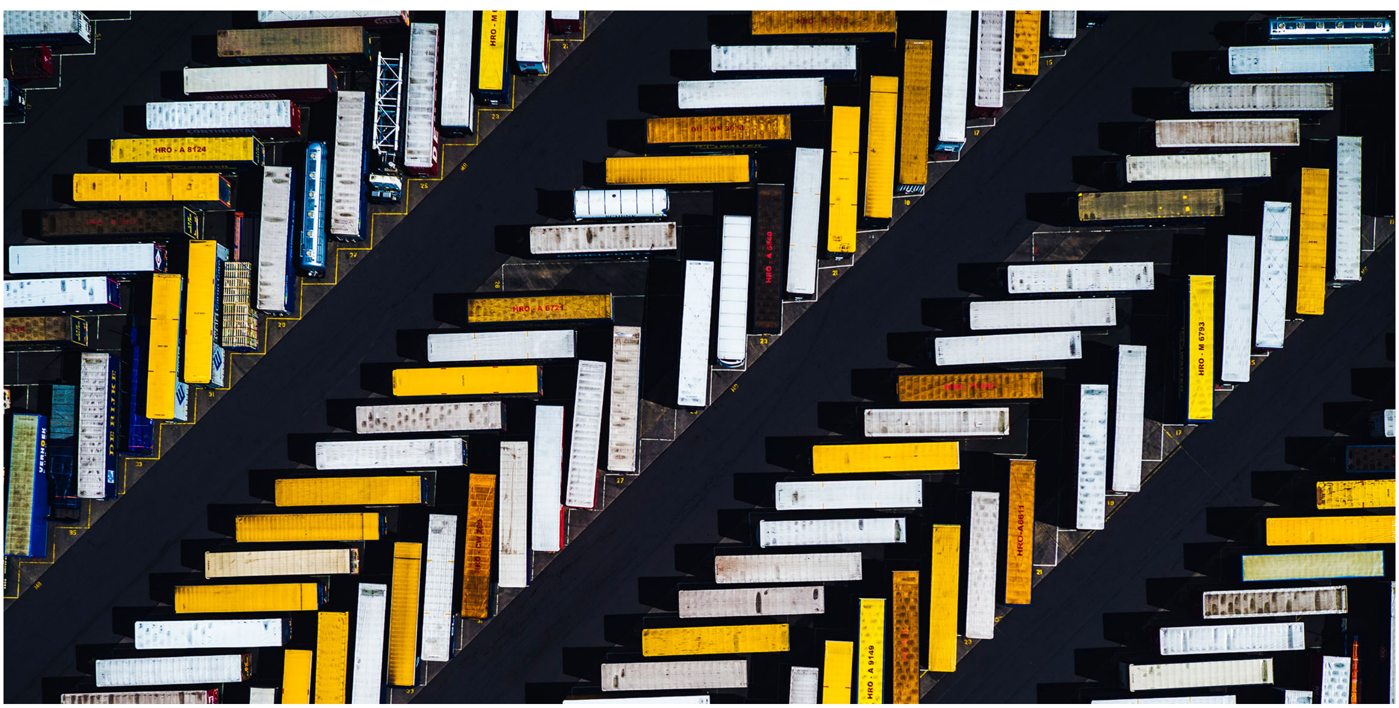
This can also occur as financial markets move with business cycles, causing fluctuations in market dynamics and shifts in the relationships between different signals. These cyclical patterns can create changes in the overall market structure, which in turn impacts the effectiveness of various signals. For example, during periods of economic expansion, certain signals related to growth-oriented companies or industries may exhibit stronger predictive power, whereas during periods of contraction, signals related to defensive or counter-cyclical sectors might become more valuable.

BlackRock's Systematic Investment Team has been working to continuously improve AIM by researching new approaches to address this challenge. One research direction we're exploring focuses on developing adaptive learning algorithms. These algorithms attempt to identify and adjust to changes in the distribution of financial data over time. By continuously monitoring the performance of the model and the characteristics of the input data, adaptive learning algorithms could detect shifts in the underlying distribution and update the model parameters accordingly. Techniques such as online learning, transfer learning, and domain adaptation could be explored in this context to develop more robust models that can better generalize from training data to live data.

Another promising research direction involves the incorporation of domain-specific knowledge and economic indicators into the model to better capture the underlying dynamics of financial markets. By incorporating information related to market cycles, macroeconomic factors, and other relevant data, the model may be better equipped to adapt to changes in the relationships between different signals.

