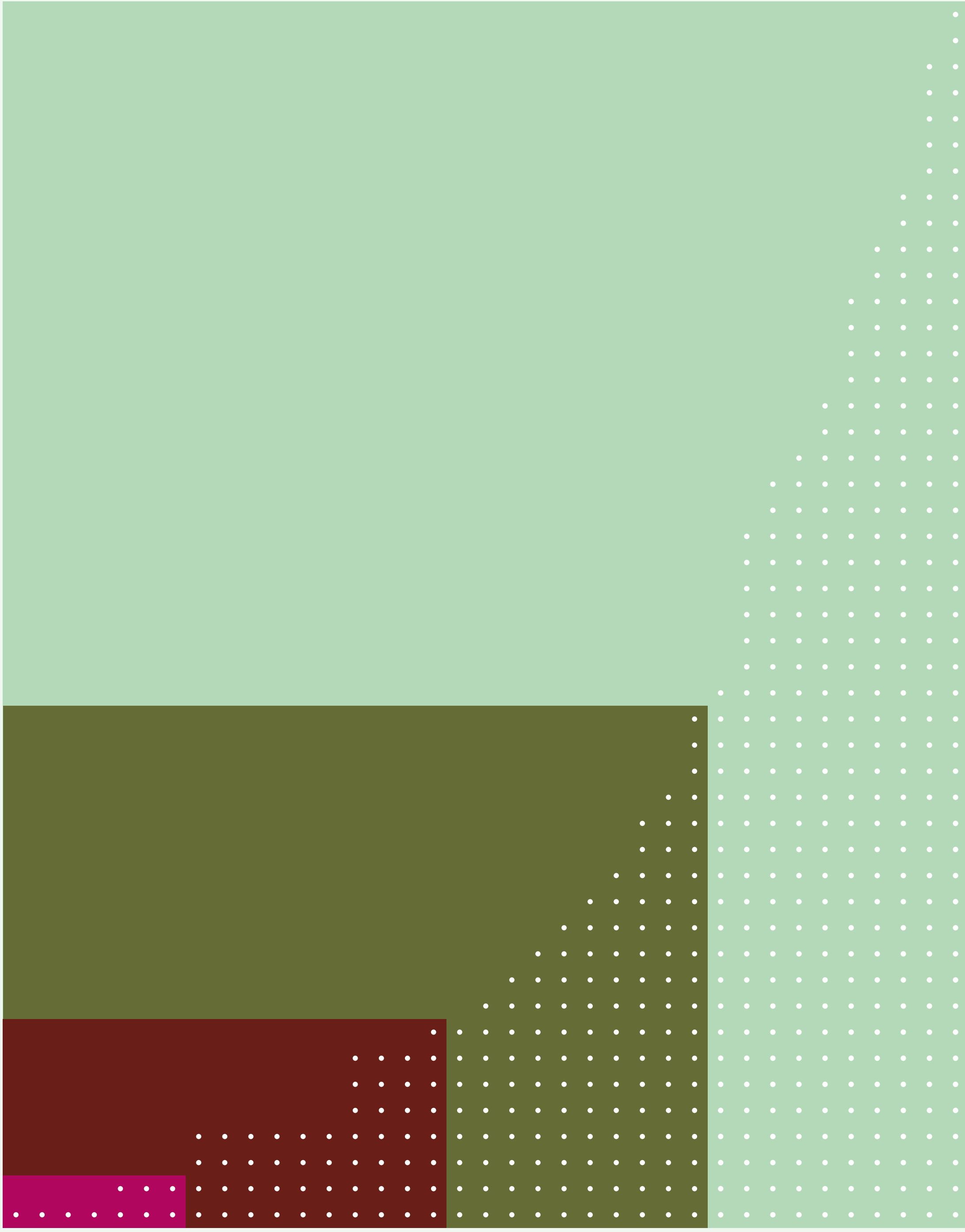
Dimensional



The Evolution of Dimensional's

FIXED INCOME INVESTING

Dimensional launched its first bond strategy nearly 40 years ago, pioneering a systematic approach to value-added fixed income investing. Over the decades, we have implemented fixed income strategies in markets around the world, developing deep expertise into what drives expected returns across bonds. Through an incremental process, we have developed new investment applications and enhancements, resulting in a broad set of systematic solutions designed to meet the diverse needs of investors.

From the beginning, Dimensional has based its fixed income approach on a singular investment philosophy and a deep understanding of the drivers of a bond's return. Whether investing in fixed income or equities, we believe market prices reflect the aggregate expectations of market participants and provide real-time information about differences in expected returns. We do not invest based on predictions of future changes in interest rates, as decades of empirical research have shown forecasts to be unreliable. We believe combining market principles with a systematic investment approach differentiates Dimensional from peers.

