CANDRIAM
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The Fair Value Enigma: Deciphering Fixed Income in Today's Economy.

MAY 2024

Marketing communication

About the authors.

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Louis joined Candriam in 2022 as a Fixed Income & ESG Quantitative Analyst intern before transitioning to his current role as Fixed Income Quantitative Analyst. Prior to joining Candriam, he worked for Anaxis AM and OFI AM.

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Diquel Dos Santos has led the Fixed Income Quantitative Research Team since 2019, holding his current title since 2023. He has been a researcher developing quantitative strategies for both discretionary and systematic funds since 2010, after joining Candriam in 2001 as a quantitative analyst developing pricing, arbitrage and relative value tools for alternative investments funds.

He began his career at Société Générale CIB in 1999, joining CIC Crédit Mutuel a year later to work within their Structured Products team.

Diquel holds an engineering degree from ENSIIE (Ecole Nationale Supérieure d'Informatique pour l'Industrie et l'Entreprise) in France and a Masters degree in mathematical finance from the University of Paris Panthéon-Sorbonne.

Executive summary.

In an era of data-driven decision-making and complex economic dynamics, Candriam has developed a sophisticated approach to understanding and navigating the fixed income market.

This paper explores Candriam's proprietary and proven framework for assessing fair value, which integrates data analysis with expert economic insight. By capturing the nuances of factors such as economic growth, inflation and central bank policy, this framework provides actionable insights into the fair value pricing of sovereign debt and credit spreads.

Through robust modelling techniques and a focus on both long-term trends and short-term dynamics, Candriam provides portfolio managers with a powerful tool for making informed investment decisions in any market environment.

An analysis of the framework's performance in 2023 demonstrates its effectiveness in predicting market movements amid economic turbulence. Overall, Candriam's innovative approach exemplifies its commitment to excellence and innovation in fixed income investing and positions this framework as a cornerstone of its investment strategy.

The success of the Vector Error Correction Model ("VECM") framework has led us to explore its potential application to other key fixed income metrics, reflecting our commitment to continuous improvement and innovation in the ever-evolving world of fixed income.

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1. Introduction: Unveiling Fixed Income Fair Value in a Data-Driven Age.

> **You are neither right nor wrong because the crowd disagrees with you. You are right because your data and reasoning are right.**
>
> Warren Buffett

Has the recent shift from quantitative easing (QE) to quantitative tightening (QT) overpriced the bond market? What about the impact of the inflationary boom on markets, with rising prices reaching levels not seen since the 1980s? With trillions of dollars at stake, getting the fair value of fixed income right is critical. This task is particularly challenging in the fixed income universe due to the multiple and complex factors that influence the valuation of credit spreads and interest rates.

This ever-changing landscape requires a sophisticated approach. At Candriam, we have developed a proprietary fair value assessment framework that seeks to enable portfolio managers to navigate this complexity. By isolating key drivers and leveraging our proprietary economic forecasts, our proprietary framework provides actionable insights for informed investment decisions.

This paper takes a look at the inner workings of Candriam's fair value models for sovereign debt and credit spreads. We'll explore the underlying principles and construction, focusing on the Vector Error Correction Model approach we use. After a deep dive into the models, we'll demonstrate their practical application and effectiveness in navigating the complexities of fixed income fair value pricing in an ever-evolving economic landscape.

2. The Challenge of Fixed Income Valuation and Our VECM Solution.

While traditional asset valuation methods provide a relatively clear path, accurately assessing fair value in the fixed income market presents a unique challenge. This complexity stems from the ever-changing nature of economic factors, particularly since the 2008 financial crisis.

The adoption of unconventional policies such as quantitative easing by central banks to stimulate economic growth and inflation has had a significant impact on government bond yields. In addition, assessing the credit spread of an index is much more complicated than assessing the default risk of individual companies due to a variety of factors, including macroeconomic ones, that influence it.

To address these challenges, we had two key objectives:

- **Robust and consistent fair value models:** We wanted to create statistically sound models with consistent explanatory variables across different sovereign rates and credit spreads.
- **Short-term predictive power:** Our model needed to be able to effectively forecast the nuances of both rates and spreads within a 3-month horizon.

Why use a Vector Error Correction Model

We chose the Vector Error Correction Model (VECM) as our foundation because it provides the optimal balance between capturing dynamic market behaviour and providing interpretable results.

