



## Strategic Asset Allocation

Peering into the future with the help of market prices

XII BIS-CEMLA Roundtable on “Reserve Management and FX Intervention”

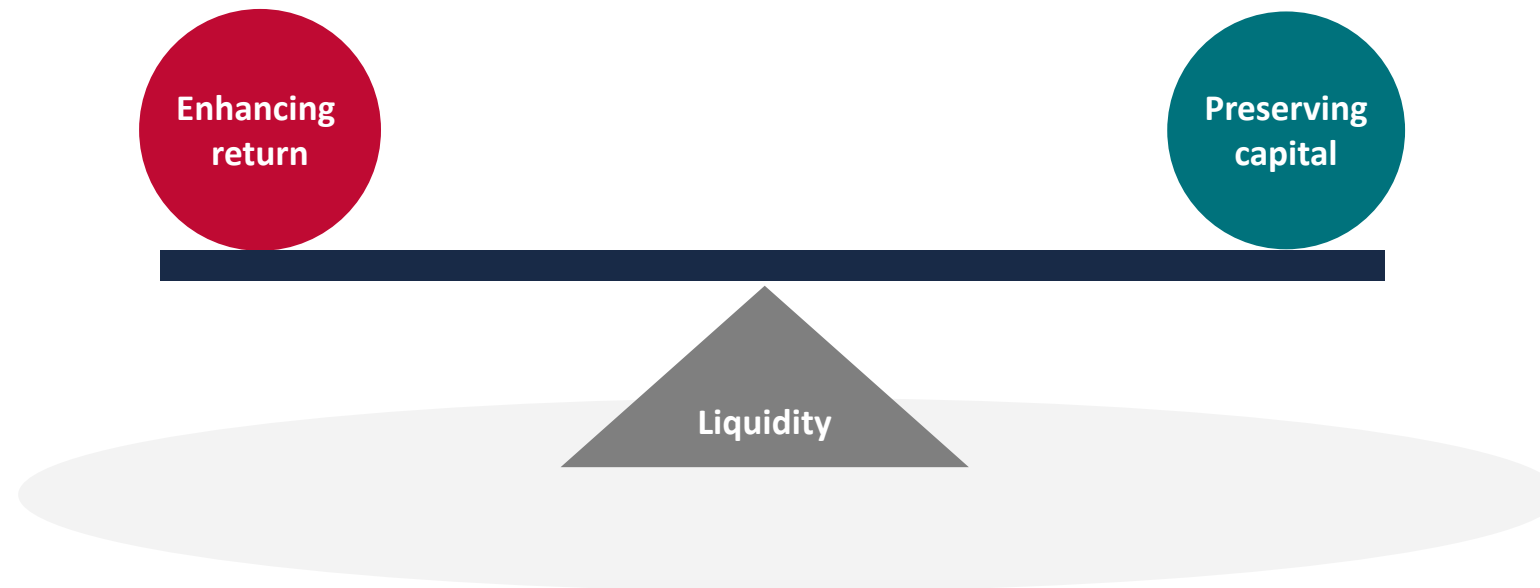


BANCO DE MÉXICO

- Banco de México maintains an international reserve portfolio of 178 billion US dollars.
- Our asset allocation is based on the following principles:
  - **The numeraire of the reserve portfolio is the U.S. dollar.** The selection of the numeraire is the most important decision in regards to currency allocation.
  - **The allocation to non-USD assets is based purely on the financial benefits of each asset class** (diversification and risk-return properties). In other words, Banco de México does not follow:
    - Asset-Liability Management approach
    - Balance of payments approach
  - The investment horizon of the portfolio is **one year**.

## Reserve management objectives

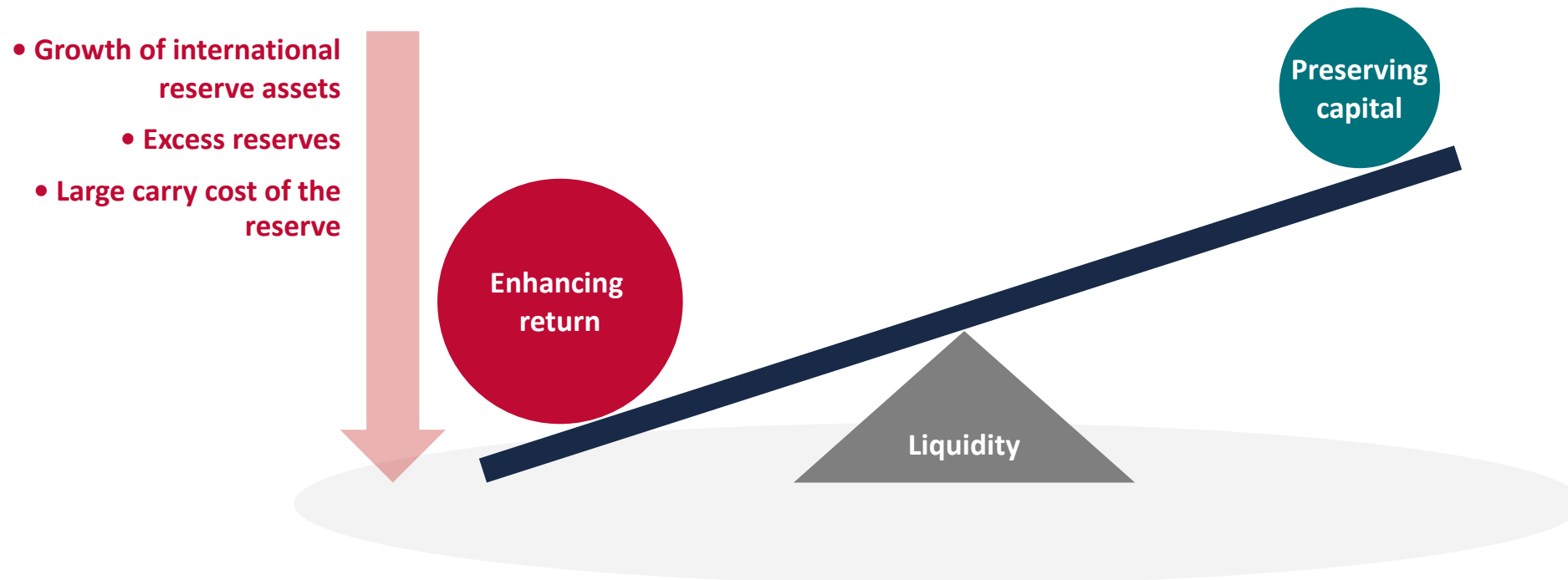
- Banco de México's international reserve portfolio has three main objectives: liquidity, enhancing return and preserving capital. These directly affect the way the Strategic Asset Allocation (the benchmark) is determined.
- Because liquidity is the main objective of the investment of the international reserves, it is taken into account for its optimization algorithms under any context.
- However, the central bank has had a flexible approach on the importance it gives to its other two objectives (enhancing the return and capital preservation), taking into account the changing environment in financial markets and the economic developments.



# Reserve management objectives

## Enhancing return (2000-2012)

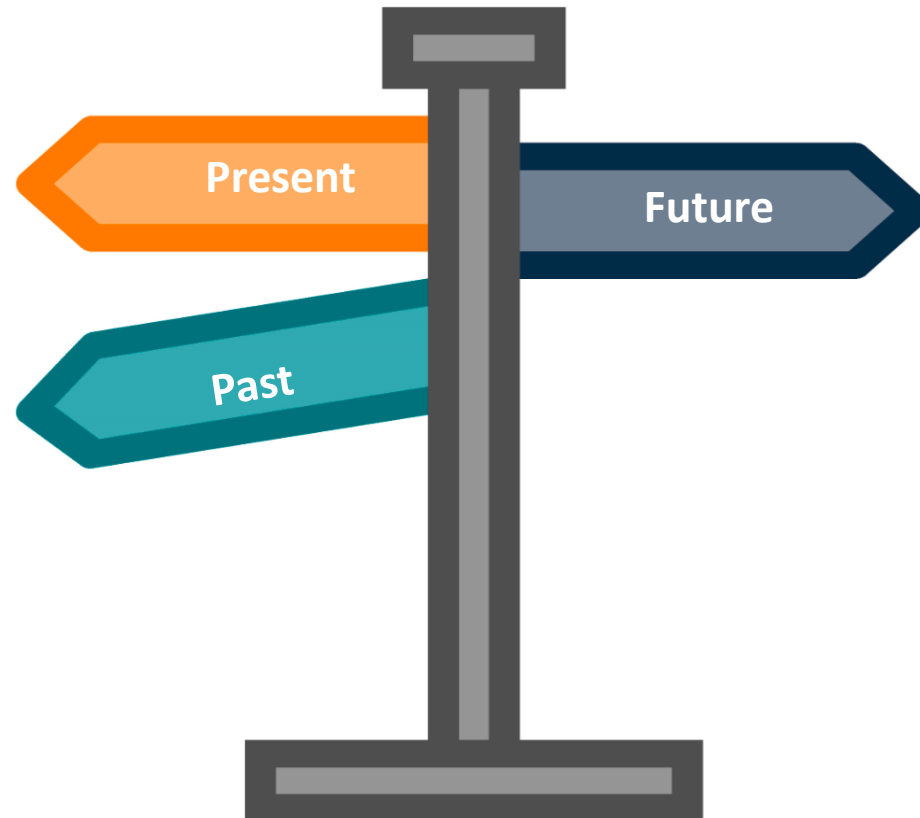
- From 2000 to 2012, and given the rapid growth of its international reserve assets, Banco de México privileged a philosophy of enhancing the return of the portfolio.
- As a result, investment guidelines were expanded to include new asset classes that increased the expected return of the international reserve assets without significantly increasing the market risk (expected standard deviation of annual returns).



# Strategic Asset Allocation Process

## Transitioning from historical to forward looking information

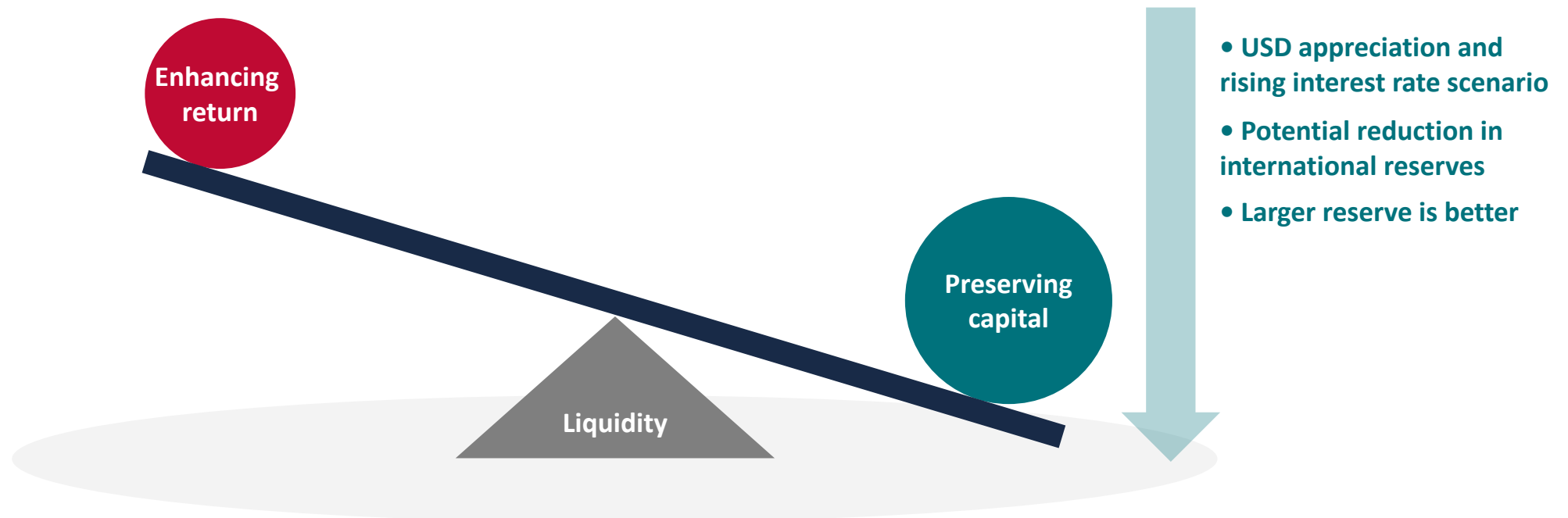
- Up until 2013, our SAA methodologies were based on the use of historical information (returns and correlations).
- At the beginning of that year, we realized that the challenges for reserve management were changing. We were not only facing a low yield environment, but also a potentially higher interest rate scenario marked by policy normalization in the United States. We realized that relying on historical information would probably lead to sub-optimal SAA.



# Reserve management objectives

## Transitioning from enhancing return to the preservation of capital

- Since then, reserve management has not become any easier. From a domestic perspective, reserve accumulation has come to a halt given lower oil prices. Moreover, Banco de México has used its reserves in several occasions to restore the adequate functioning of the FX market.
- At the same time, our expectation of rising interest rates in the U.S. and a US dollar appreciation scenario could result in capital losses.
- Additionally, policy uncertainty increased significantly, mainly because the long-standing paradigms of economic integration have been put into question.
- As a consequence, we shifted the focus of our asset allocation framework by prioritizing the preservation of capital.



# Strategic Asset Allocation Process

## Risk Factor Analysis

- Beginning in 2013, our SAA analysis was extended to include a comprehensive assessment of our risk exposures.
- The decisions taken by Banco de México proved successful in mitigating market risk and diminishing the volatility of the return of the international reserve's portfolio.

