The Case for Macro Risk Budgeting and Portfolio Tranching in Reserves Management

By

Alejandro Reveiz, PhD
Director Foreign Reserves Department

Banco de la República, Colombia

1. Introduction

The set of objectives in reserves management are normally predefined and include: protecting the economy against potential external shocks on the current account or on capital flows; invest the reserves minimizing the potential of a loss and ensuring the availability of international liquidity when necessary. Whereas the adoption of a floating exchange rate in theory reduces the need for reserves to protect against external shocks, in the context of free capital movements it will be a function of the efficiency of international markets.

In practical terms, Reserves Management is a process with a high effective complexity. The manager is confronted with the randomness of markets – including its own through the impact on the Reserves of Central Bank intervention – and the regularities that arise from its guidelines (i.e. credit and market risk, as well as liquidity policies) and the foreign exchange intervention mechanisms.

Recently, given the increase in the size of the foreign reserves in recent decades for some central banks, as a result and in response to globalization and more volatility on currency flows, portfolio foreign investment and other related factors as contagion effects, the pressure to generate long-term returns has increased. However, the goal of increased returns is subdued to the security and liquidity objectives in international reserves management. As a result, the process of asset allocation and the construction of an efficient set of investment guidelines, as well as a risk policy, must be framed by a liquidity policy and, generally, to an asymmetric exposure to risk where capital loses are to be avoided in specific time horizons; i.e. a fiscal year.

Foreign reserves portfolios have three main sources of returns: benchmark returns from asset allocation[1], the profits made by actively managing the authorised deviations from the benchmark and the profits from repo transactions or security lending programmes, i.e. security loan programmes.

$$R_{\text{Portafolio}} = R_{\text{Benchmark}} + R_{\text{Deviations}} + R_{\text{Securities loans}}$$

Excluding legal and operational risk[2], the main risks affecting returns in foreign reserves management are liquidity risk, market risk and credit risk, that in turn are traduced in potential loses of the benchmark, the active management of deviations and the securities lending and repo programmes – see Figure 1.

---

[1] It is preferable to use composites of readily and publicly available market indexes in order to foster transparency in reserves management.

[2] Which are not compensated in terms of returns

Figure 1 – Mapping from Risks to Returns
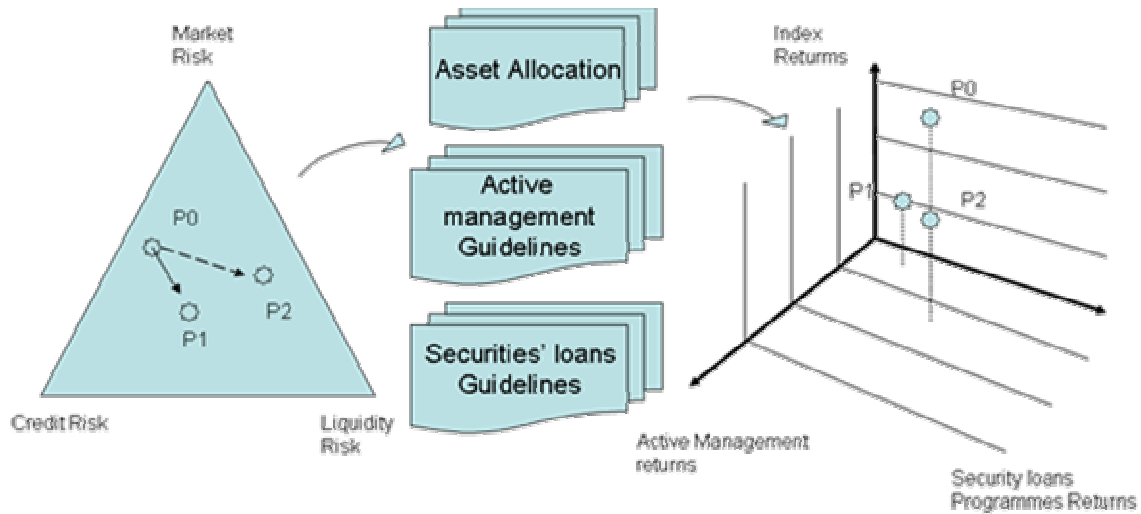
The choices on the levels of liquidity, market and credit risks are subordinated to the objectives and risk aversion of the Central Bank. In particular, the relationships among these risks are constrained by liquidity and risk policies, as well as the universe of assets and the maximum risk exposures allowed by the top decision-making body, in the case of Banco de la República is the Reserves Committee, which is composed by the members of the Board of Directors[3]. Risks can be managed by modifying the universe of assets and its allocation on the benchmark, the active management or the securities lending programmes.