The VECM uses a two-step process to analyse rates and spreads through macroeconomic factors. It explicitly takes into account the impact of QE and incorporates our proprietary default probability model, namely the Stock-to-Spread (S2S) model. The VECM aims to allow us to produce reliable fair value forecasts over a 3-month horizon under different market and economic scenarios.

Vector Error Correction Model (VECM) in a nutshell:

VECM is a powerful econometric model capable of capturing complex economic interactions and producing reliable forecasts. It works in two stages:

- **Long run equilibrium:** This stage identifies stable, long-term relationships between variables, establishing a baseline for fair value.
- **Short-term movements:** This stage captures temporary fluctuations and incorporates error correction terms to adjust for deviations from the long-run equilibrium.

By incorporating both long-term trends and short-term dynamics with our economic scenario expectations, this framework aims to provide fund managers with a comprehensive picture of fair value and a powerful tool for navigating the complexities of the fixed income market.

2.1. Unveiling Long-Term Drivers: The Core Equations

The first step in our VECM framework focuses on identifying the fundamental drivers of government bond yields and credit spreads over the long term. Traditionally, inflation and economic growth have been seen as the main drivers of interest rates. However, central bank interventions, especially unconventional policies such as quantitative easing after 2008, have added another layer of complexity by affecting real yields.

Similarly, credit spreads are primarily driven by default risk, which we price using our proprietary S2S model, an extension of the Merton's model, which generates fair value default probabilities and credit spreads. However, other factors are also at play, such as growth expectations, investor risk appetite, central bank actions and specific risks such as eurozone debt redenomination[1], which is explained by the volatility of Italian credit default swaps (CDS).

Building the equations

Taking these factors into account, we have constructed six long-term equations: one for each government bond rate - US and German 10-year bonds - and credit spread - US and European high yield (HY) and investment grade (IG) debt. These equations represent the long-term fair value of these rates and spreads. We have carefully selected the variables based on economic relevance, consistency across models and statistical robustness.

Key variables

For sovereign rates:

	US 10Y	German 10Y
Inflation	US Inflation	German Inflation
Growth	US real GDP potential	Eurozone Services PMI
Non-conventional monetary policy	Fed balance sheet	ECB balance sheet

PMI: Purchasing Managers' Index

For credit spreads:

	US HY	EU HY	US IG	EU IG
Implied Default Risk	S2S Spread	S2S Spread	S2S Spread	S2S Spread
Growth	US PMI	Eurozone PMI	US PMI	Eurozone PMI
CB Policy/ Inflation			Fed fund target rate	Eurozone HICP[2]
Redenomination Risk				Italy 5-year CDS volatility

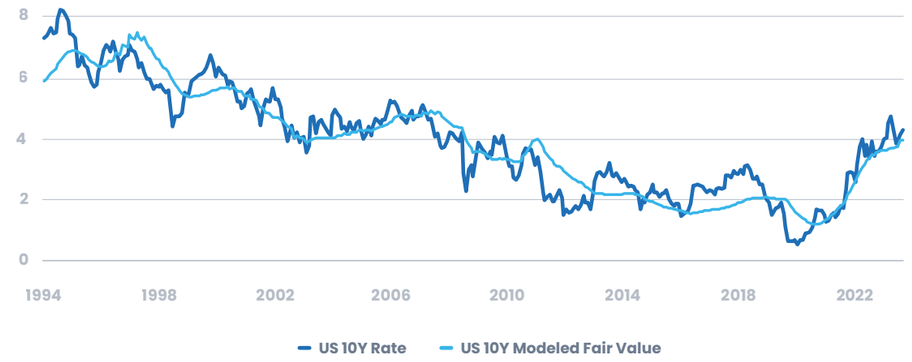
Illustrative cases:

As an example, we show below the graph of our long-term fair value for the 10Y US Treasury and EU IG credit spread, based on (expanding) regressions realised on a monthly basis. We have found high levels of explanatory power (R^2 = 91.2% and R^2 = 78% respectively) and very good statistical behaviour (residuals show stationarity and coefficients show stability over time):

US 10Y Rate

$$Yield_t^{US\ 10Y} = \alpha + \beta_t^{CPI} \cdot Inflation_t^{US\ 10Y} + \beta_t^{Croissance} \cdot Growth_t^{US\ 10Y} + \beta_t^{QE} QE_t^{US\ 10Y} + \varepsilon_t^{US\ 10Y}$$