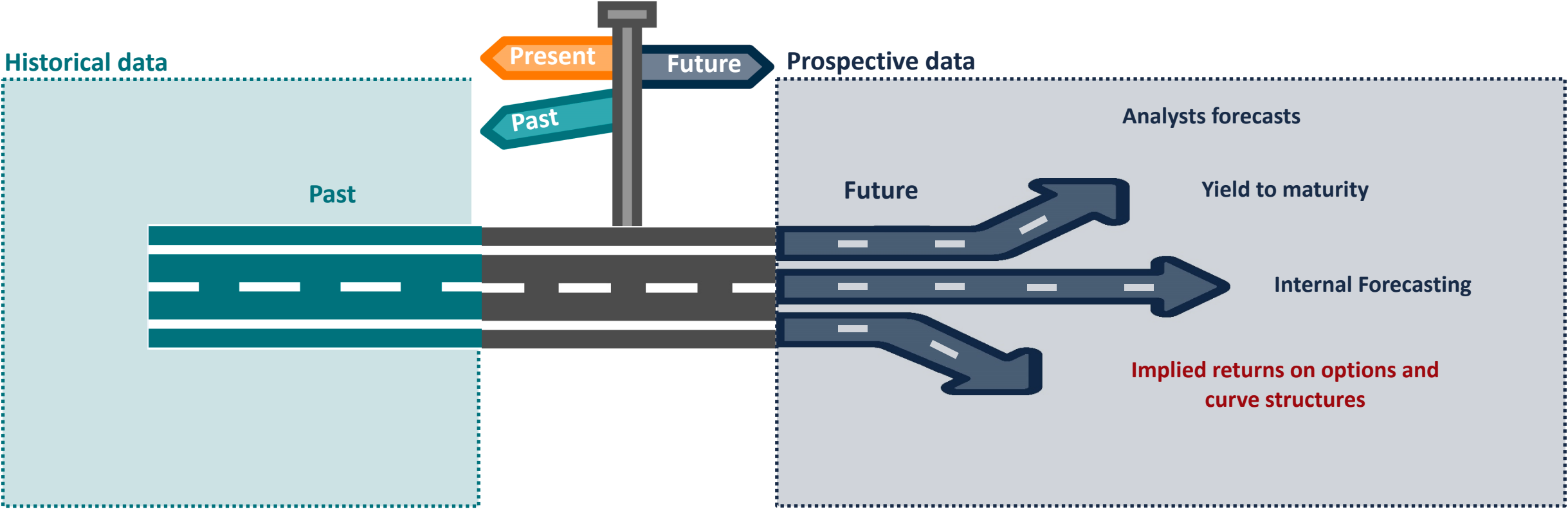
### Risk Factor Analysis Matrix

<b>Interest Rate Risk</b>  Duration Curve exposure	<b>Exchange Rate and Commodities Risk</b>  Numeraire: USD Exposure to non-USD currencies Exposure to gold
<b>Credit Risk</b>  Exposure to non-government bonds Counterparty risk	<b>Liquidity Risk</b>  Liquidity portfolio Liquidity analysis per asset class

# Strategic Asset Allocation Process

## Peering into the future with the help of market prices

- In 2018 and 2019, Banco de México worked on enhancing its SAA framework, so that it could become more robust, forward-looking, and more aligned to the objective of capital preservation.
- The core of such methodology is to rely on market-based information to extract the inputs to our SAA models.





# SAA Process: Improving our inputs - non-normality of market returns

- During 2018 we focused on improving the inputs for our optimization model. In Black Litterman models there are several assumptions that are not fulfilled in reality so we looked for alternatives to correct them.

## Assumption 1:

Asset returns are *Normally* distributed.

## Asset returns are generally not normally distributed:

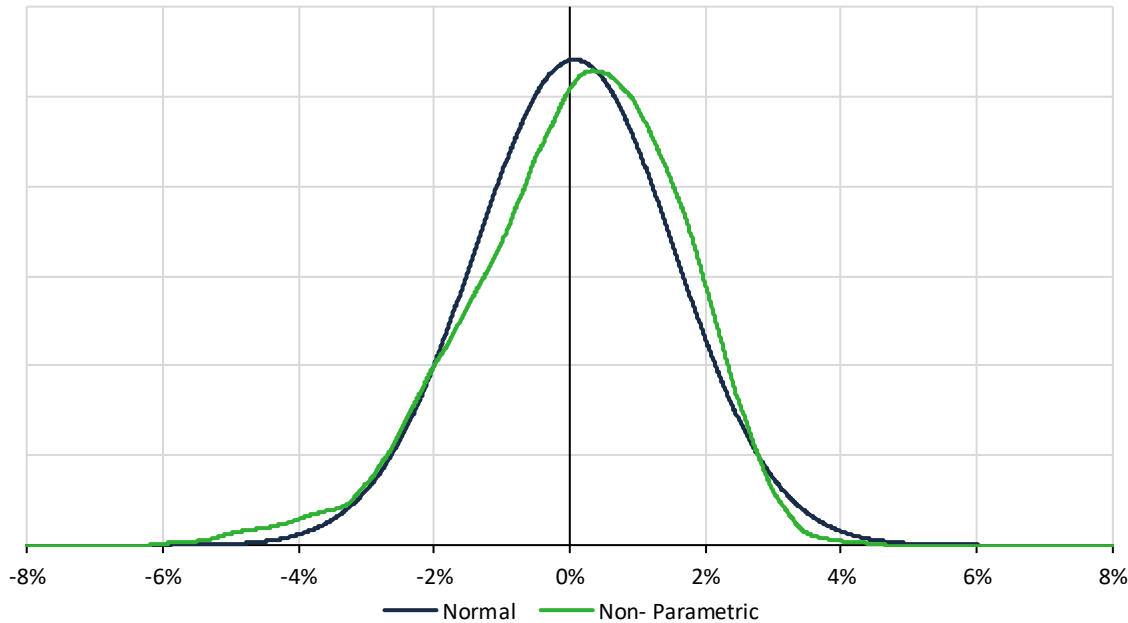
- Symmetry*: distributions are usually not symmetric.
- Skew*: their skew is not necessarily zero.
- Kurtosis*: the distributions tend to be wider or narrower and generally have fatter tails.

Solution

Modeling the **marginal distributions** of financial assets in a non-parametric way through a *kernel*\*

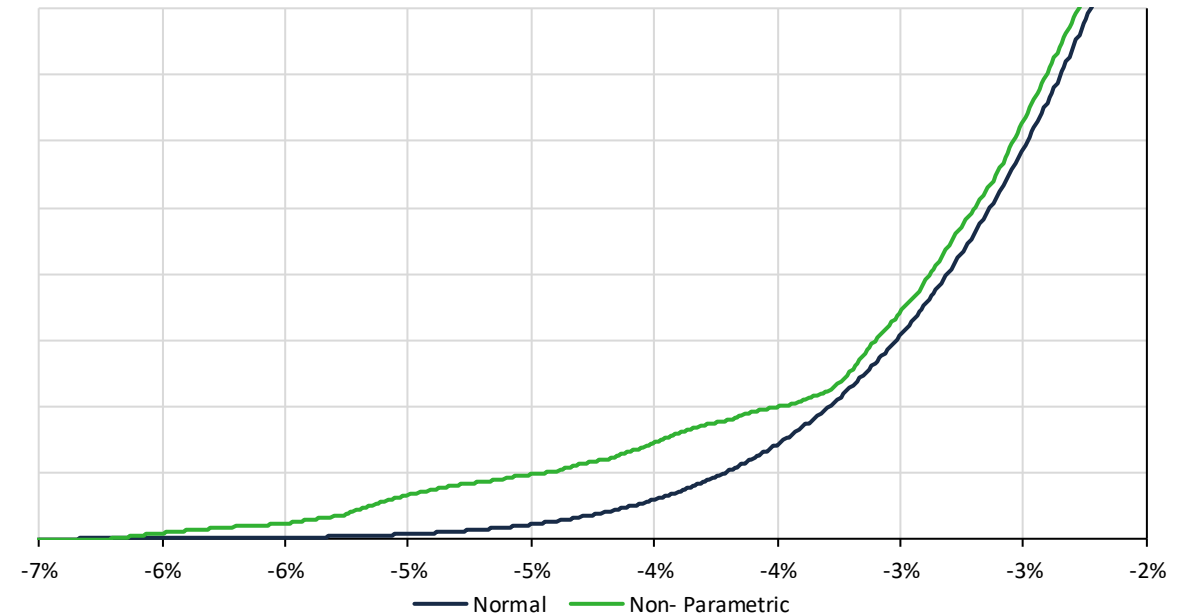
Distribution of annual returns\*\* of UST >10 years

Density



Distribution of annual returns\*\* of UST >10 years (left tail)

Density



Source: Bank of Mexico with data from Bank of America / Merrill Lynch. \* The density associated with the Epanechnikov kernel minimizes the over/under estimation of the distribution tails with respect to other methods such as Gaussian, Uniform or Rectangular kernel; therefore achieving greater relative efficiency. Bibliography: Lecture Notes on Nonparametrics. Bruce E. Hansen. University of Wisconsin. Spring 2009. \*\* Non-overlapping annual returns. Data from 2013-2017.

# SAA Process: Improving our inputs – joint distribution (copula)

## Assumption 2:

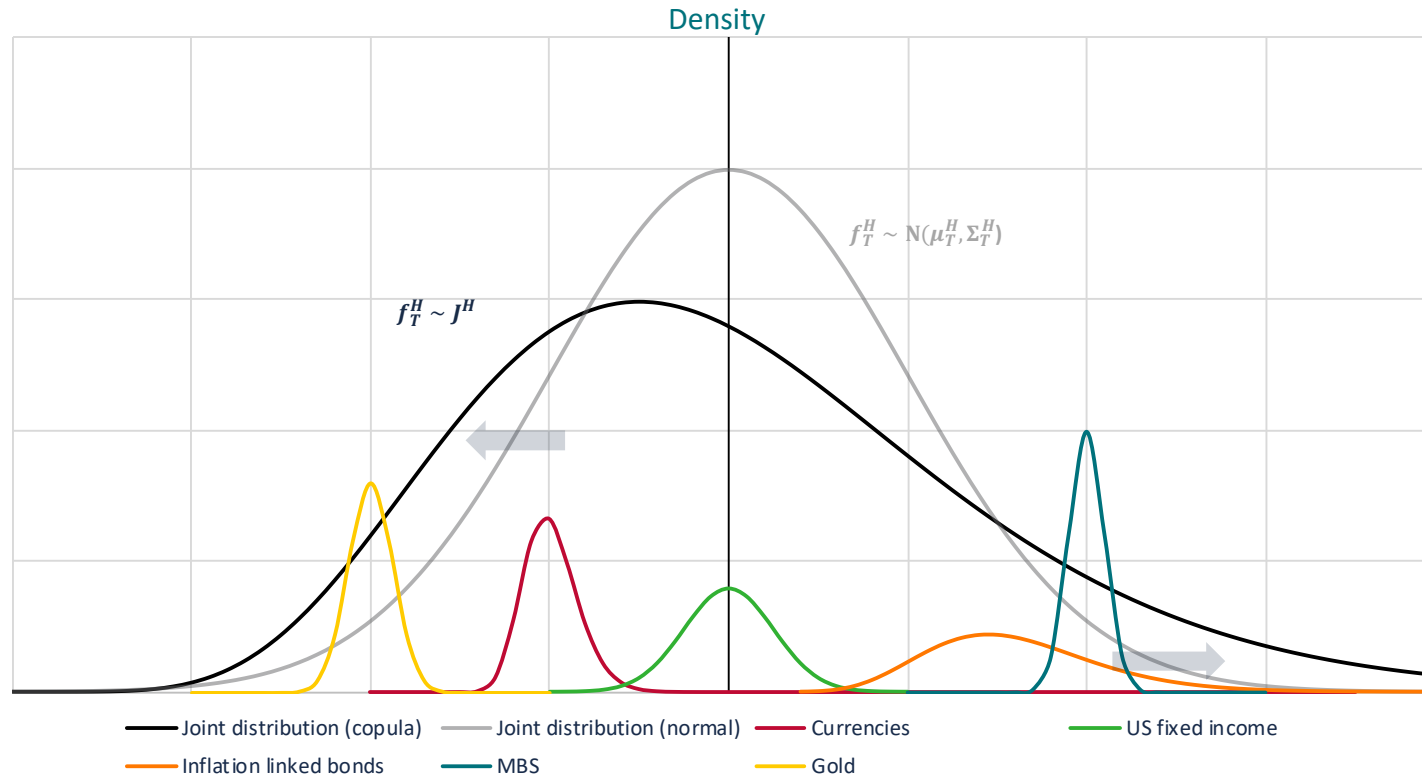
The **joint distribution** of all the assets is **Normal**.

When the distributions of the assets are **not normal**, their joint distribution will not necessarily be Normal and, therefore, can not be modeled using simply the mean and variance parameters.

Solution

Estimate joint distributions through a **copula\***, which is the joint probability function that best approximates the dependence between several variables.