Starting with a single strategy in 1983, we expanded our offering to help clients tailor their exposure across the duration and credit spectrums and choose between a domestic or global opportunity set. We also implemented meaningful enhancements to our approach through time, leading to improvements in risk management and trading strategies.

Ongoing work by academics and Dimensional researchers, advancements in market mechanisms and shifts in how clients view the role of fixed income contributed to this evolution. These intertwining developments have provided many opportunities for innovation and informed new investment solutions.

Let's take a walk through the decades.

In 1983, Dimensional got its start in fixed income with the launch of a **US ultra-short duration** strategy, implementing findings from Professor Eugene Fama's research on the relation between forward interest rates and subsequent returns.[1]

What we knew then—and what remains true today—is that a bond's return has three primary components: the yield, the expected capital appreciation or depreciation over the holding period based on the current yield curve, and the return due to future interest rate changes. The first two components are known and observable today and combine to form the forward rate. Fama's work found that observed forward rates contain reliable information about future differences in expected bond returns.

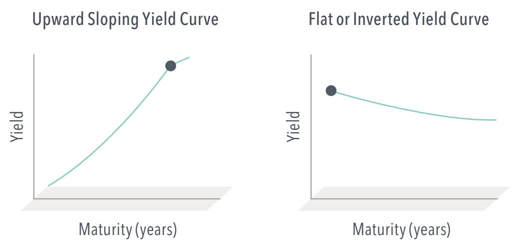
This research led to the development of Dimensional's **variable maturity approach,** which remains integral to our strategies today. Dimensional uses the information available in forward rates to identify bonds with the highest expected returns, within a strategy's guidelines, and varies duration by targeting those securities. Generally, this approach implies that, within pre-defined ranges or relative to a benchmark, our strategies will pursue longer duration bonds where yield curves are upward sloping and shorter duration bonds where yield curves are flat or inverted.

1980s

MAJOR RESEARCH AND MARKET IMPROVEMENTS	**Information in the Term Structure**	Eugene Fama's pioneering research finds that implied forward rates from the current term structure provide reliable information about expected returns across the duration spectrum.
STRATEGY APPLICATIONS AND ENHANCEMENTS	**Variable Maturity Approach**	Dimensional launches its first fixed income strategy in 1983. The new approach uses information in the current term structure to identify areas of higher expected return on the yield curve without relying on future interest rate predictions.

Variable Maturity Approach

● Portfolio position



Current market prices, as reflected in yield curves, contain information about differences in expected returns among bonds. Dimensional uses this information to improve expected returns by varying the duration of the portfolio based on the current yield curve.

Dimensional expanded its offering in the 1990s to include global bonds with the launch of a **global short duration** strategy. The approach was guided by Fama's 1980s research on forward and spot exchange rates[2] and additional work in the 1990s between Fama and Dimensional on currency-hedged global investing.

Investing in global bonds on a currency-hedged basis offered investors several potential benefits, including a broader opportunity set for identifying bonds with higher expected returns and diversification of duration exposure. Using information in forward rates, we can identify bonds issued in different currencies that offer higher expected returns and increase a portfolio's allocation to those securities. Because global yield curves do not move in tandem, a global portfolio can also manage the risk of unexpected changes in rates across individual yield curves.

Dimensional's first **intermediate duration** strategy was also introduced in the 1990s, designed to meet the needs of investors seeking a marketlike portfolio duration while pursuing greater-than-market returns. The strategy pursued a targeted duration similar to a market benchmark while allocating to a subset of bonds offering higher expected returns. This approach—rather than investing across all maturities[3]—was the crucial insight underpinning the strategy. The design of this portfolio established a value-added approach for duration-constrained investing and formed the basis for future benchmark-relative strategies.[4]

1990s

Currency-Hedged Global Yield Curves

In collaboration with Eugene Fama, Dimensional finds that forward rates across currency-hedged global yield curves provide information about differences in expected returns among global bonds.

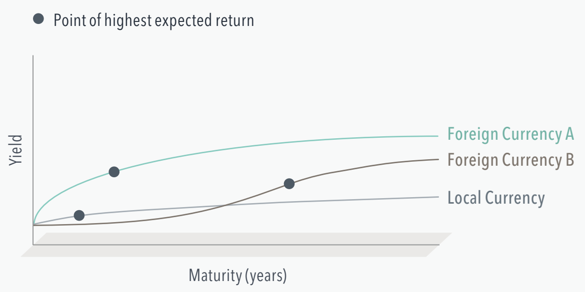
Global Opportunity Set

Dimensional begins investing in currency-hedged global bonds, expanding the opportunity set for pursuing higher expected returns.