US 10Y Fair Value



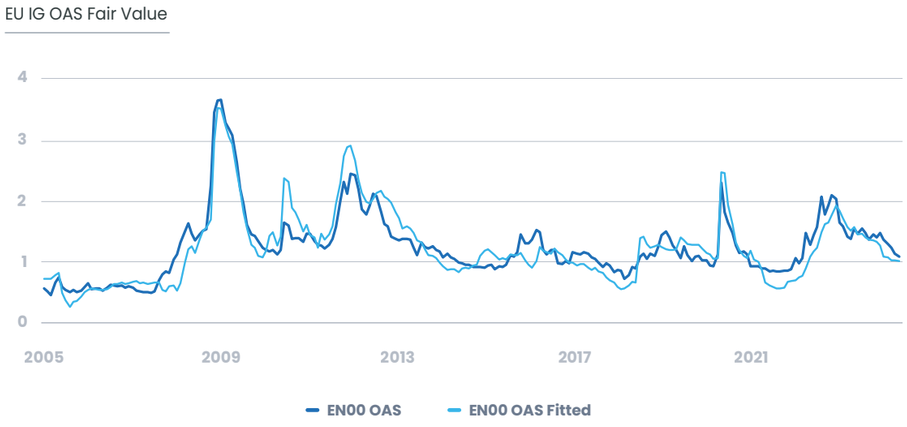
Source: Bloomberg, Federal Reserve Economic Data | St. Louis Fed, Candriam

1 Euro redenomination risk is the risk that a euro asset will be redenominated into a devalued legacy currency

2 In the euro area, the benchmark for measuring consumer price inflation is the Harmonised Index of Consumer Prices (HICP). It is characterised by its "harmonised" nature, which means that all Member States of the European Union follow the same methodology in calculating this index.

EU IG Credit Spread:

$$Spread_t^{EU\ IG} = \alpha + \beta_t^{S2S} \cdot S2S_t^{EU\ IG} + \beta_t^{PMI} \cdot PMI_t^{EU\ IG} + \beta_t^{HICP} \cdot HICP_t^{EU\ IG} + \beta_t^{EZ\_REDO} \cdot EZ\_REDO_t^{EU\ IG} + \varepsilon_t^{EU\ IG}$$



OAS: option-adjusted spread
Source: Bloomberg, FactSet, Candriam

Limitations and next steps:

However, a significant challenge arises when Treasury yields and credit spreads deviate from their long-term fair values for extended periods of time. As a result, the trading signals generated can be misleading, as mean-reversion behaviour cannot be guaranteed within a 3-month horizon. In addition, the current model does not take into account potential changes in the economic or financial landscape. Ideally, our model should incorporate forward-looking expectation terms to dynamically adapt and account for these potential changes.

2.2. Capturing Short-Term Dynamics and Integrating Economic Views

While our long-term fair value equations provide a solid foundation, accurately predicting short-term movements in interest rates and credit spreads is a more complex challenge. To meet this challenge, we prioritise variables that are consistent across models and offer a high degree of responsiveness to changing market conditions.

The role of residuals: Restoring force

Our first step is to use the residuals (errors) from the long-run equations. These residuals act as a corrective force, indicating how far the current rate/spread is from its long-term fair value. If a yield is above its fair value, the residual will be positive, indicating a higher probability of a decline in the near future (mean reversion).

Beyond residuals: Incorporating portfolio manager views

Residuals alone aren't enough. Portfolio managers' views on future economic scenarios are also crucial for short-term forecasting. Therefore, to get the full picture, we include additional variables that reflect short-term economic expectations:

- **Government rates:** We consider factors such as changes in oil prices (a proxy for economic growth) and central bank policy adjustments (which can quickly affect interest rates).
- **Credit spreads:** Investor risk appetite plays an important role. We use the CBOE Volatility Index (VIX) and the Euro Stoxx 50 Volatility Index (V2X), which measure the financial market volatility to gauge this sentiment. In addition, near-term growth expectations are factored in using Purchasing Managers' Index (PMI) data, a reliable indicator of economic activity.