For instance, overall market risk increases when the benchmark has a longer duration, more market risk is allocated to the active management strategies or a higher duration gap is allowed between the securities loans' maturity and the investments of the cash collateral[4]. Similarly, credit risk exposures can be modified by including Asset Backed Securities or corporate bonds in the benchmark, the active management guidelines or the cash investment guidelines of the securities lending programmes.

The process of mapping risk exposures to the expected returns presented in figure 1 can be achieved using a 3 step process: the asset allocation, the construction of active management guidelines and the definition of the guidelines for the securities loans programs.

---

[3] For instance, a portfolio invested in money market instruments (deposits, CD's, etc) may have low market and liquidity risks and high credit risk, whereas a portfolio invested in sovereign bonds will be exposed to higher market risk and lower credit and liquidity risk. On the other hand, a portfolio with holdings in mortgage backed securities and corporate bonds may be exposed significantly to all the risks. However, one could expect it to generate higher returns.

[4] Only overnight investments are authorized at present.

2. Asset Allocation

When determining the benchmark arising from the asset allocation, central bankers are faced with many challenges including the explicit definition of the credit and market risk aversion and the choice of the universe of assets and risks allowed in the portfolios. The latter is also linked to the expected liquidity needs for intervention or other motives. Preservation of capital is a mostly favoured definition in terms of risk aversion, as well as a universe of assets including sovereign debt from developed countries. It is advisable that the market risk aversion function is defined more precisely, say for instance, loses should not occur in a given period with a probability higher than 5% using a predefined risk model, with the risk estimation methodology, as well as the sample, explicitly defined.

At Banco de la República, a target probability of 5% to record losses with an interval between 10% and 2.5% has been decided by the Reserves Committee, in order to avoid changing the benchmark too frequently, i.e. a dynamic benchmark is avoided. In addition, potential changes to the asset allocation from the above mentioned rule are complemented with analysis on inflationary pressures' expectations and asymmetries in the distribution of interest rate returns at low interest rate levels. The choice of the universe of assets included in the benchmark results from the overall reserves management strategy, i.e. liquidity policies, risk policies, the objectives of the active management programme, fee schedules, payment options (fixed, performance based or both), etc.

Liquidity restrictions inherent in reserves management result in a sub-optimal portfolio when compared to the overall market, as some asset classes must be avoided or limited in a reserves portfolio. Thus, in order to generate higher returns – potentially moving closer to the market's efficient frontier- two approaches can be sought: (i.) increase the threshold of loss tolerance with the same asset classes or (ii.) add new asset classes or risks into the acceptable universe. The latter can be done by either increasing the asset classes in the benchmark or allowing disparate risks for asset allocation and active management, which can have complementary or exclusive risks.

When more risks are allowed in the asset allocation process, the resulting benchmark will by closer to the market's efficient frontier. However, the portfolio will be synchronized with the additional risks. For example, including Mortgage Backed Securities (MBS) will expose the portfolio permanently to prepayment risk (extension and call risks), negative convexity, model risks etc. Also, the relative value products or spread products tend to trade in less efficient markets. As

model risk in those instruments is significant (rationality in the investors cannot be readily assumed), issue selection is determinant in the creation of returns[5].