Conclusion

As a proliferation of new data results in a multiplication of innovative new investment signals, AIM seeks to help systematic investors automate and better optimize the process of signal combination. AIM provides a customizable foundation for the creation of alpha models. The calibration and refinement of alpha models by expert portfolio managers brings this system to life — enabling models to be designed and optimized for navigating a wide range of investment objectives and market conditions.



For investors in Italy: This document is marketing material. Before investing please read the Prospectus and the PRIIPS KID available on www.blackrock.com/it, which contain a summary of investors' rights.

Risk warnings

Capital at risk. The value of investments and the income from them can fall as well as rise and are not guaranteed. Investors may not get back the amount originally invested.

Past performance is not a reliable indicator of current or future results and should not be the sole factor of consideration when selecting a product or strategy.

Changes in the rates of exchange between currencies may cause the value of investments to diminish or increase. Fluctuation may be particularly marked in the case of a higher volatility product or strategy and the value of an investment may fall suddenly and substantially. Levels and basis of taxation may change from time to time.

Important information

This material is provided for educational purposes only and is not intended to be relied upon as a forecast, research or investment advice, and is not a recommendation, offer or solicitation to buy or sell any securities or to adopt any investment strategy. The opinions expressed are subject to change. References to specific securities, asset classes and financial markets are for illustrative purposes only and are not intended to be and should not be interpreted as recommendations. Reliance upon information in this material is at the sole risk and discretion of the reader. The material was prepared without regard to specific objectives, financial situation or needs of any investor.

This material may contain "forward-looking" information that is not purely historical in nature. Such information may include, among other things, projections, forecasts and estimates of yields or returns. No representation is made that any performance presented will be achieved by any BlackRock Funds, or that every assumption made in achieving, calculating or presenting either the forward-looking information or any historical performance information herein has been considered or stated in preparing this material. Any changes to assumptions that may have been made in preparing this material could have a material impact on the investment returns that are presented herein. Past performance is not a reliable indicator of current or future results and should not be the sole factor of consideration when selecting a product or strategy.

The information and opinions contained in this material are derived from proprietary and nonproprietary sources deemed by BlackRock to be reliable, are not necessarily all-inclusive and are not guaranteed as to accuracy.

In the U.S., this material is for Institutional use only – not for public distribution.

In Canada, this material is intended for permitted clients as defined under Canadian securities law, is for educational purposes only, does not constitute investment advice and should not be construed as a solicitation or offering of units of any fund or other security in any jurisdiction.

This material is for distribution to Professional Clients (as defined by the Financial Conduct Authority or MiFID Rules) only and should not be relied upon by any other persons.

In the UK and Non-European Economic Area (EEA) countries: This is Issued by BlackRock Investment Management (UK) Limited, authorised and regulated by the Financial Conduct Authority. Registered office: 12 Throgmorton Avenue, London, EC2N 2DL. Tel: + 44 (0)20 7743 3000. Registered in England and Wales No. 02020394. For your protection telephone calls are usually recorded. Please refer to the Financial Conduct Authority website for a list of authorised activities conducted by BlackRock.

In the European Economic Area (EEA): This is Issued by BlackRock (Netherlands) B.V. is authorised and regulated by the Netherlands Authority for the Financial Markets. Registered office Amstelplein 1, 1096 HA, Amsterdam, Tel: 020 – 549 5200, Tel: 31-20-549-5200. Trade Register No. 17068311. For your protection telephone calls are usually recorded.

For Italy, for information on investor rights and how to raise complaints please go to https://www.blackrock.com/corporate/compliance/investor-right available in Italian.

For qualified investors in Switzerland: This document is marketing material.

This document shall be exclusively made available to, and directed at, qualified investors as defined in Article 10 (3) of the CISA of 23 June 2006, as amended, at the exclusion of qualified investors with an opting-out pursuant to Art. 5 (1) of the Swiss Federal Act on Financial Services ("FinSA"). For information on art. 8/9 Financial Services Act (FinSA) and on your client segmentation under Art. 4 FinSA, please see the following website: www.blackrock.com/finsa.

BlackRock Advisors (UK) Limited-Dubai Branch is a DIFC Foreign Recognised Company registered with the DIFC Registrar of Companies (DIFC Registered Number 546), with its office at Unit L15-01A, ICD Brookfield Place, Dubai International Financial Centre, PO Box 506661, Dubai, UAE, and is regulated by the DFSA to engage in the regulated activities of 'Advising on Financial Products' and 'Arranging Deals in Investments' in or from the DIFC, both of which are limited to units in a collective investment fund (DFSA Reference Number F000738).