Our modelling of short-term fluctuations:

For sovereign rates:

	US 10Y	German 10Y
Residuals	Long-term equation	Long-term equation
Oil[3]	WTI	Brent
Central bank rates	Fed fund rate	ECB deposit rate

For credit spreads:

	US HY	EU HY	US IG	EU IG
Residuals	Long-term equation	Long-term equation	Long-term equation	Long-term equation
Growth	US PMI	Eurozone PMI	US PMI	Eurozone PMI
Risk Appetite	VIX	V2X	VIX	V2X

Returning to our example of US 10-year rates, we estimate a regression on the three-month variation of 10-year yields using the following explanatory variables:

- **Residuals from the long-term equation**
- **Three-month change in WTI**
- **Three-month change in the Fed funds target rate**

$$\gamma_t^{WTI} \cdot (WTI_{t+3} - WTI_t) + \gamma_t^{FFTR} \cdot (FFTR_{t+3} - FFTR_t) + \gamma_t^{Res} \cdot \varepsilon_t^{US\ 10Y} = Yield_{t+3}^{US\ 10Y} - Yield_t^{US\ 10Y}$$

3 West Texas Intermediate (WTI) is a blend of several American light crude oils and serves as the benchmark for the US oil market. The other benchmark for the global oil market is Brent crude, which is produced in the North Sea and is easier to transport, giving it access to a wide range of global markets.

Similarly, for the EU investment grade (IG) credit spread, we estimate a regression on the three-month variation of credit spreads with the following explanatory variables:

- **Residuals from the long-term equation**
- **Three-month change in PMI**
- **Three-month change in V2X**

$$\gamma_t^{PMI} \cdot (PMI - PMI_t) + \gamma_t^{V2X} \cdot (V2X_{t+3} - V2X_t) + \gamma_t^{Res} \cdot \varepsilon_t^{EU\ IG} = Spread_{t+3}^{EU\ IG} - Spread_t^{EU\ IG}$$

Model performance and validation:

We have back-tested our model against historical data to assess its effectiveness in predicting short-term movements. The "hit ratio" metric measures how often our model correctly predicted the direction of the rate/spread change within a 3-month horizon. The results are promising, with hit ratios above 70% for both US 10Y rates and EU IG credit spreads at a threshold of 15 basis points (bps).

US 10Y Rate

	Threshold							
	0	**0.05**	**0.1**	**0.15**	**0.2**	**0.25**	**0.3**	**0.5**
Hit Ratio	65.78%	68.9%	71.2%	72.9%	71.7%	71.4%	73.2%	63.3%
Nb Signals	339	280	233	192	152	119	97	30

Source: Candriam

EU IG Spread

	Threshold							
	0	**0.05**	**0.1**	**0.15**	**0.2**	**0.25**	**0.3**	**0.35**
Hit Ratio	72.41%	75.5%	77.5%	77.9%	79.7%	85.1%	87.5%	91.3%
Nb Signals	174	143	120	86	64	47	32	23

Source: Candriam

Our adoption of the two-step VECM framework represents a concerted effort to merge economic fundamentals with portfolio manager insights, creating a robust and flexible approach to fair value in the ever-changing terrain of the fixed income market. By integrating recent economic phenomena such as unconventional monetary policy alongside our proprietary S2S model, we strengthen its predictive power and strive for a holistic understanding of market dynamics. But the key question remains: does it deliver on its promises?

3. Bridging the Gap: How to Translate Fair Value Models into Investment Decisions.

This section provides an insight into the practical implementation of our VECM framework within Candriam's investment approach. We provide Portfolio Managers (PMs) with a robust tool to assess whether sovereign interest rates and credit spreads are currently undervalued, overvalued or fairly priced based on their economic forecasts for the next three months.

As previously outlined, our framework operates in two distinct stages:

1. **Long-term fair value:** This first stage establishes a baseline fair value for rates and spreads by incorporating current economic conditions through our long-term fair value equations.
2. **Short-term forecast:** In this stage, we incorporate PMs' economic forecasts for the next three months into the model to generate signals for the period ahead.

This section explains our process for generating these fair value signals on a monthly basis, using our investment team's economic assumptions. We will also assess the effectiveness of the model in predicting the behaviour of US 10Y rates and EU IG credit spreads throughout 2023.

3.1. Generate actionable signals

Let's look at how our framework translates fair value models into actionable signals for portfolio managers (PMs) using the US 10-year Treasury rate as a case study.

Step 1: Long-term fair value

Long-term fair value is calculated using the latest economic data, including inflation, growth indicators and central bank monetary policy.