Representation of the joint and marginal density of selected assets

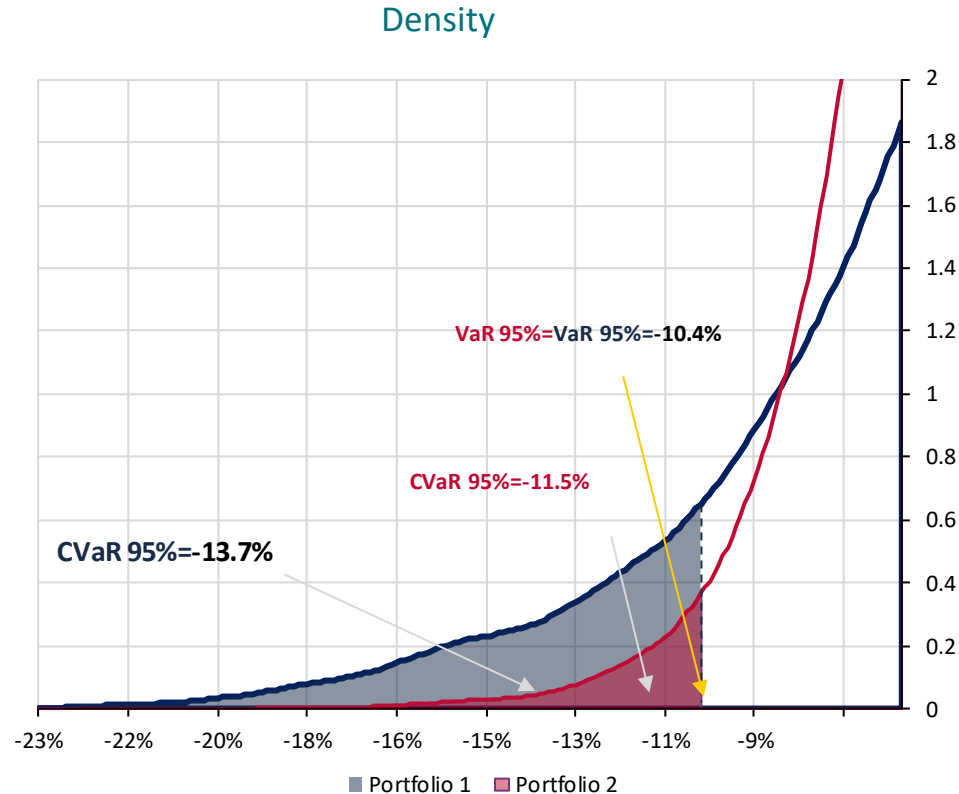


Fuente: Banco de México \* A copula is a multivariate probability function that captures the dependence between random variables. Sklar's theorem guarantees that any joint distribution function can be expressed in terms of its marginal distribution functions and a copula that describes the dependence structure between them. Bibliography: Atillio Meucci, "The Black-Litterman Approach: Original Model and Extensions. Atillio Meucci", Oct 2010. "Beyond Black-Litterman: Views on Non- Normal Markets", Nov 2005. Ruschendorf, L., Mathematical Risk Analysis: Dependence, Risk Bounds, Optimal Allocations and Portfolios, 2013.

# SAA Process: Adjusting our optimization model

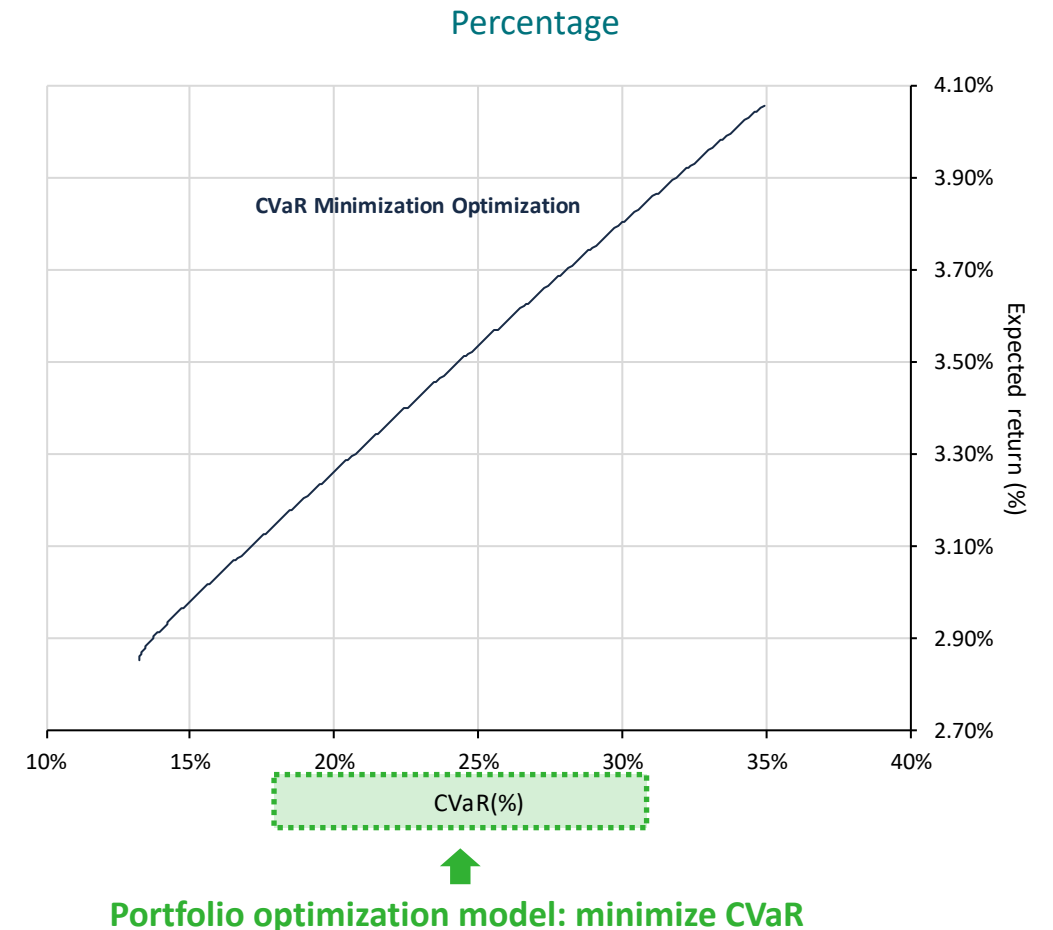
- Volatility might not be the best indicator of portfolio risk if our prioritized objective is to **minimize capital losses**. In that case, we are better off with variables that focus on the **left tail of the distribution of returns**, such as value at risk (VaR) or conditional value at risk (CVaR) metrics.
- VaR has been criticized for not capturing the appropriate shape of the left tail of the distribution of returns. Therefore, using the CVaR appears to be a more accurate way for estimating potential losses in the worst case scenarios.

## Density function of the returns of two portfolios



Source: Banco de México.

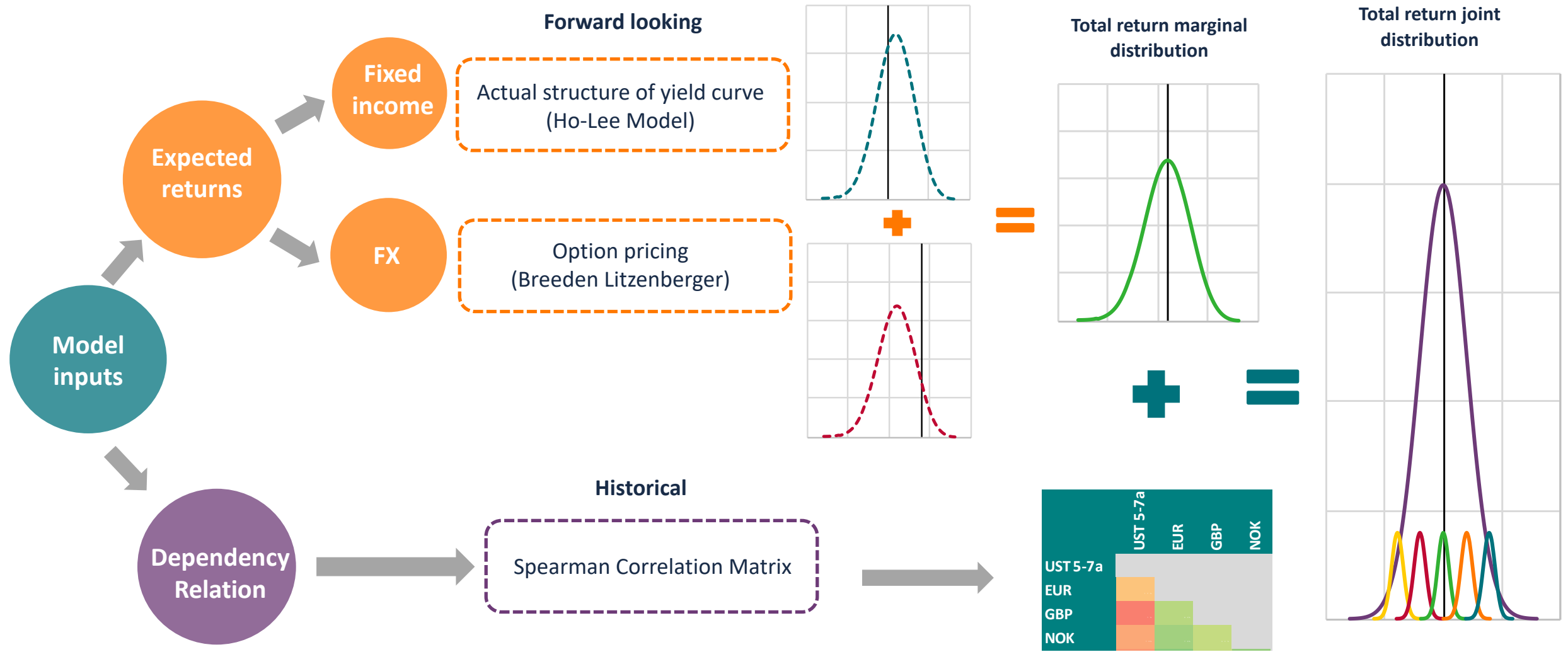
## Efficient Frontiers for CVaR minimization



Source: Banco de México.

# Strategic Asset Allocation Process - Inputs

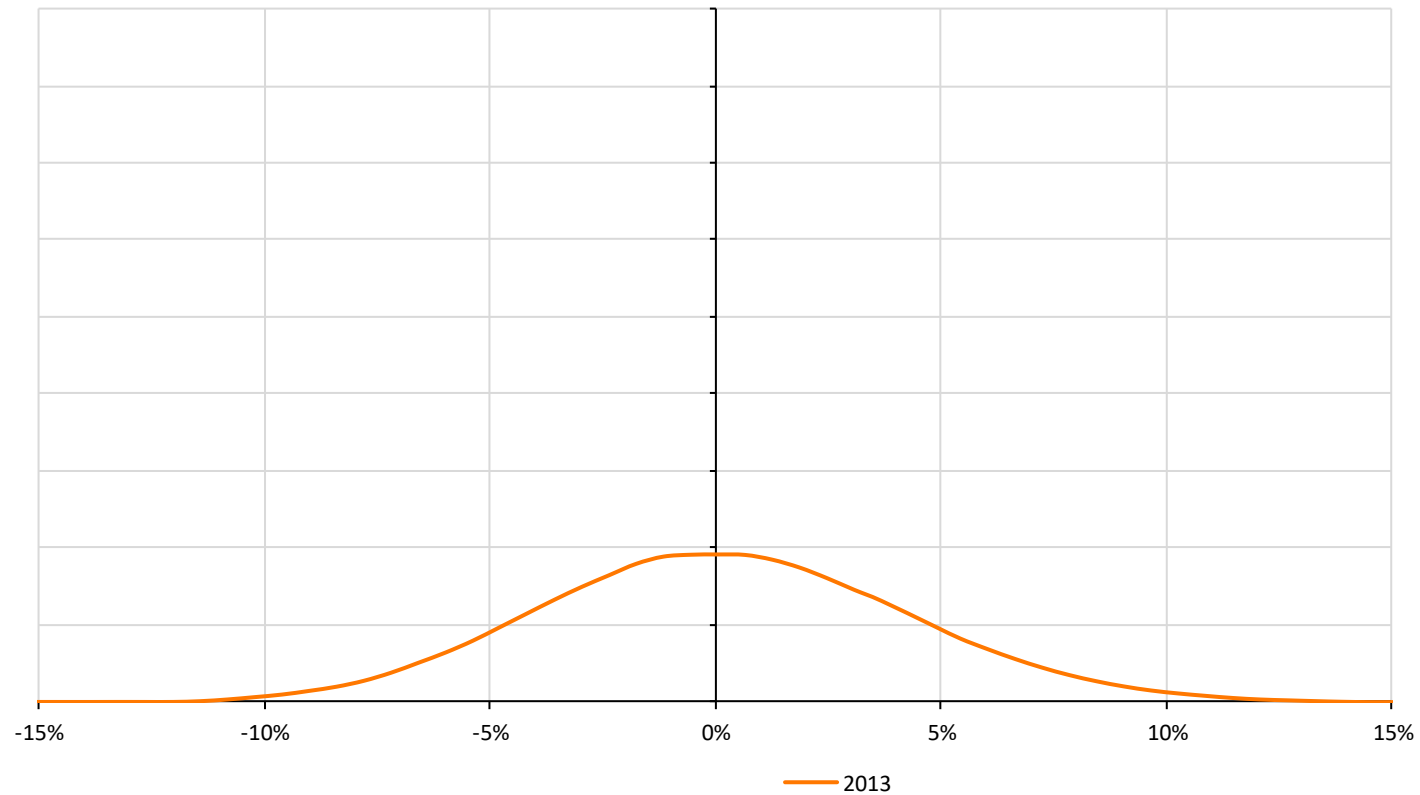
- Therefore, the composition of the international reserve portfolio is determined using an optimization methodology that minimizes **CVaR** for a given level of expected return, using market prices as the main source of information.



# How do the expected returns distributions of eligible assets look like?

- Expected return distributions for US dollar fixed income assets have improved significantly when compared to previous years, due to the higher level of interest rates and the reduction in market volatility.