Investing with Duration Constraints

Dimensional develops its first strategy intended to outperform a market benchmark while targeting a similar average duration.

Global Bonds: Expanding the Opportunity Set



Yield curves in different countries often have different levels and slopes. Investing in multiple yield curves on a currency-hedged basis can enhance diversification and reduce volatility. Dimensional applies the variable maturity approach to yield curves in markets around the world in pursuit of higher expected returns.

In the new century, the 2002 introduction of the **Trade Reporting and Compliance Engine** (TRACE) proved to be a major advance for the US bond market. The system requires dealers to report over-the-counter secondary market transactions in USD-denominated corporate bonds, agency bonds and securitised products within 15 minutes of an execution. With TRACE, the fixed income market finally had bond trade transparency similar to the price visibility afforded to equity investors with the ticker tape.

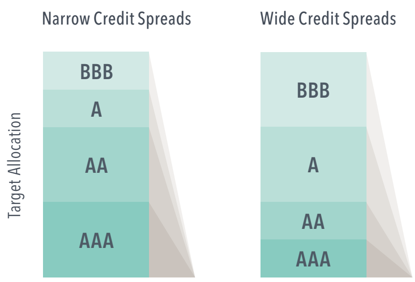
2000s

Prior to this development in the bond market, Dimensional's fixed income strategies focused on the highest-quality investment grade issues. After TRACE launched, Dimensional spent several years studying bond trade data, which provided a higher-resolution view of the full corporate bond market. The research confirmed that differences in forward rates contain reliable information about differences in expected returns not only across the duration spectrum but also across the credit spectrum and ultimately informed our **variable credit approach.**

Variable credit was first introduced in Dimensional's **credit** and **core fixed income** strategies, which extended the eligible credit range down to BBB rated bonds. This approach uses information in forward rates (as captured, for example, by credit spreads) to identify bonds with higher expected returns across eligible yield curves of varying credit quality and dynamically allocate to those securities. In practice, the approach increases exposure to eligible bonds with lower credit quality when credit spreads are wider and those securities offer higher expected returns. Conversely, variable credit reduces exposure to eligible bonds with lower credit quality when credit spreads are narrower and expected returns for those securities are lower.

MAJOR RESEARCH AND MARKET IMPROVEMENTS	**Improved Bond Trade Transparency**	FINRA launches the Trade Reporting and Compliance Engine (TRACE), introducing transaction price and volume transparency to US-denominated bond issues.	**Information in Credit Spreads**	TRACE data spurs robust research into credit markets. Dimensional finds that current credit spreads provide information about subsequent credit premiums.
STRATEGY APPLICATIONS AND ENHANCEMENTS	**Variable Credit Approach**	Dimensional creates its first strategies that invest across the full investment grade spectrum, implementing an approach that uses information in current credit spreads to vary credit exposure in pursuit of higher expected returns.	**Market-Based Credit Monitoring**	Dimensional uses price data from TRACE to continually monitor market-informed credit ratings and maintain the credit profile of strategy holdings consistent with each mandate.

Variable Credit Approach



Dimensional's variable credit approach uses information contained in forward rates and credit spreads to dynamically vary exposure across credit qualities to bonds with higher expected returns.

TRACE also provided us with additional opportunities for enhancing Dimensional's risk management processes. We began systematically incorporating TRACE data on traded prices and quantities into our **market-informed credit ratings,** alongside a host of other considerations, such as information in prices of credit default swaps. Specifically, we began to continually monitor market yields of corporate and agency bonds and assign a lower credit rating to those bonds whose yields suggested a higher level of credit risk than indicated by their stated credit ratings. Additionally, because most global borrowers issue bonds denominated in USD, we could infer internal credit ratings for the vast majority of non-US issuers and apply our internal credit monitoring process to non-US and global strategies. This allowed us to improve our credit monitoring process, as our research shows that bonds trading at substantially higher yields than peers with the same credit rating generally perform more like lower-quality bonds and also experience a higher frequency of downgrades.

TRACE has also informed the development of our **inventory modelling** and enhanced our **trade cost analysis.** Dimensional has always employed a flexible trading approach to reduce implementation costs in our portfolios. Having visibility into daily bond trade data, including whether a dealer was involved in the transaction, allowed us to begin modelling dealer inventory. Gaining an understanding of dealer inventory and holding periods enables us to have a better view of available market liquidity across different bonds, which, paired with our flexible trading approach, generally allows us to trade at favourable prices. Further, TRACE has enabled extensive trade cost analysis that helps measure and monitor outcomes of our flexible trading approach relative to others in the marketplace. Our ongoing analysis and monitoring efforts have consistently validated the benefits of our approach and informed improvements over time.