In addition, in the case of an external management programme, external advisor's desired management style is of great importance. For example, Risk Budgeting is a decision process in which portfolio construction is based on the selection of exposures to different risks factors – with an overall tracking error explicitly defined ex-ante – that aims to maximize the diversification benefit implicit in the correlation matrix from a set of signals and, if desired, an expected information ratio for each risk factor's strategy – see Figures 2 and 3. In this context, for active management, managers' ability to modify portfolio's covariance matrix is critical in order to maximize the diversification benefit; this is more effectively done when all asset classes permissible are not included in the benchmark[6], hence the manager has the flexibility and not the obligation to expose the portfolio to such risks at times it deems appropriate.

Figure 2 – Active Risk Budgeting

---
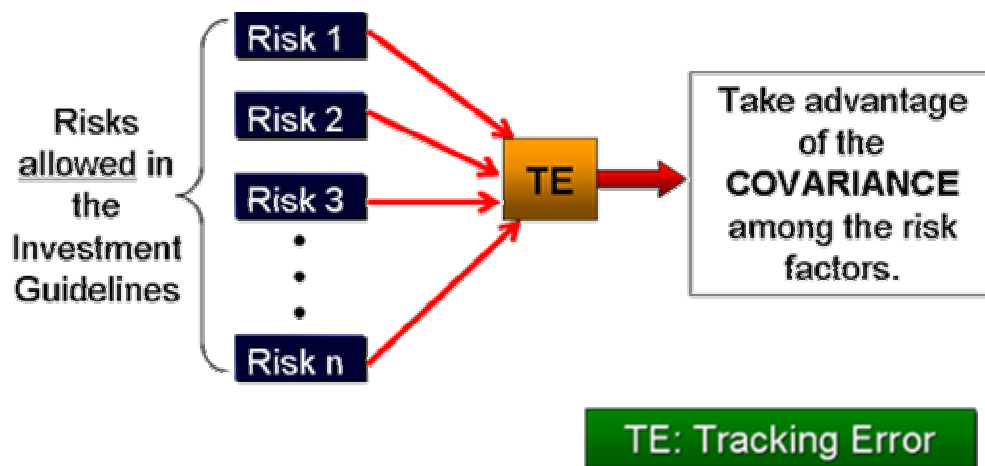
[5] An investor does not necessarily want to hold the specific instruments of the MBS indexes but model risk can be too significant to deviate from those pools.

[6] Although it could be argued that benchmark returns are more easily beat by allowing additional risk types in active management, this issue is solved by defining a target of excess returns over the benchmark that accounts for the expected long term difference of returns; i.e. 30 b.p. over benchmark returns. I will come back on this issue later in the document.

Figure 3 – Active Risk Budgeting
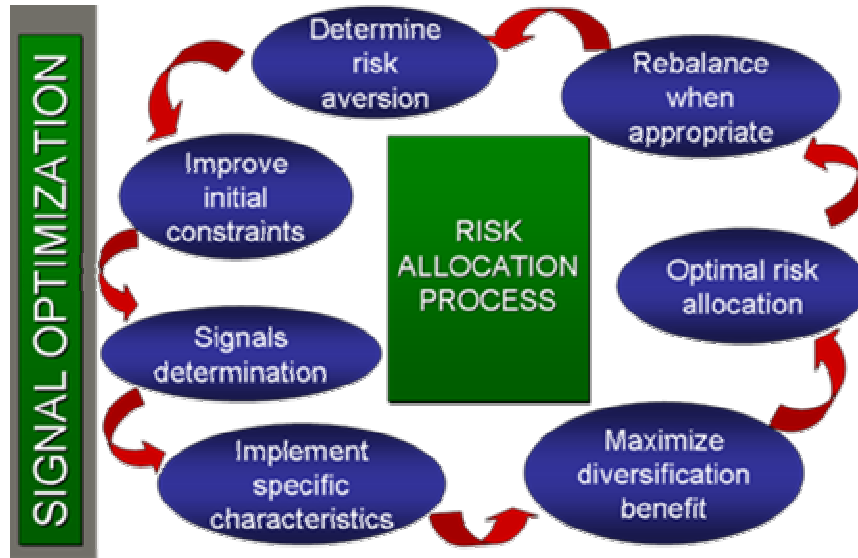
But most importantly two questions must be addressed. Are expected returns used in the asset allocation processes open to forecasting errors, *forecasting fallibility*? If this is so, for the resulting optimal portfolio the underlying diversification benefit could be improved. Is it then possible to obtain a similar long-term additional expected return by constructing active management guidelines, with additional risk types, that result in overall lower risk for the benchmark and the active management combined? This is possible if the guidelines can be designed such that they yield an excess return that is independent (orthogonal) to benchmark returns. This is to say that benchmark and active management returns have low correlation; with the latter attaining a very high diversification benefit as the result of the increased degrees of freedom in risk allocation. The dynamics of correlations – which are in quite volatile – is also a compelling argument as benchmarks are designed to remain unchanged for long periods of time and active management may take advantage of their dynamics[7].