US Dollar: Expected Distribution of Annual Returns of UST 3-5 Years  
Density

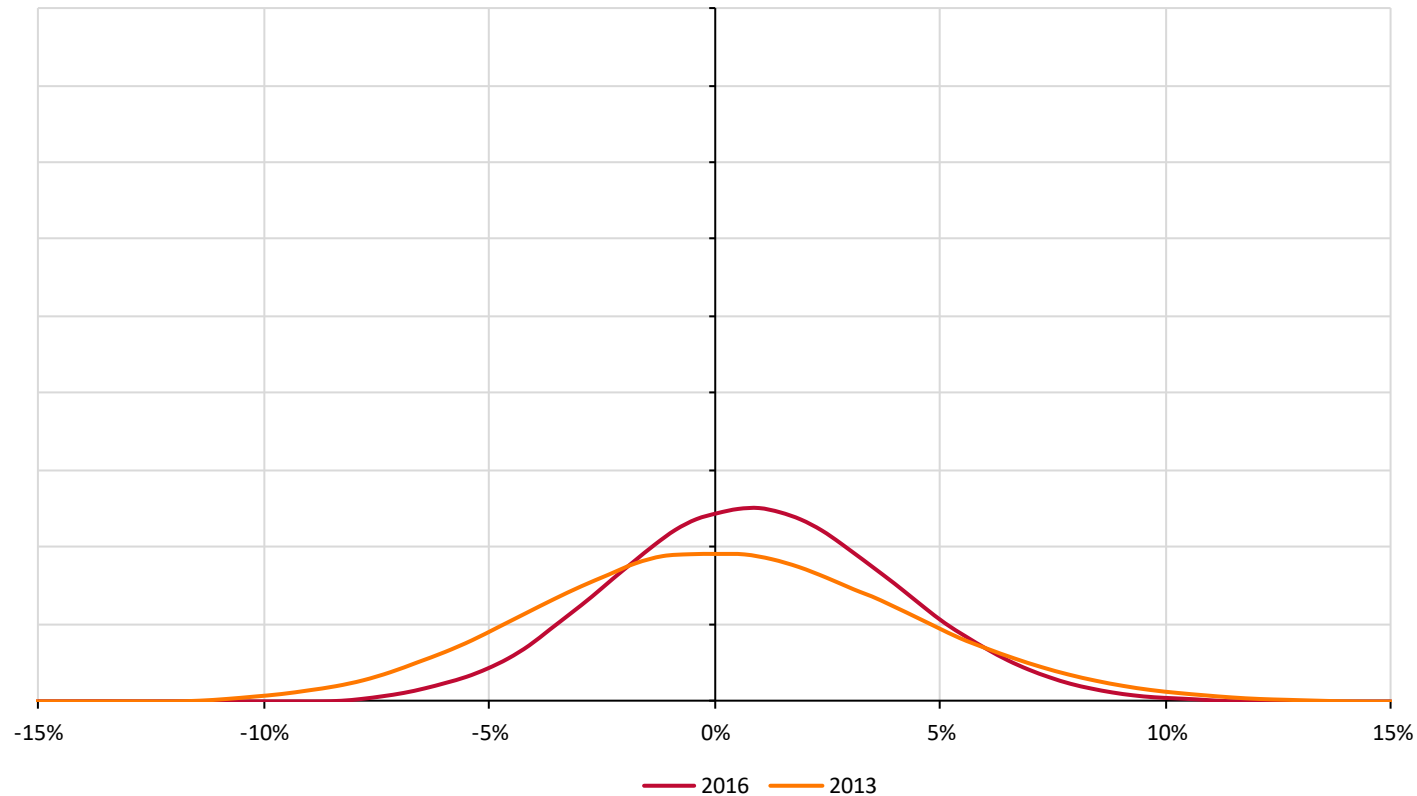


Source: Bank of Mexico with data from Bank of America / Merrill Lynch and Bloomberg. Non-overlapping returns.

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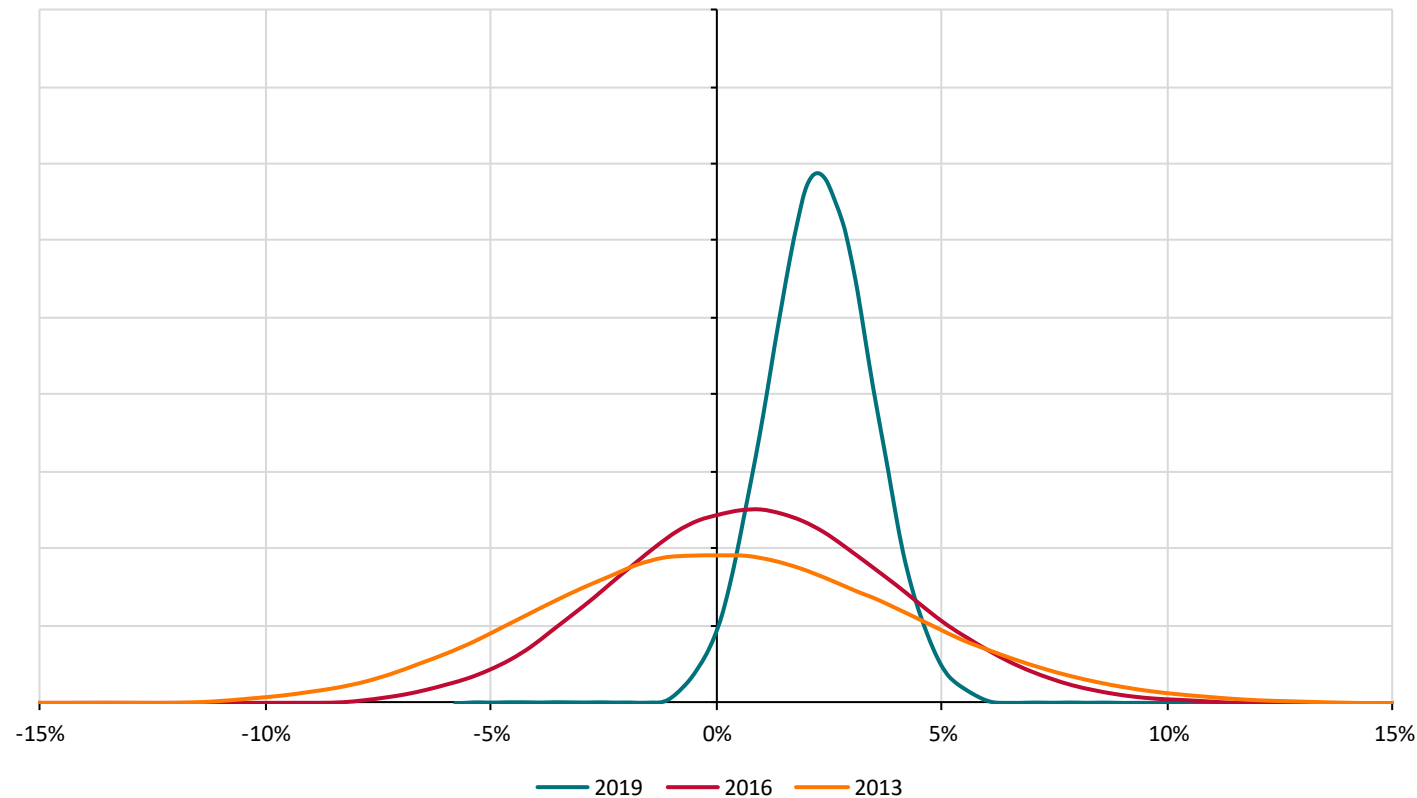


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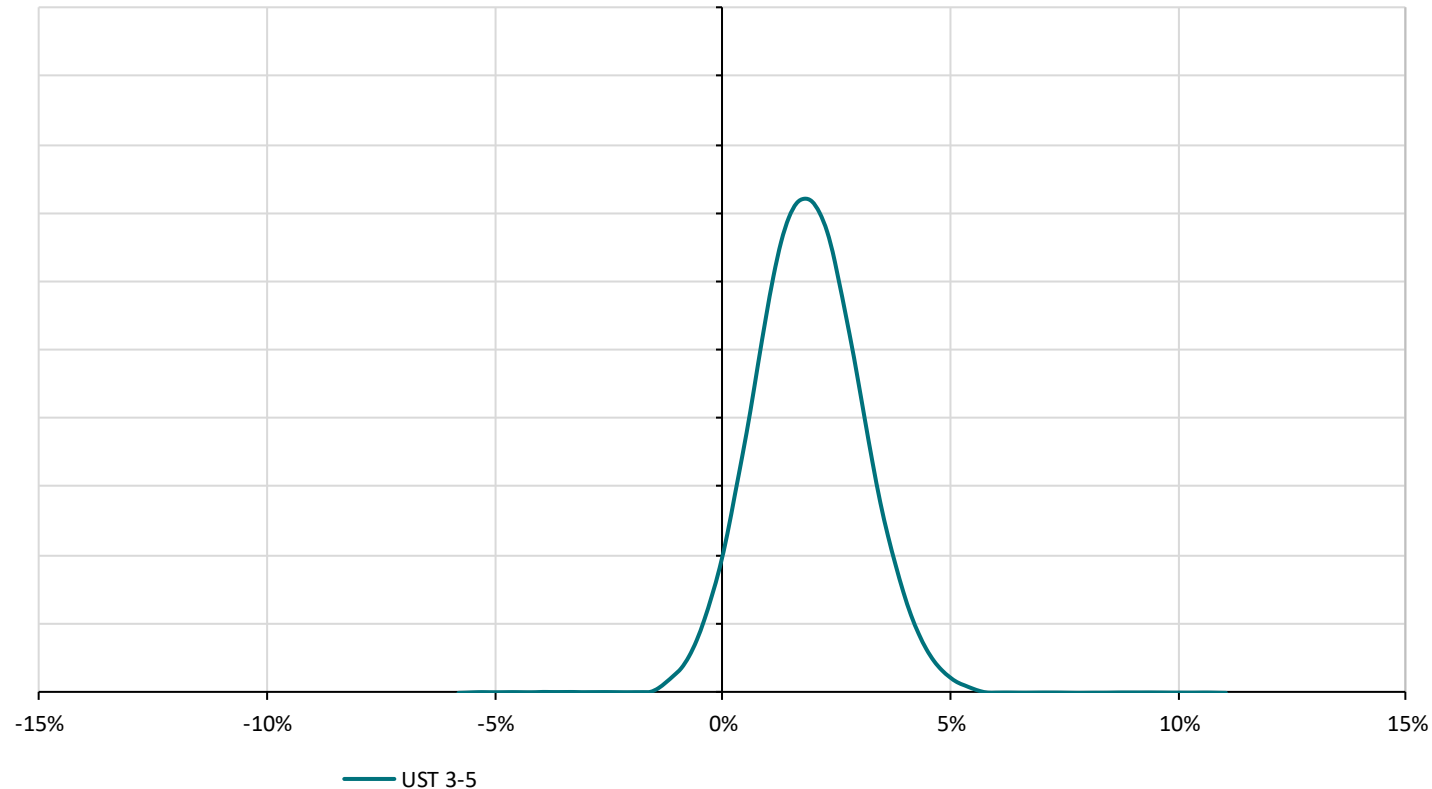
**1.** Expected returns in USD fixed income assets look more attractive as monetary policy normalization in the US pushed interest rates higher.

Source: Bank of Mexico with data from Bank of America / Merrill Lynch and Bloomberg. Non-overlapping returns.

# How do the expected returns distributions of eligible assets look like?

- Moreover, the distribution of US dollar fixed income returns is statistically more efficient than that of fixed income assets denominated in other currencies by showing higher expected returns (due to relatively higher yields in the US), and a lower variance (due to the high volatility associated with FX exposures).

Distribution of Annual Returns of 3-5 Year Government Bonds in Selected Currencies  
Density



Source: Bank of Mexico with data from Bank of America / Merrill Lynch and Bloomberg.

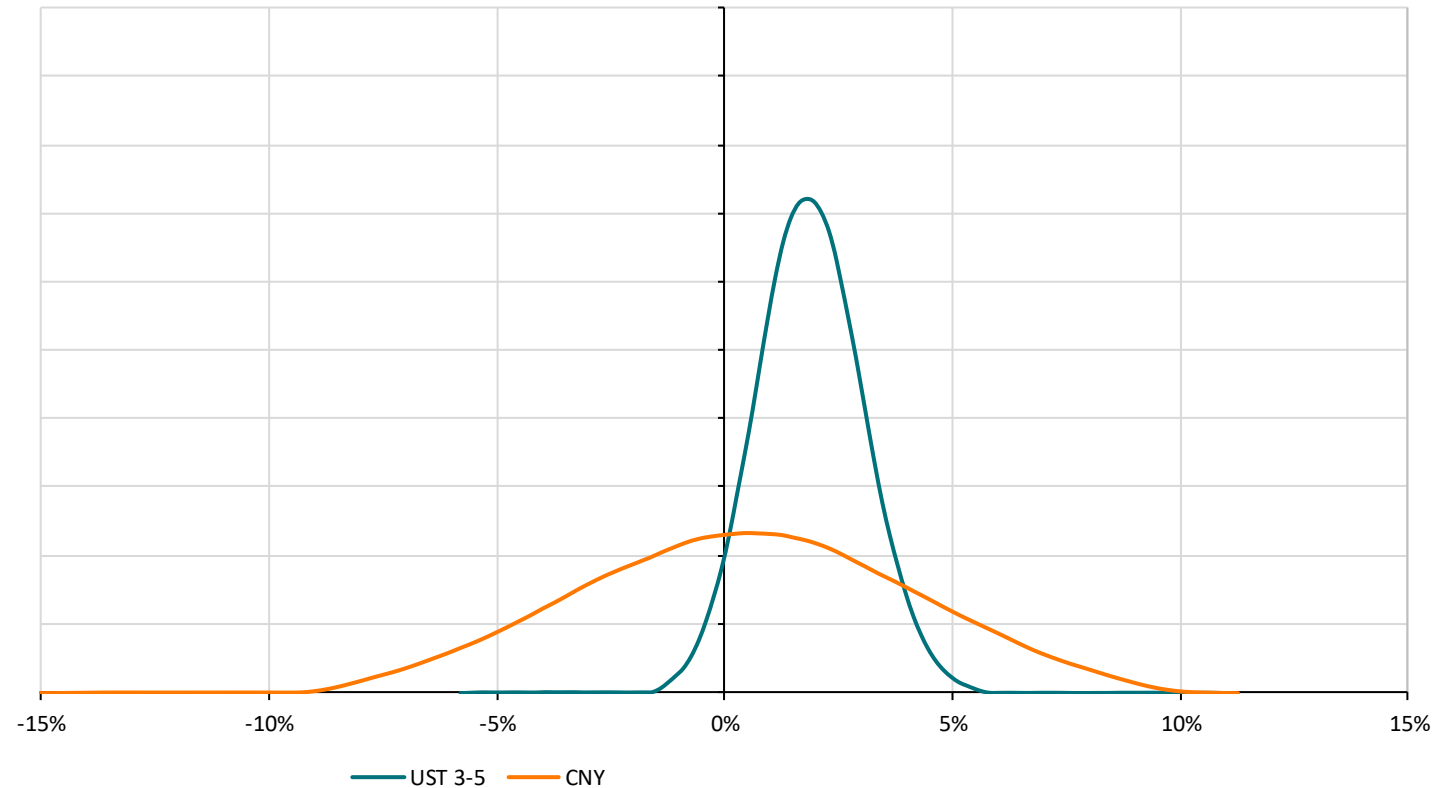
Note: the annual return for currencies includes both government bonds income and FX returns measured in USD terms. In the particular case of CNH, the 3 month local rate return is used.