In DIFC, the information contained in this document is intended strictly for Professional Clients as defined under the Dubai Financial Services Authority ("DFSA") Conduct of Business Rules. The information contained in this document, does not constitute and should not be construed as an offer of, invitation or proposal to make an offer for, recommendation to apply for or an opinion or guidance on a financial product, service and/or strategy. Whilst great care has been taken to ensure that the information contained in this document is accurate, no responsibility can be accepted for any errors, mistakes or omissions or for any action taken in reliance thereon. You may only reproduce, circulate and use this document (or any part of it) with the consent of BlackRock. The information contained in this document is for information purposes only. It is not intended for and should not be distributed to, or relied upon by, members of the public. The information contained in this document, may contain statements that are not purely historical in nature but are "forward-looking statements." These include, amongst other things, projections, forecasts or estimates of income. These forward-looking statements are based upon certain assumptions, some of which are described in other relevant documents or materials. If you do not understand the contents of this document, you should consult an authorised financial adviser.

In South Africa, please be advised that BlackRock Investment Management (UK) Limited is an authorised Financial Services provider with the South African Financial Services Conduct Authority, FSP No. 43288.

For investors in Israel: BlackRock Investment Management (UK) Limited is not licensed under Israel's Regulation of Investment Advice, Investment Marketing and Portfolio Management Law, 5755-1995 (the "Advice Law"), nor does it carry insurance thereunder.

In Latin America, for Institutional Investors and Financial Intermediaries Only (Not for public distribution). This material is for educational purposes only and does not constitute an offer or solicitation to sell or a solicitation of an offer to buy any shares of any fund (nor shall any such shares be offered or sold to any person) in any jurisdiction in which an offer, solicitation, purchase or sale would be unlawful under the securities law of that jurisdiction. It is possible that some or all of the funds mentioned in this document have not been registered with the securities regulator of Argentina, Brazil, Chile, Colombia, Mexico, Panama, Peru, Uruguay or any other securities regulator in any Latin American country and thus might not be publicly offered within any such country. The securities regulators of such countries have not confirmed the accuracy of any information contained herein. No information discussed herein can be provided to the general public in Latin America.

In Argentina, only for use with Qualified Investors under the definition as set by the Comisión Nacional de Valores (CNV).

In Brazil, this private offer does not constitute a public offer, and is not registered with the Brazilian Securities and Exchange Commission, for use only with professional investors as such term is defined by the *Comissão de Valores Mobiliários*.

In Chile, the offer of each security not registered with the Comisión para el Mercado Financiero ("CMF") is subject to General Rule No. 336 issued by the SVS (now the CMF). The subject matter of this offer may include securities not registered with the CMF; therefore, such securities are not subject to the supervision of the CMF. Since the securities are not registered in Chile, there is no obligation of the issuer to make publicly available information about the securities in Chile. The securities shall not be subject to public offering in Chile unless registered with the relevant registry of the CMF.

In Colombia, the offer of each Fund is addressed to less than one hundred specifically identified investors, and such Fund may not be promoted or marketed in Colombia or to Colombian residents unless such promotion and marketing is made in compliance with Decree 2555 of 2010 and other applicable rules and regulations related to the promotion of foreign financial and/or securities related products or services in Colombia.

IN MEXICO, FOR INSTITUTIONAL AND QUALIFIED INVESTORS USE ONLY. INVESTING INVOLVES RISK, INCLUDING POSSIBLE LOSS OF PRINCIPAL. THIS MATERIAL IS PROVIDED FOR EDUCATIONAL AND INFORMATIONAL PURPOSES ONLY AND DOES NOT CONSTITUTE AN OFFER OR SOLICITATION TO SELL OR A SOLICITATION OF AN OFFER TO BUY ANY SHARES OF ANY FUND OR SECURITY.