Step 2: Short-term forecast

To generate a short-term signal for the next three months, we consider two key elements:

1. **Restoring force:** This metric measures the deviation of the current price from its long-term fair value. For example, if the current price is above fair value, this suggests a potential downward move.
2. **Economic scenario:** PMs enter their three-month economic expectations. For the 10-year rate, these forecasts may include the expected Fed Funds target rate and oil prices.

It's worth noting that precise forecasts for oil prices are not required. PMs provide levels that correspond to their economic scenarios, such as high oil prices indicating robust economic growth.

Step 3: Interpreting the signal

By combining the restoring force and the economic scenario, we generate a forecast for the 10-year rate over the next three months. This forecast is then compared to the current rate and a signal is generated if there is a deviation of 15 basis point[4] or more:

- **Positive signal (long):** If the forecast is more than 15 basis points (bps) below the current rate, this indicates that actual rate is overvalued by the market and a potential buying opportunity.
- **Negative signal (short):** If the forecast is more than 15 bps above the current rate, it indicates that actual rate is undervalued by the market and a possible opportunity to sell.
- **Neutral signal:** If the deviation is within 15 bps , the model doesn't give a clear signal, indicating that the rate is probably fairly valued.

4 As explained in the previous section, this 15bps threshold has been calibrated through backtesting

Putting it into action

Consider a scenario where the Fed Funds target rate is expected to be 5.5% and the oil price is forecast to be around $75 over the next three months. The model predicts a 10-year rate of 4.08%, while the current rate is 4.20%. As the deviation is only 12 bps (below the 15 bps threshold), the model doesn't generate a signal, suggesting that the 10-year rate is likely to be fairly valued in this scenario.

		Fed fund target rate scenario				
		5	5.25	5.5	5.75	6
WTI ($) scenario	55	3.65	3.73	3.81	3.89	3.97
	65	3.78	3.86	3.95	4.03	4.11
	75	3.92	4.00	**4.08**	4.16	4.24
	85	4.05	4.14	4.22	4.30	4.38
	95	4.19	4.27	4.35	4.43	4.51

Similar approaches are used to assess credit spreads, such as the eurozone IG credit spread. PMs provide forecasts for factors such as growth and volatility, and the model generates a forecast spread to compare with the current spread to determine a long, short or neutral signal.

At the time of calculation, the EU IG spread was 109 basis points, with a medium-low volatility regime and a euro area manufacturing PMI of 45.7. With no change in the economic regime for 3 months, the predicted spread was 114 bps. However, the deviation was within the range of -15 to +15 bps and did not generate any long or short neutral signals.

		European manufacturing PMI				
		40.7	43.2	45.7	48.2	50.7
Volatility regime	Low Vol	125	113	102	91	80
	Mid Low Vol	136	125	**114**	103	91
	Mid Vol	148	137	126	115	103
	Mid High Vol	160	149	138	126	115
	High Vol	172	161	149	138	127

Source: Bloomberg, Candriam

Sensitivity analysis:
Understanding the impact of variables

We also perform sensitivity analysis to measure the impact of economic variables on the 10-year rate. For example, a $10 increase in the price of oil can increase the market value by 14 basis points, while a 25bp change in the Fed Funds rate can affect the market value by 8 bps.

For the EU IG credit spread, a change in the volatility regime implies a move of 12bps . Similarly, a 5 point increase in the PMI reduces the spread by 11 bps.

This sensitivity analysis allows PMs to understand the relative impact of different economic factors on their forecasts.

3.2. Model in Action:
A Look at 2023 Performance

In this section, we look at the historical performance of our VECM framework in 2023, a year marked by significant economic events such as the SVB banking crisis and the Credit Suisse debacle. We'll examine how the model navigated these volatile conditions and its effectiveness in generating actionable signals.

Model behaviour in context

Our analysis focuses on signals generated at the beginning of each month, which coincides with Candriam's Fixed Income Strategic Committee meetings. These meetings bring together PMs, analysts and economists to share economic and market outlooks for the following months.

This assessment is guided by a proprietary scorecard covering value, cycle, sentiment and technicals. Signals from the VECM framework contribute specifically to the Value section of this scorecard.

Performance of US 10-year rates

As explained earlier, a significant deviation (more than 15 basis points) between the predicted rate and the spot rate triggers a short (sell) or long (buy) signal. Neutral signals indicate that the rate is fairly valued.