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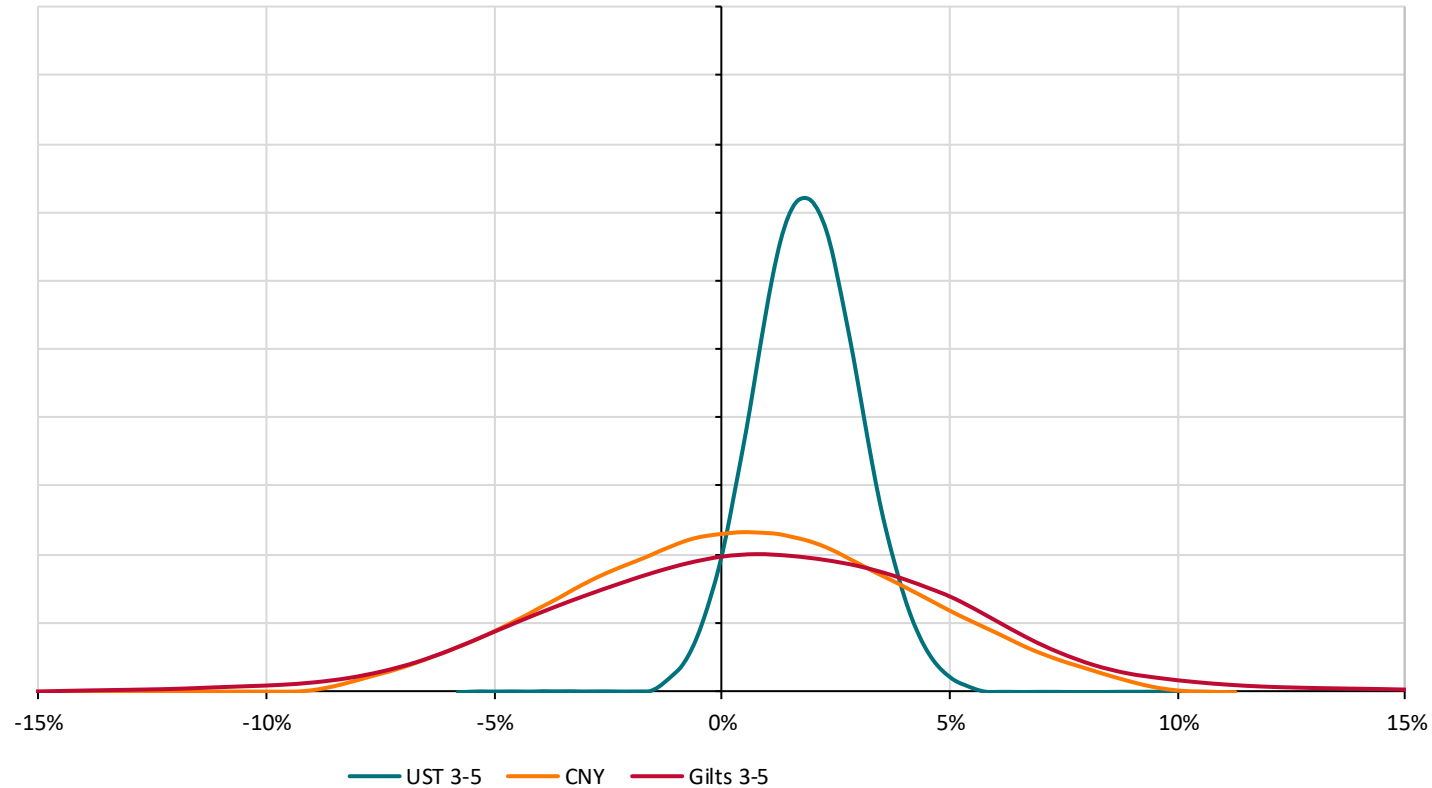
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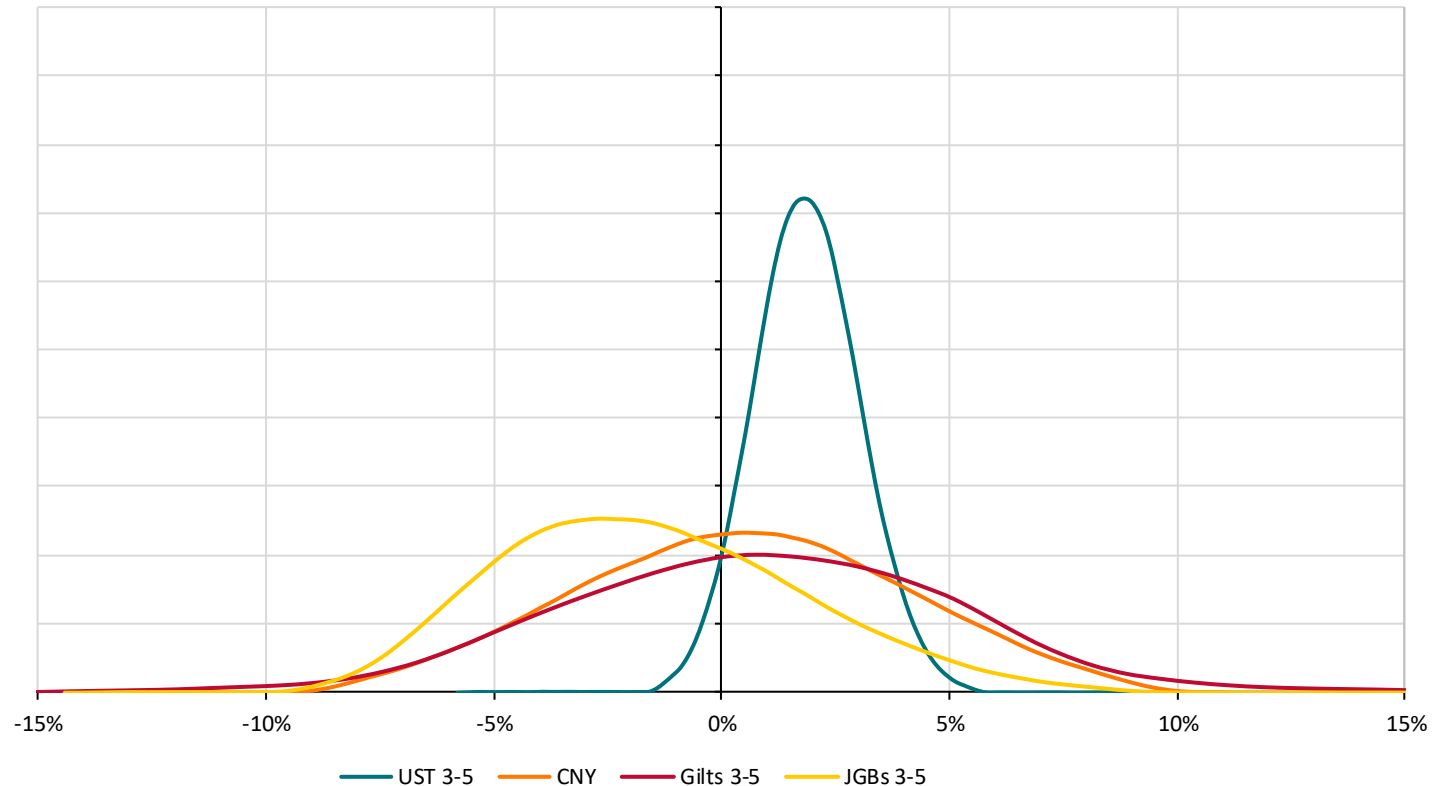
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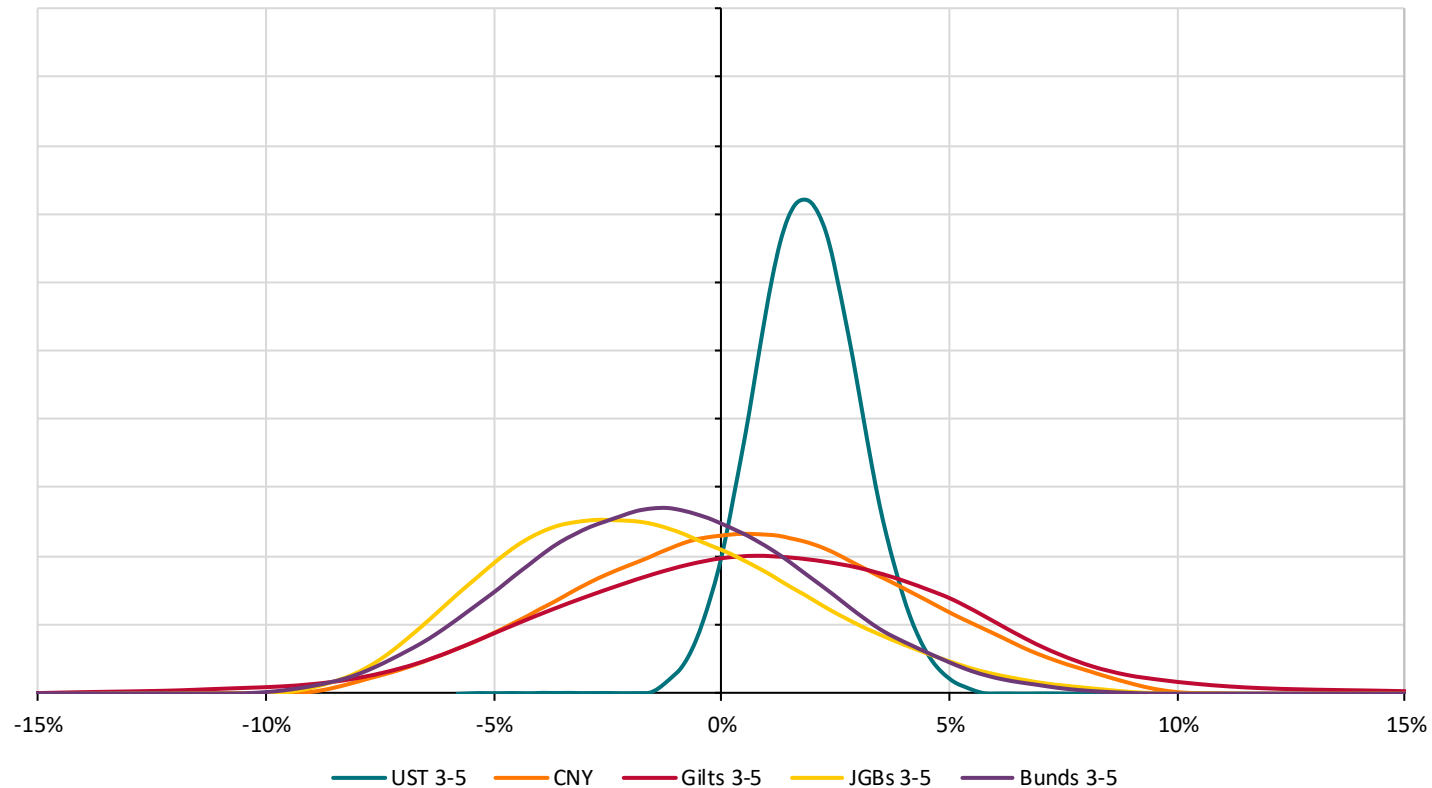
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Distribution of Annual Returns of 3-5 Year Government Bonds in Selected Currencies  
Density