This information does not consider the investment objectives, risk tolerance or the financial circumstances of any specific investor. This information does not replace the obligation of financial advisor to apply his/her best judgment in making investment decisions or investment recommendations. It is your responsibility to inform yourself of, and to observe, all applicable laws and regulations of Mexico. If any funds, securities or investment strategies are mentioned or inferred in this material, such funds, securities or strategies have not been registered with the Mexican National Banking and Securities Commission (Comisión Nacional Bancaria y de Valores, the "CNBV") and thus, may not be publicly offered in Mexico. The CNBV has not confirmed the accuracy of any information contained herein. The provision of investment management and investment advisory services ("Investment Services") is a regulated activity in Mexico, subject to strict rules, and performed under the supervision of the CNBV. These materials are shared for information purposes only, do not constitute investment advice, and are being shared in the understanding that the addressee is an Institutional or Qualified investor as defined under Mexican Securities (Ley del Mercado de Valores). Each potential investor shall make its own investment decision based on their own analysis of the available information. Please note that by receiving these materials, it shall be construed as a representation by the receiver that it is an Institutional or Qualified investor as defined under Mexican law. BlackRock México Operadora, S.A. de C.V., Sociedad Operadora de Fondos de Inversión ("BlackRock México Operadora") is a Mexican subsidiary of BlackRock, Inc., authorized by the CNBV as a Mutual Fund Manager (Operadora de Fondos), and as such, authorized to manage Mexican mutual funds, ETFs and provide Investment Advisory Services. For more information on the Investment Services offered by BlackRock Mexico, please review our Investment Services Guide available in www.blackrock.com/mx. This material represents an assessment at a specific time and its information should not be relied upon by the you as research or investment advice regarding the funds, any security or investment strategy in particular. Reliance upon information in this material is at your sole discretion. BlackRock México is not authorized to receive deposits, carry out intermediation activities, or act as a broker dealer, or bank in Mexico. For more information on BlackRock México, please visit: www.blackrock.com/mx. BlackRock receives revenue in the form of advisory fees for our advisory services and management fees for our mutual funds, exchange traded funds and collective investment trusts. Any modification, change, distribution or inadequate use of information of this document is not responsibility of BlackRock or any of its affiliates. Pursuant to the Mexican Data Privacy Law (Ley Federal de Protección de Datos Personales en Posesión de Particulares), to register your personal data you must confirm that you have read and understood the Privacy Notice of BlackRock México Operadora. For the full disclosure, please visit www.blackrock.com/mx and accept that your personal information will be managed according with the terms and conditions set forth therein.

In Peru, this private offer does not constitute a public offer, and is not registered with the Securities Market Public Registry of the Peruvian Securities Market Commission, for use only with institutional investors as such term is defined by the *Superintendencia de Banca, Seguros y AFP*.

In Uruguay, the Securities are not and will not be registered with the Central Bank of Uruguay. The Securities are not and will not be offered publicly in or from Uruguay and are not and will not be traded on any Uruguayan stock exchange. This offer has not been and will not be announced to the public and offering materials will not be made available to the general public except in circumstances which do not constitute a public offering of securities in Uruguay, in compliance with the requirements of the Uruguayan Securities Market Law (Law Nº 18.627 and Decree 322/011).

For investors in Central America, these securities have not been registered before the Securities Superintendence of the Republic of Panama, nor did the offer, sale or their trading procedures. The registration exemption has made according to numeral 3 of Article 129 of the Consolidated Text containing of the Decree-Law No. 1 of July 8, 1999 (institutional investors). Consequently, the tax treatment set forth in Articles 334 to 336 of the Unified Text containing Decree-Law No. 1 of July 8, 1999, does not apply to them. These securities are not under the supervision of the Securities Superintendence of the Republic of Panama. The information contained herein does not describe any product that is supervised or regulated by the National Banking and Insurance Commission (CNBS) in Honduras. Therefore, any investment described herein is done at the investor's own risk. This is an individual and private offer which is made in Costa Rica upon reliance on an exemption from registration before the General Superintendence of Securities ("SUGEVAL"), pursuant to articles 7 and 8 of the Regulations on the Public Offering of Securities ("Reglamento sobre Oferta Pública de Valores"). This information is confidential, and is not to be reproduced or distributed to third parties as this is NOT a public offering of securities in Costa Rica. The product being offered is not intended for the Costa Rican public or market and neither is registered or will be registered before the SUGEVAL, nor can be traded in the secondary market. If any recipient of this documentation receives this document in El Salvador, such recipient acknowledges that the same has been delivered upon their request and instructions, and on a private placement basis.

In Singapore, this document is provided by BlackRock (Singapore) Limited (company registration number: 200010143N) for use only with institutional as defined in Section 4A of the Securities and Futures Act, Chapter 289 of Singapore. This advertisement or publication has not been reviewed by the Monetary Authority of Singapore.