Econometric and statistical analysis performed at Banco de la República with multiple sets of guidelines for active management have shown that low correlation between active management excess returns and benchmark returns is attainable with a satisfactory long term excess return consistent with the Board of Directors risk aversion. Thus, the asset allocation process at Banco de la República is constructed with a limited set of assets – United States Treasury Securities, German Government Bonds and Japanese Government Bonds and

---

[7] One could also argue that Central Banks do not have liabilities in such risks (assets) and therefore these must be approached with an opportunistic bias in order to increase average returns.

active management is set up such that it has low correlation with benchmark returns and long term positive excess returns.

At this point it must be noted that the overall currency composition of the international reserves reflect the outflows of the balance of payments. Moreover, at Banco de la República, liquidity is ensured by using 3 distinct portfolio tranches: (i.) the working capital that covers around 2 to 4 normal foreign exchange option auctions interventions[8]; (ii.) an intermediate tranche, or passive portfolio, composed of United States, German and Japanese government bonds that do not allow any active management and its size is estimated so that in aggregate these first two tranches cover, with a 99% of confidence, one year's intervention[9] and (iii.) a stable tranche subdivided in two distinct mandates (benchmarks) with currently four external and an internal managers, whom can take active risk by deviating from the benchmarks in its underlying risks or other non-benchmark risks. A maximum ex-ante tracking error is imposed as a soft target to all managers, combined with specific limits for all risks, sectors, counterparties, etc.

3. Active Management

As previously mentioned active management is designed to yield orthogonal returns to the benchmarks and a risk budget is allocated to each manager in a *macro risk budgeting* allocation process. The starting point is the definition by the Board of Directors of the maximum targeted tracking error tolerated for active management, say 100 b.p. per mandate[10].

Two types of mandates were constructed taking into account differences in asset management styles – spread and relative value managers in the US and Global managers in Europe. The former, the *asset rotation* mandate, has a benchmark of 100% US treasuries and deviations into other asset classes very liquid in the US, such as MBS, Asset Backed Securities (ABS), Agency Debentures, low volatility Collateralized Mortgage Obligations (CMO) and other instruments[11] while the *global mandate* has a benchmark similar to the indexed tranche with a higher exposure to Japanese and German Government Bonds in order to obtain the desired overall currency exposure. The global mandate managers can deviate into supranationals, agencies, and other acceptable bond markets, as well as FX

---

[8] Information on the intervention mechanisms can be found at www.banrep.gov.co.

[9] The liquidity policy also states that as soon as one year's intervention is covered with less than 90% of confidence, if contingency lines are not available or have been used, the third tranche is to be orderly liquidated in order to avoid significant exposure to bid/offer spreads widening.

[10] It can also be expressed as total tracking error tolerated for the overall investment portfolio (50 b.p.), which is then allocated to the active management tranche.

[11] US Asset Rotation mandates cannot take open FX exposures and are allowed limited deviations in effective duration, spread duration and effective negative convexity.

risk[12]. Both mandates have to outperform the benchmarks by a target of 30 b.p. which is linked to a mixture of a fixed and a performance fee schedule.

The overall tracking error[13] authorised by the Reserves Committee is allocated between the internal and the external management. The passive portfolio, which corresponds to the intermediate indexed tranche, is not given any tracking error, whilst the active internal portfolio, with a global mandate, is allocated a tracking error that is consistent with its abilities and historical performance. Similarly, the tracking error allocated to the external management is in turn split between the global and asset rotation mandates and is then allocated to each specific manager – see figure 4.