**2.** USD fixed income assets dominate FI securities denominated in other currencies.

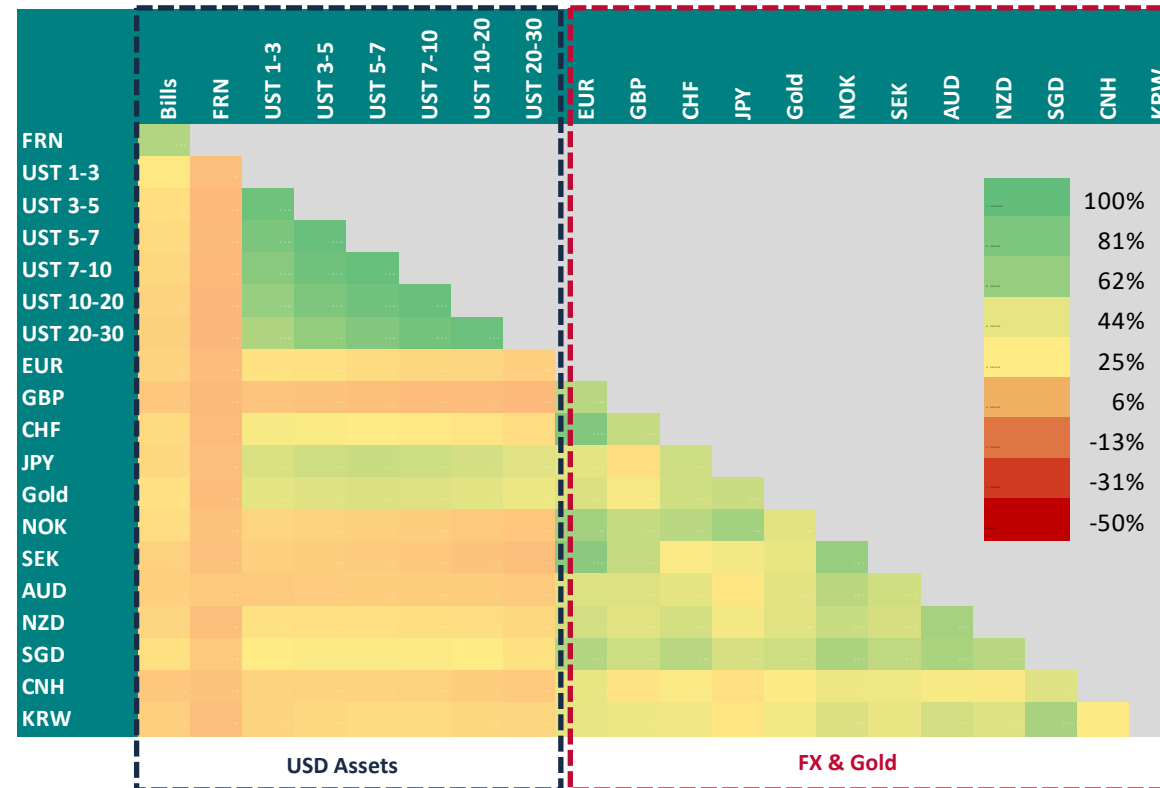
Source: Bank of Mexico with data from Bank of America / Merrill Lynch and Bloomberg.

Note: the annual return for currencies includes both government bonds income and FX returns measured in USD terms. In the particular case of CNH, the 3 month local rate return is used.

# How do the historical relationships between assets are incorporated?

- Correlation matrices confirm that currencies offer diversification benefits, though these are more prominent for non-traditional reserve currencies.

Correlation Matrix Between UST at Different Maturities and Selected Currencies  
Density

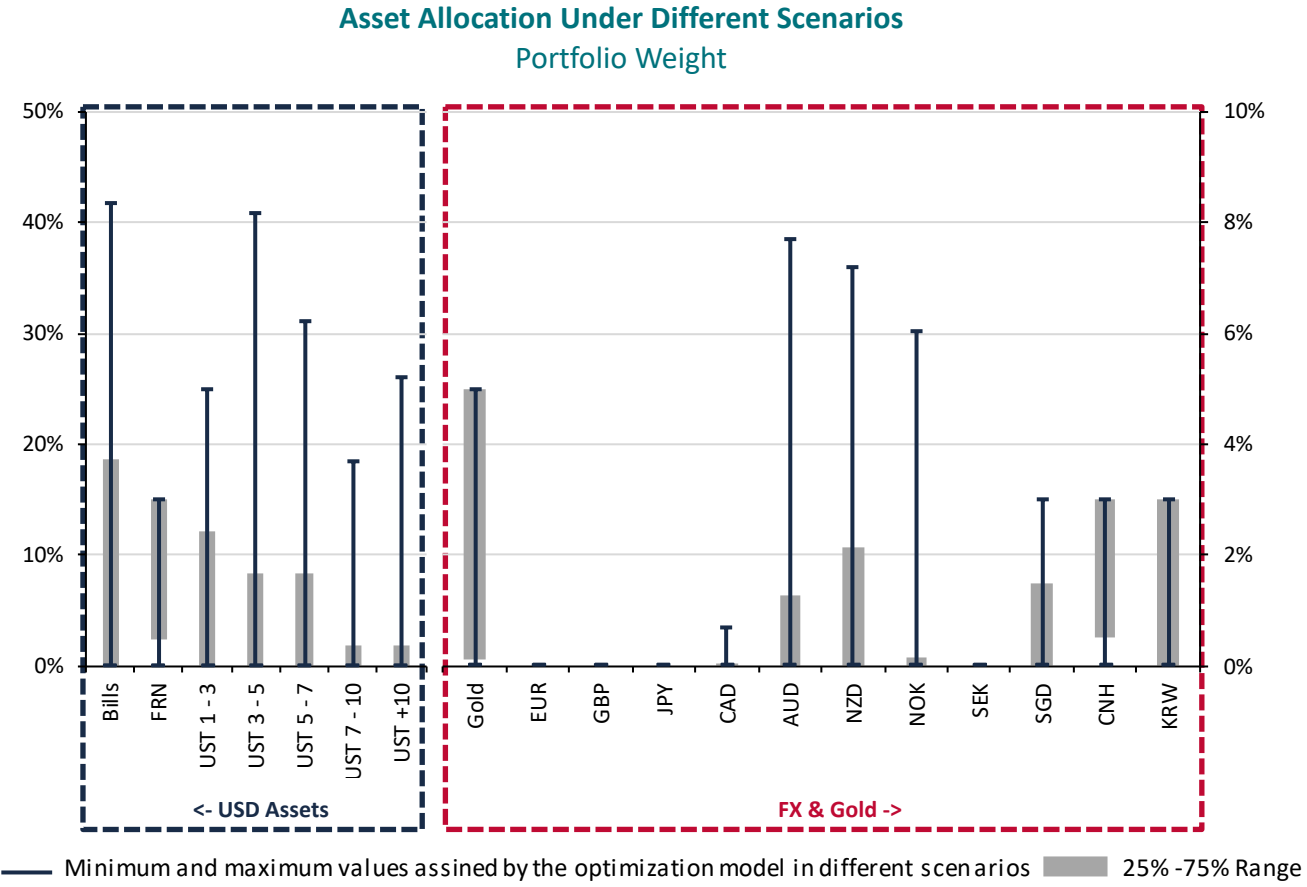


**3.** Non-traditional reserve currencies dominate traditional reserve currencies.

Source: Bank of Mexico with data from Bank of America / Merrill Lynch and Bloomberg.  
Note: Spearman Correlation calculated using non-overlapping annual returns with data from 2013 to 2017

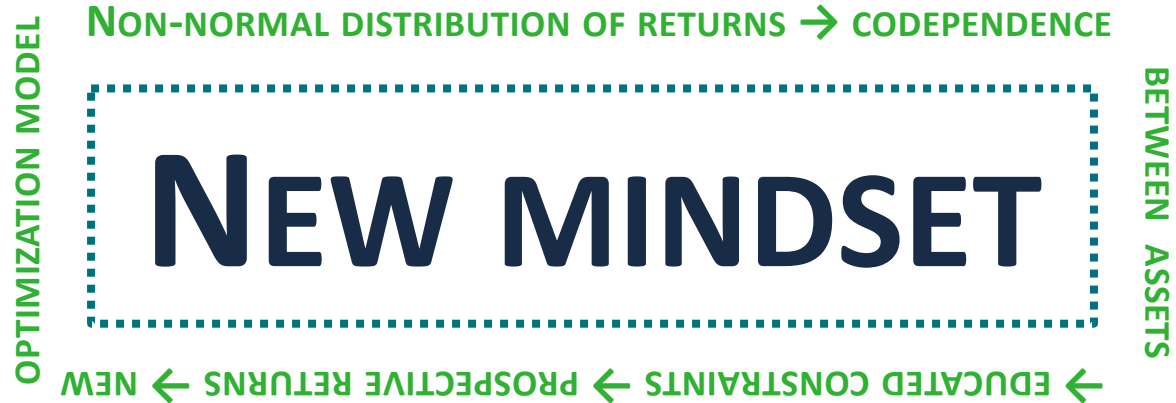
# How are the restrictions to the model determined?

- To have educated restrictions set on our models, we run the optimization process under different historical scenarios (i.e. global financial crisis, European debt crisis), and see what would have been the optimal allocation under these circumstances. We then determine the minimum and maximum allocation for each asset class to be used in the new asset allocation analysis.



**4.** Restrictions allow for some discretionary considerations in the SAA process (i.e. liquidity, market structure, traditional reserve assets)

Source: Bank of Mexico with data from Bank of America / Merrill Lynch and Bloomberg.  
 Note: the portfolio is optimized using historic weekly non-overlapping returns for different time periods: the dotcom crisis (2000-2002), restrictive monetary policy period in the US (2004-2007), US financial crisis (2007-2009), European sovereign crisis (2010-2012), as well as other periods (2015-2018, 2013-2018, 2000-2018, 2002-2004).

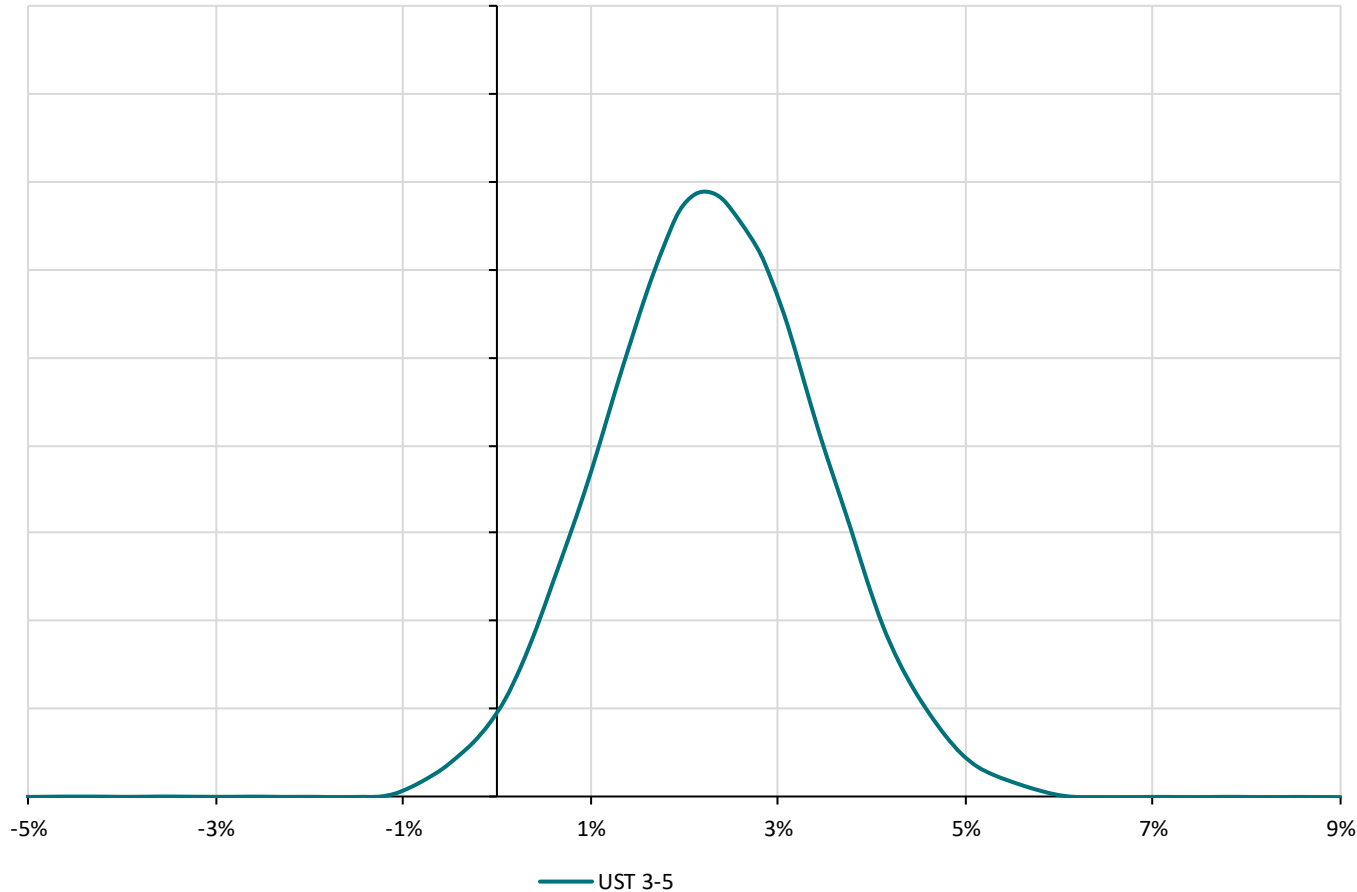


**WHAT IS THE RESULT?**

# What is the result?

- The portfolio's expected distribution of returns has an attractive risk-return profile when compared to that of a UST 3-5 years exposure. In fact, the distribution is farther right in terms of expected return, and it is also narrower (measured in terms of volatility or other left tail measures).