In Hong Kong, this material is issued by BlackRock Asset Management North Asia Limited and has not been reviewed by the Securities and Futures Commission of Hong Kong. This material is for distribution to "Professional Investors" (as defined in the Securities and Futures Ordinance (Cap. 571 of the laws of Hong Kong) and any rules made under that ordinance.) and should not be relied upon by any other persons or redistributed to retail clients in Hong Kong.

In South Korea, this information is issued by BlackRock Investment (Korea) Limited. This material is for distribution to the Qualified Professional Investors (as defined in the Financial Investment Services and Capital Market Act and its sub-regulations) and for information or educational purposes only, and does not constitute investment advice or an offer or solicitation to purchase or sells in any securities or any investment strategies.

In Taiwan, independently operated by BlackRock Investment Management (Taiwan) Limited. Address: 28F., No. 100, Songren Rd., Xinyi Dist., Taipei City 110, Taiwan. Tel: (02)23261600.

In Australia & New Zealand, issued by BlackRock Investment Management (Australia) Limited ABN 13 006 165 975, AFSL 230 523 (BIMAL) for the exclusive use of the recipient, who warrants by receipt of this material that they are a wholesale client as defined under the Australian Corporations Act 2001 (Cth) and the New Zealand Financial Advisers Act 2008 respectively.

This material provides general information only and does not take into account your individual objectives, financial situation, needs or circumstances. Before making any investment decision, you should therefore assess whether the material is appropriate for you and obtain financial advice tailored to you having regard to your individual objectives, financial situation, needs and circumstances. Refer to BIMAL's Financial Services Guide on its website for more information. This material is not a financial product recommendation or an offer or solicitation with respect to the purchase or sale of any financial product in any jurisdiction.

This material is not intended for distribution to, or use by, any person or entity in any jurisdiction or country where such distribution or use would be contrary to local law or regulation. BIMAL is a part of the global BlackRock Group which comprises of financial product issuers and investment managers around the world. BIMAL is the issuer of financial products and acts as an investment manager in Australia. BIMAL does not offer financial products to persons in New Zealand who are retail investors (as that term is defined in the Financial Markets Conduct Act 2013 (FMCA)). This material does not constitute or relate to such an offer. To the extent that this material does constitute or relate to such an offer of financial products, the offer is only made to, and capable of acceptance by, persons in New Zealand who are wholesale investors (as that term is defined in the FMCA). BIMAL, its officers, employees and agents believe that the information in this material and the sources on which it is based (which may be sourced from third parties) are correct as at the date of publication. While every care has been taken in the preparation of this material, no warranty of accuracy or reliability is given and no responsibility for the information is accepted by BIMAL, its officers, employees or agents. Except where contrary to law, BIMAL excludes all liability for this information.

In China, this material may not be distributed to individuals resident in the People's Republic of China ("PRC", for such purposes, not applicable to Hong Kong, Macau and Taiwan) or entities registered in the PRC unless such parties have received all the required PRC government approvals to participate in any investment or receive any investment advisory or investment management services.

The information provided here is not intended to constitute financial, tax, legal or accounting advice. You should consult your own advisers on such matters. BlackRock does not guarantee the suitability or potential value of any particular investment. Investment involves risk including possible loss of principal. International investing involves risks, including risks related to foreign currency, limited liquidity, less government regulation, and the possibility of substantial volatility due to adverse political, economic or other developments. These risks are often heightened for investments in emerging/developing markets or smaller capital markets.

Any research in this document has been procured and may have been acted on by BlackRock for its own purpose. The results of such research are being made available only incidentally. The views expressed do not constitute investment or any other advice and are subject to change. They do not necessarily reflect the views of any company in the BlackRock Group or any part thereof and no assurances are made as to their accuracy.

This document is for information purposes only and does not constitute an offer or invitation to anyone to invest in any BlackRock funds and has not been prepared in connection with any such offer.

FOR PROFESSIONAL, INSTITUTIONAL INVESTORS, QUALIFIED INVESTORS, WHOLESALE INVESTORS AND PERMITTED, PROFESSIONAL AND QUALIFIED CLIENT USE ONLY. THIS MATERIAL IS NOT TO BE REPRODUCED OR DISTRIBUTED TO PERSONS OTHER THAN THE RECIPIENT.

231753T-0823

BlackRock.