The table below summarises the 2023 US 10-year rate signals and subsequent changes. The first column shows the first day of each month. The second column shows the value of the US 10-year rate at the beginning of each month. The "Signal" column shows the short-term signal given by our model on the corresponding day. Finally, the last column shows the ex-post evolution of the US 10-year rate over the next three months[5].

	US 10Y Rate	Signal	Subsequent 3M Change
01/01/2023	3.82	Neutral	-0.38
01/02/2023	3.36	Neutral	0.20
01/03/2023	3.92	Neutral	-0.34
01/04/2023	3.43	Neutral	0.30
01/05/2023	3.56	Short	0.42
01/06/2023	3.58	Short	0.45
01/07/2023	3.73	Short	0.78
01/08/2023	3.98	Neutral	0.75
01/09/2023	4.02	Long	0.26
01/10/2023	4.51	Long	-0.68
01/11/2023	4.72	Long	-0.80
01/12/2023	4.28	Neutral	-0.15

Source: Bloomberg, Candriam

Key observations:

- Out of 6 signals (3 short and 3 long), 5 correctly predicted the direction of the subsequent rate movement.
- The short signal on 01/07/2023 and the long signal on 01/11/2023 were particularly noteworthy as they coincided with significant price movements over the next 3 months.
- These results provide encouraging evidence of the model's ability to generate valuable signals in a volatile year.

5 As a reminder, we compare the signal with the variation over the next three months, as this investment horizon is consistent with the model's construction.

EU IG credit spread performance

We followed a similar approach for the EU IG credit spread, analysing signals and subsequent changes throughout 2023. Here's a summary table:

	EU IG Credit Spread (bp)	Signal	Subsequent 3M Change
01/01/2023	158	Neutral	-3
01/02/2023	142	Short	4
01/03/2023	138	Short	17
01/04/2023	155	Neutral	-7
01/05/2023	146	Short	-10
01/06/2023	155	Neutral	-10
01/07/2023	148	Neutral	-8
01/08/2023	136	Neutral	11
01/09/2023	145	Long	-8
01/10/2023	140	Long	-11
01/11/2023	147	Long	-24
01/12/2023	137	Long	-23

Source: FactSet, Candriam

Key observations:

- Of the 7 signals (4 long and 3 short) in 2023, 6 correctly predicted the direction of the credit spread move.
- Of particular note was the short signal on 01/03/2023 and the long signals on 01/11/2023 and 01/12/2023.
- This further validates our modelling choices, variable selection and the predictive power of the model.

The VECM framework provides Candriam's portfolio managers with actionable signals on sovereign interest rates and credit spreads. This two-step model, which incorporates long-term fair value and short-term economic forecasts, effectively translates economic scenarios into practical investment decisions. The model's success in predicting market movements during the volatile year of 2023 validates its contribution to Candriam's overall investment strategy.

4. Conclusion: A Powerful Tool for Sovereign Rates and Credit Spreads.

With Candriam's top-down approach, we've outlined our proactive strategy for assessing the fair value of sovereign interest rates and credit spreads. Our methodology not only adapts flexibly to major economic shifts such as quantitative easing/ tightening and inflation volatility, but also incorporates our investment teams' nuanced perspectives on future economic scenarios, thereby enhancing forecasting accuracy. In addition, the inclusion of Candriam's proprietary S2S model, extended to credit indices, has proven to be a key factor in effectively explaining credit spreads.

Consistent validation through robust backtesting results, coupled with practical implementation, has increased confidence in our approach and sparked discussion within our decision-making processes for Candriam's fixed income strategies. This success is prompting us to consider extending our framework to other key fixed income metrics, reflecting our unwavering commitment to innovation and continuous improvement.

€145 B

AUM at end Dec. 2023*

+600

Experienced and committed professionals

+ 25 years

Leading the way in sustainable investing

*As of 31/12/2022, Candriam changed the Assets Under Management (AUM) calculation methodology, and AUM now includes certain assets, such as non-discretionary AUM, external fund selection, overlay services, including ESG screening services, [advisory consulting] services, white labelling services, and model portfolio delivery services that do not qualify as Regulatory Assets Under Management, as defined in the SEC's Form ADV. AUM is reported in USD. AUM not denominated in USD is converted at the spot rate as of 31/12/2023.

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