Distribution of non-overlapping annual returns of UST 3-5 Years and the Optimized Portfolio  
Density



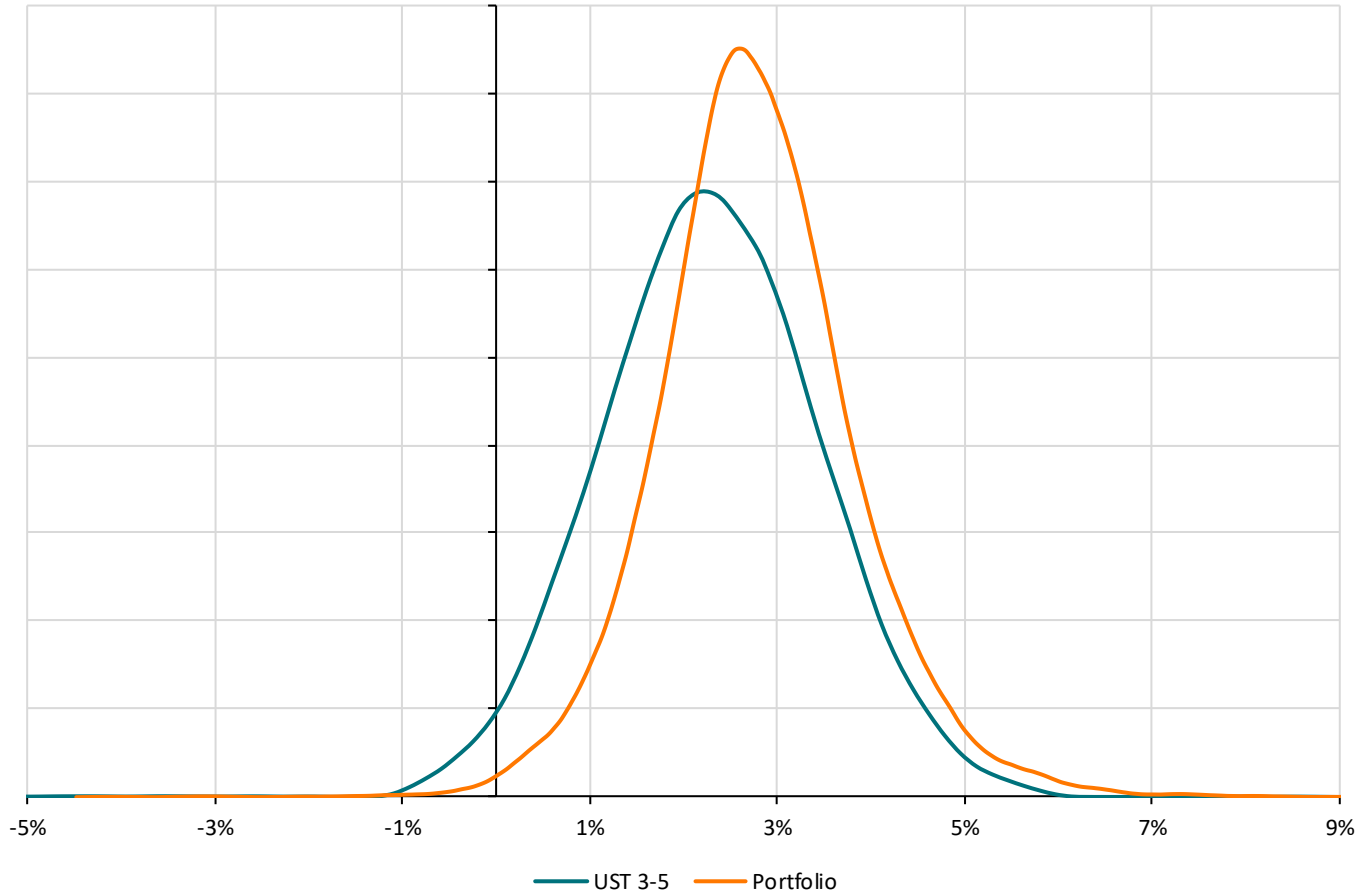
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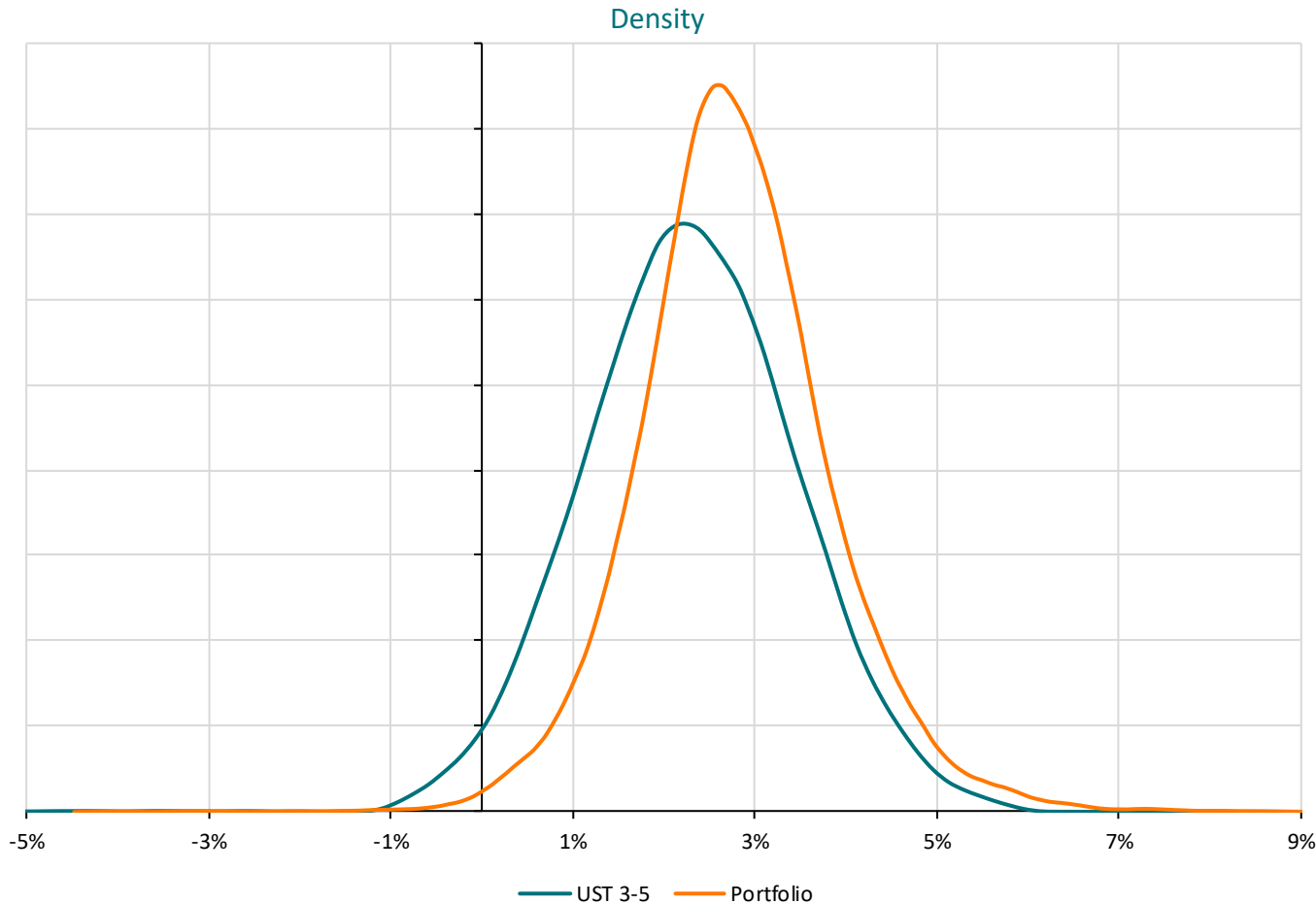


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# What is the result?

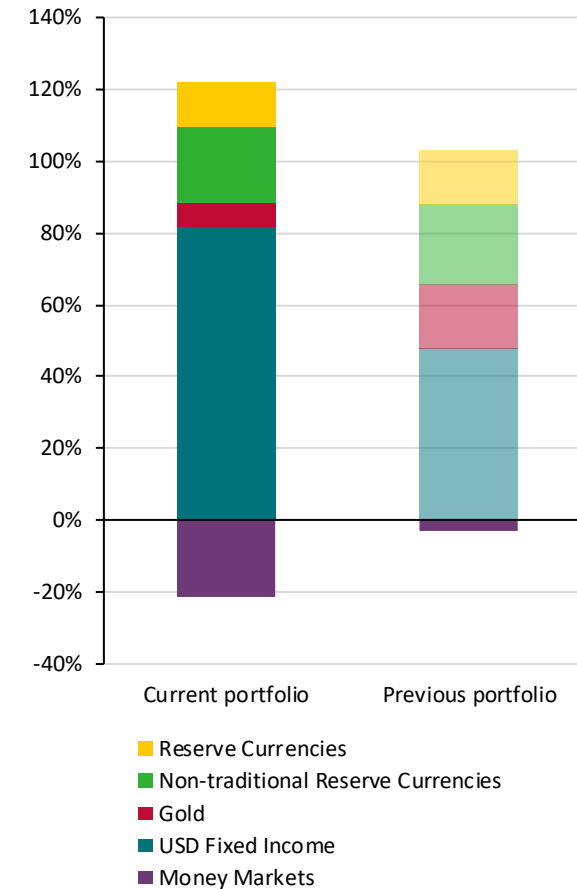
- The portfolio's expected distribution of returns has an attractive risk-return profile when compared to that of a UST 3-5 years exposure. In fact, the distribution is farther right in terms of expected return, and it is also narrower (measured in terms of volatility or other left tail measures).
- Moreover, given the aforementioned arguments, the bulk of our risk exposure lies within the US fixed income markets.

Distribution of non-overlapping annual returns of UST 3-5 Years and the Optimized Portfolio



Source: Bank of Mexico with data from Bank of America / Merrill Lynch and Bloomberg.

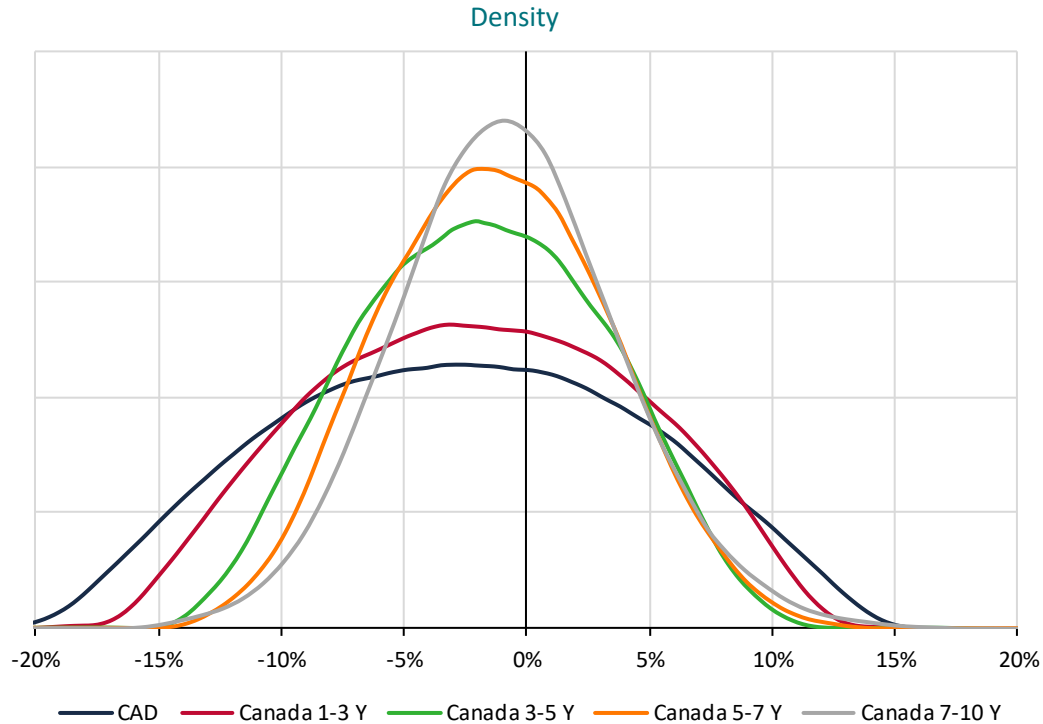
Contribution to CVaR Percentage



# New findings: A new understanding of FX and FI risk combined

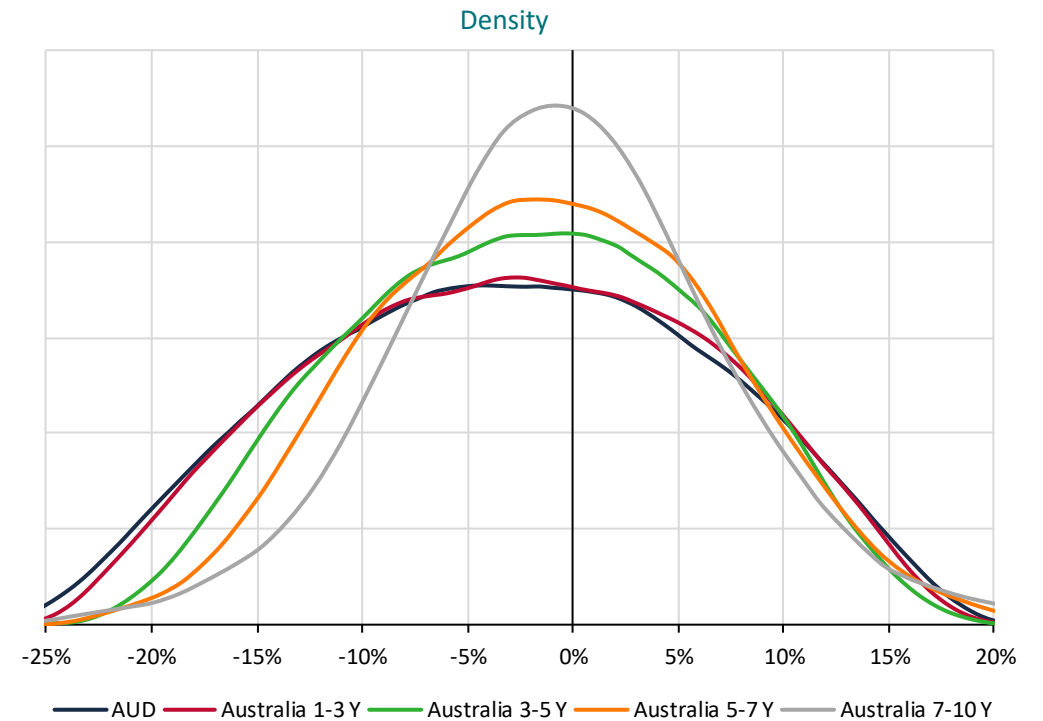
- Our traditional approach to investing in a new currency included the use of short-term securities. Nevertheless, this year we learned that there is a powerful diversification benefit of using as an investment vehicle the long end of sovereign yield curves. Intuitively, this is attained due to the fact that - excluding a credit event - yields and FX returns are negatively correlated.
- Therefore, this year we incorporated new fixed income yield curves and reasigned our non-USD investments from the short to the long end of the curve.