While TRACE opened up several opportunities for enhancing our investment approach, Dimensional also expanded into new strategy offerings in the 2000s to meet investor needs. These solutions included our first **US municipal bond** and **inflation-linked** strategies, which applied our understanding of the drivers of fixed income returns to new areas of the market.

"Throughout the decades, the one constant in our fixed income evolution has been our reliance on market prices. This has set us apart from other investment managers."

Dave Plecha
Global Head of Fixed Income

Trade Cost Analysis

Using TRACE data, Dimensional can compare its execution prices to those of other market participants and finds that its flexible trading approach provides trade price advantages that lower costs to investors.

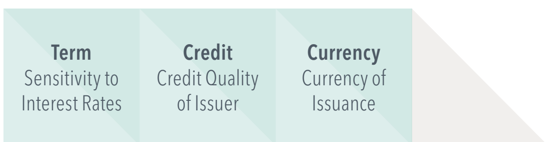
Inventory Modelling for Trade Price Advantages

Dimensional begins monitoring transaction data through TRACE to develop dealer inventory models and locate bonds to capitalise on possible counterparty motivations.

Drivers of Expected Returns in Fixed Income

Decades of empirical research show forward rates provide information about differences in expected returns among bonds of different durations, credit qualities and currencies of issuance.

Dimensional evaluates new research and implements strategies based on these sources, or dimensions, of expected returns.



The most recent decade saw the advent of direct trading between bond buyers and sellers. Dimensional executed its first **peer-to-peer bond trade** in 2014. By eliminating the bond dealer's role in a transaction, trading parties could obtain lower bid-ask spreads, leading to cost savings. Today, peer-to-peer trading is an essential component of our daily implementation.

2010s

In the 2010s, Dimensional also continued expanding its fixed income offering into new solutions, including our first strategies to offer exposure to **high-yield** bonds, **sustainability** and **social fixed income** strategies, and an innovative **inflation-linked US municipal bond** strategy.

TRACE also aided Dimensional's entry into high yield. Leveraging daily corporate bond trade data, we performed extensive analysis into high-yield debt (bonds with credit ratings of BB or lower), concluding that the highest credit quality portion of the high-yield market (BB rated bonds) can be appropriate for certain strategies designed to target credit exposure, resulting in improved diversification and increased return potential. Our work on high-yield bonds culminated in making BB rated bonds eligible in our **targeted credit** strategy, which emphasises securities rated A through BB.

Near the close of the decade, Dimensional introduced a new strategy that combines multiple innovations developed over decades of fixed income investing. Our **global core plus** strategy was designed for investors seeking a value-added core solution with a duration similar to that of the aggregate global bond market. In this strategy, we apply expertise in investing

MAJOR RESEARCH AND MARKET IMPROVEMENTS	**Direct Bond Market Trading**	Advanced trading platforms enable trades directly between asset owners, eliminating middle men from transactions and creating opportunities to reduce transaction costs.	**Credit Research Expanded to High-Yield Bonds**	Dimensional finds that BB rated bonds can increase expected returns in a strategy that invests only in investment grade bonds—without significant impact to liquidity.
STRATEGY APPLICATIONS AND ENHANCEMENTS	**Peer-to-Peer Bond Trading Capabilities**	Dimensional starts executing peer-to-peer trades where possible to seek reduced transaction costs in strategies.	**Extended Variable Credit Approach to High Yield**	BB rated bonds become eligible in certain Dimensional strategies, providing greater ability to target higher expected returns with Dimensional's variable credit approach.

Peer-to-Peer Trading

Today's technology enables buyers and sellers to connect anonymously and directly. With no dealer markup to pay, both parties can take a share of the bid-ask spread, resulting in a more favourable price. We believe Dimensional's investment philosophy and flexible approach to bond trading are well suited for peer-to-peer platforms.

within duration constraints and use information in forward rates to systematically vary the allocation across bonds of different durations, credit qualities (down to BB) and currencies of issuance. These potential sources of value are integrated into a single investment solution representing decades of progress in systematic fixed income investing.

Looking Ahead

At Dimensional, we are on a continual search for new research and ideas that may lead to advancements in fixed income investing. However, we do not lose sight of the foundational understanding of fixed income returns that has benefited investors over time.

We have seen trends come and go, and we expect to see more in the future. A current example is the rise of "smart beta" approaches in fixed income. Some investment managers propose that additional variables, such as company size, leverage, or bond momentum, are linked to expected bond returns. A recent study by Dimensional, conducted as part of our ongoing research into fixed income markets, found that most of the information these variables provide is already reflected in forward rates, originally examined by Fama in the 1970s.

"In science, what you want is the minimum number of factors that will explain something, not the maximum number."

Professor Eugene Fama
Nobel laureate, Director and Consultant

The paper, "The Cross-Section of Corporate Bond Returns,"[5] offered strong empirical support for the ability of forward rates to explain differences in expected returns across corporate bonds. In addition, the research found that, if a company's stock underperforms the equity market in a given month, its bonds tend to underperform the bond market in the next month. While we have for many years evaluated a bond issuer's recent stock price as part of our credit investing approach, this finding contributes to our understanding of the relation between short-term equity returns and expected bond returns.

As the 2020s begin, we have entered new areas, such as mortgage-backed securities, where TRACE reporting requirements make the market more transparent. We are also preparing to meet the challenges of conducting peer-to-peer trading in Europe.

Change is a constant, and we expect the evolution of research, market microstructure and client needs to create new opportunities for investment innovation. At Dimensional, we look forward to continuing this tradition of innovation—in fixed income and elsewhere. It is key to our mission of delivering the best solutions we can to investors.

1. Eugene F. Fama, "Forward Rates as Predictors of Future Spot Rates," *Journal of Financial Economics* 3, no. 4 (1976): 361–377; Eugene F. Fama, "The Information in the Term Structure," *Journal of Financial Economics* 13, no. 4 (1984): 509–528.
2. Eugene F. Fama, "Forward and Spot Exchange Rates," *Journal of Monetary Economics* 14, no. 3 (1984): 319–338.
3. Wei Dai, Joseph Kolerich, and Douglas Longo, "Pursuing Higher Expected Returns with Duration Constraints," Dimensional Fund Advisors, October 2017.
4. Dimensional's benchmark-relative strategies are managed to consider the duration of a specified index without seeking to match the index's holdings or other specific characteristics of the index.
5. Marlena Lee, Philipp Meyer-Brauns, Savina Rizova, and Samuel Wang, "The Cross-Section of Corporate Bond Returns," Dimensional Fund Advisors, February 2020.

GLOSSARY

Forward interest rate
The yield and expected capital appreciation of a bond based on current market prices.

Duration
A measurement of a bond's price sensitivity to interest rate changes. Generally, higher duration bonds are more interest rate sensitive than lower duration bonds.

Yield curve
A graph that plots yields at a specific point in time of bonds with similar credit quality but different maturity dates. A curve's slope can vary through time based on changes in the shape of the curve and the level of yields. Generally, curves can be upward sloping, downward sloping or flat.

Spot exchange rate
The current settlement price to exchange one currency for another in the market.

Currency hedging
Investing in financial instruments intended to offset the impact of exchange rate fluctuations on bonds traded in a foreign currency.

Term exposure
A portfolio's general level of interest rate risk as reflected in its average duration.

Duration constraint
The average duration range allowed in a portfolio, which is usually specified relative to a market benchmark.

Over-the-counter
The secondary market where buyers and sellers trade bonds directly or through a dealer that maintains an inventory of bond issues.

Investment grade
Bonds with a relatively low risk of default, as indicated by their credit rating. Bonds rated AAA, AA, A and BBB are considered investment grade.

Credit spread
The yield difference between bonds of similar maturity but different credit quality. A narrow spread indicates a smaller difference between yields of higher and lower credit quality bonds. A wide spread indicates a larger yield difference between higher and lower credit qualities.

Inventory modelling
The evaluation of specific bond issues and quantities held by a bond dealer.

Trade cost analysis
Describes various methods for assessing an investment manager's trading efficiency.

Liquidity
An asset's ability to be bought or sold quickly without a significant change in its price. The US Treasury bond market tends to offer the highest level of liquidity to bond investors.

Bid-ask spread
The difference between the highest price a buyer is willing to pay for a bond (bid) and the lowest price for which a seller is willing to sell it (ask).

High-yield debt
Bonds with credit ratings below those of investment grade (BB and lower).

ON THE COVER

Over the course of nearly 40 years, Dimensional has pioneered a systematic approach to fixed income investing that uses information in current market prices to pursue higher expected returns. Research insights, market structure improvements and clients' evolving needs have fueled innovation through the years. The front cover visualises advances across four distinct decades and depicts the growing count of Dimensional fixed income strategies from 1983 through 2019.

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