Implied annual returns distribution: Canadian dollar and sovereign curve



Source: Central Bank of Mexico

Implied annual returns distribution: Australian dollar and sovereign curve

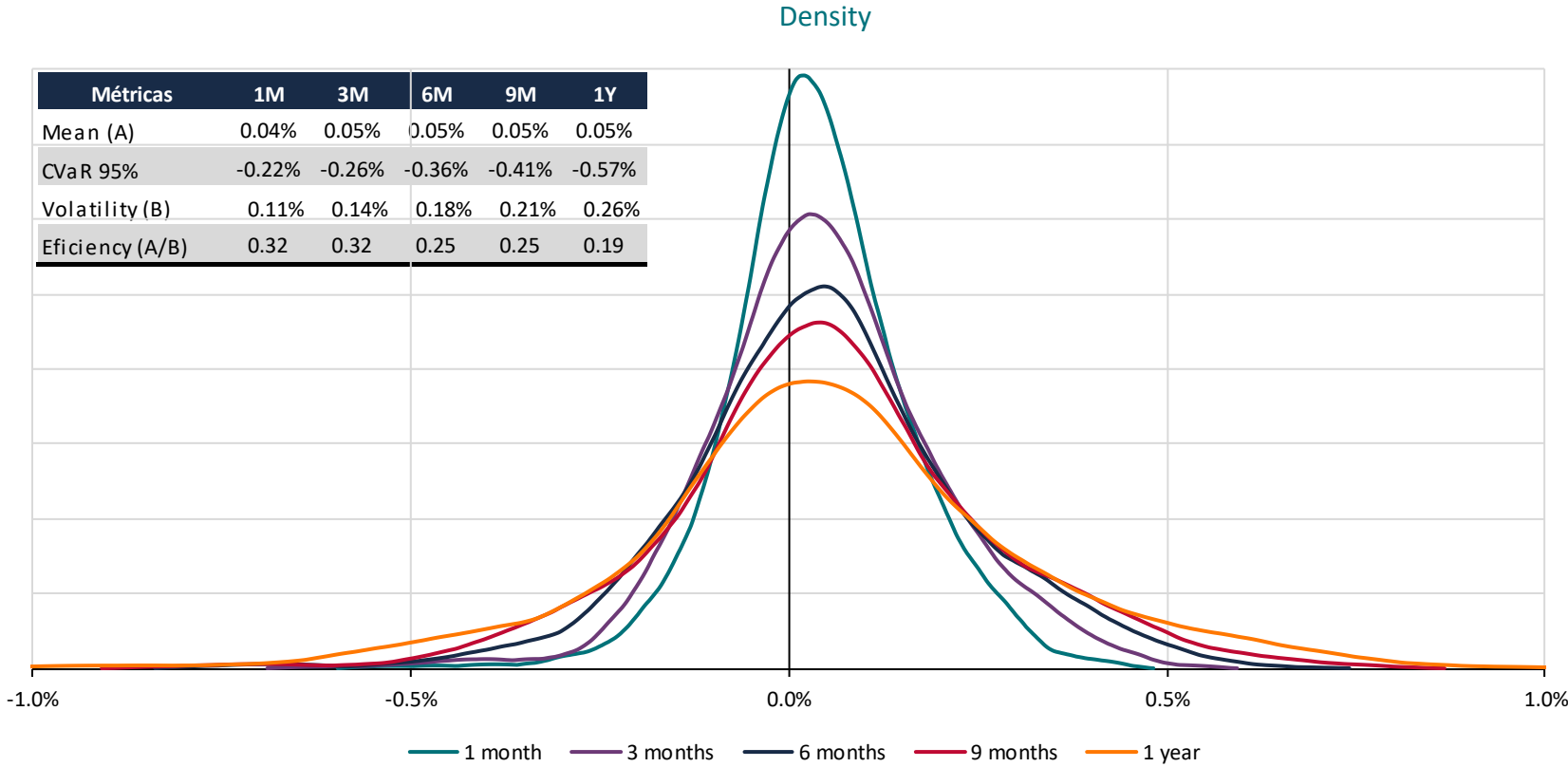


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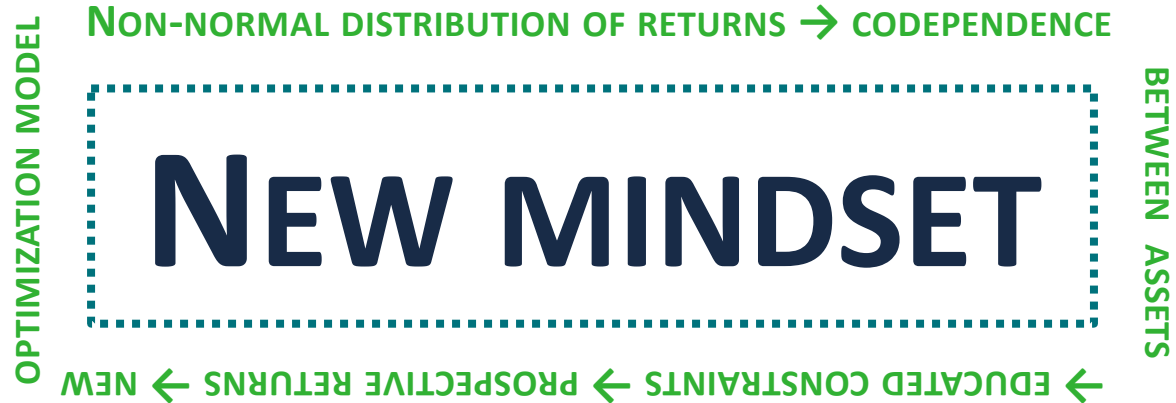
# New findings: investment horizon

- Some of the traditional SAA premises (including having a long-term approach to SAA) might not be optimal and may only be the consequence of legacy. In that regard, we replicated our approach at different frequencies in order to gauge the impact of the investment horizon decision.
- Our finding suggests that increasing the frequency of the optimization procedure generates a strategy with a better risk-return profile. However, given practical issues such as transaction costs, we believe 3 months is the right spot and we are now in the process of using this tool within our tactical decisions.

Distribution of realized weekly returns of optimization strategies at different frequencies



Source: Central Bank of Mexico with data from Bloomberg indices. To analyze the investment horizon we used non-overlapping weekly returns from 2006 and assuming independence we accumulated for 3, 6, 9 and 12 months. For each iteration, given a fixed date starting in 2006, we used 5 years of historical returns to adjust the marginal probability density of each asset and to determine the maximum likelihood parameters of a t-student copula. Given the t copula parameters, we simulated 10,000 realizations of the percentiles of each asset, which were then transformed into returns with the help of each marginal density. Once we get the compounded returns for each horizon, we defined individual and group boundaries for the allocation and implement the optimization by maximizing the excess returns for a fixed level of risk defined as the 95% CVaR. Finally, we evaluated the portfolio returns using the weights obtained from the optimization for the different horizons. This process was implemented for each week between 2006 and 2018.



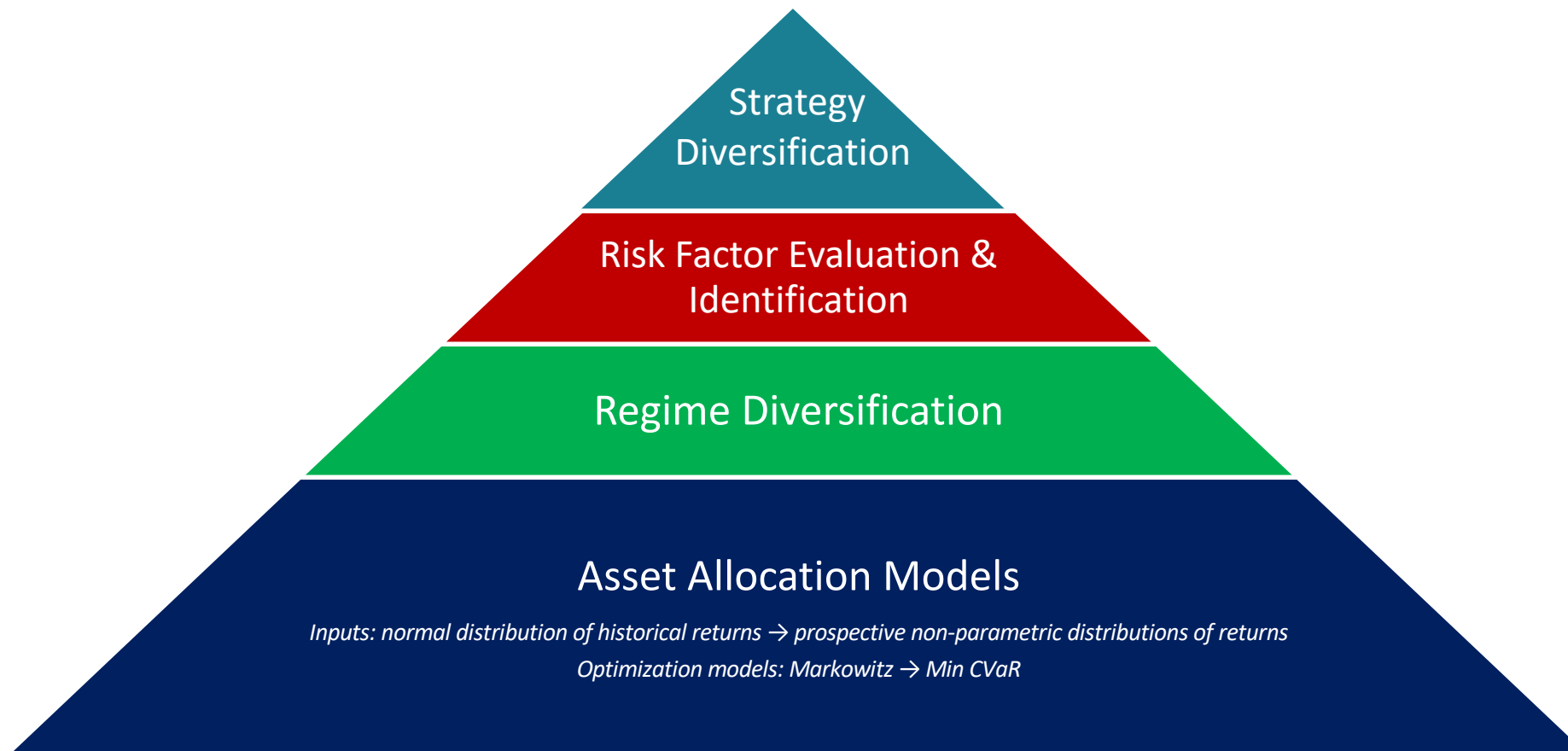
**IS THERE AN ADDITIONAL ALTERNATIVE  
TO FURTHER DIVERSIFY THE  
PORTFOLIO?**

# Investment strategies diversification - Absolute return portfolios

- With time, we also realized that the use of benchmark portfolios to frame investment decisions could expose us to risks that we may not always want to bear. For instance, a sudden increase of interest rates (normalization of term-premium).
- As such, having alternative investment portfolios – not subject to a benchmark – could allow portfolio managers to focus in those strategies in which they have their highest conviction. In fact, they could even benefit from the normalization of interest rates through carrying a negative duration in their portfolios.
- With said objective in mind, we launched a pilot program of **absolute return portfolios** through our External Asset Management Program.

Strategy Diversification		
	Benchmarked Strategies	Non-Benchmarked Strategies
Return	<ul style="list-style-type: none"> <li>• Portfolio's return highly correlated to the benchmark's return</li> </ul>	<ul style="list-style-type: none"> <li>• Higher flexibility. The investment decisions depend solely on the degree of conviction and downside-risk management considerations</li> <li>• Ability to adopt long and short positions</li> <li>• Capital preservation in an environment of higher interest rates (particularly in United States)</li> <li>• Higher returns through active management</li> </ul>
Risk	<ul style="list-style-type: none"> <li>• Exposure to risk factors inherent to the benchmark</li> </ul>	<ul style="list-style-type: none"> <li>• Dynamically allocate risk to maximize risk-adjusted return opportunities</li> </ul>

- Financial markets in the last few years have posed unprecedented challenges for reserve managers.
- Banco de México has approached this new economic and financial landscape with a reassessment of the priorities of reserve management towards the preservation of capital.
- In doing so, we have come to rethink the way in which we analyze asset class returns, and therefore, the necessary steps to determine our Strategic Asset Allocation. There is one constant however, and that is having a flexible and comprehensive approach to portfolio construction and management.



Source: Banco de México.

This document has been prepared exclusively for its use as supporting material for the XII BIS-CEMLA Roundtable in Cartagena, Colombia on the 17<sup>th</sup> and 18<sup>th</sup> of June, 2019.

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