Figure 4 – Macro Risk Budgeting
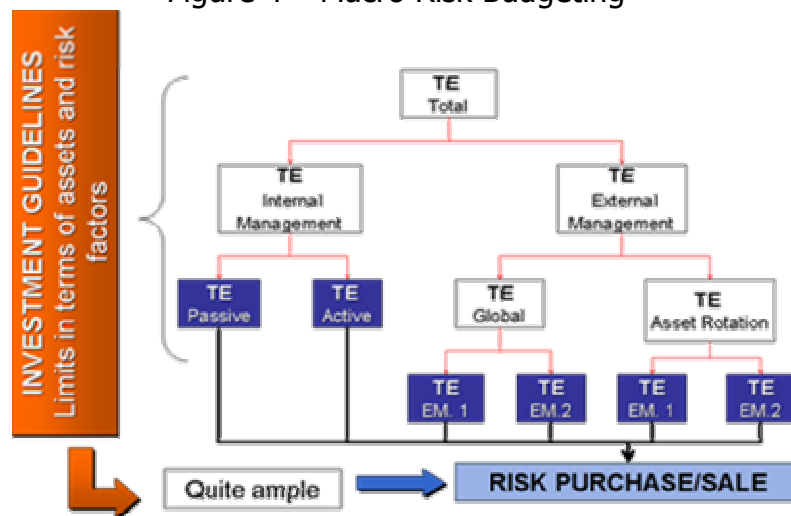
Macro risk budgeting has many strengths: (i.) risk allocation is performed in a systematic fashion starting from an explicit measure of risk aversion defined by the Board of Directors; (ii.) diversification benefits can be maximized both between mandates and styles; (iii.) managers that use risk budgeting processes have higher degrees of freedom[14]; (iv.) effective use of the risk budget can be monitored[15]; (v.) the efficiency in the manager's use of the risk budget can be ascertained in terms of risk adjusted returns (information ratios), efficiency in the risk allocation (risk ratios) and the ability to manage risk (efficiency ratios); (vi.) other sources of revenue – securities loans programmes – can be compared with active management programmes .

---

[12] Global mandates can take limited FX exposures against the benchmark, as well as effective duration and effective spread duration deviations.

[13] Defined as the ex-ante volatility of excess returns

[14] This is reinforced if the covariance matrix is not "locked-in" by including all risks in the benchmark.

[15] It is not uncommon that managers do not actively take risks allowed to them. This can be understood as an opportunity cost in the sense that this "unused" risk could be then taken by other manager.

It must be noted that the objectives of the overall programme must be clearly defined:

- Definition by the Board of Directors of the maximum tracking error permitted for active management.
- Desire to increase the return of the international reserves portfolio by, say, 30 b.p. in average by enhancing active management under the restriction of the maximum tracking error allowed.
- Obtain this excess returns from the overall active management programme[16].
- Design active management guidelines that are uncorrelated (or have low correlation) with benchmark returns.
- Design distinct mandates to maximize diversification benefits and allocate the tracking error to the mandates as a soft target[17] – *macro risk budgeting[18]*.
- Develop a fee schedule in accordance to the risk/return objectives.
- Determine the rules and procedures for manager's evaluation and replacement, i.e. periods and criteria of evaluation[19].
- Monitor risk allocation and usage by the managers.

In order to perform these tasks, a comprehensive and robust risk process was constructed that takes into account all the universe of risks allowed in the guidelines. Moreover a simulation tool, to test in an aggregate fashion all the possible exposures to all risks that arise from the guidelines was built in-house.

3.1. Introduction to the Risk models and techniques

3.1.1. Multifactor Risk Model

Banco de la República uses a commercially available multifactor risk model that accounts for linear and non-linear factors such as prepayment risk, convexity, credit quality, etc. where the returns dynamics of the returns of asset *i*, r_i, is:

---

[16] It is understood that at some point in time some mandates may have positive excess returns, whilst others may not. The objective is to obtain positive returns for all active management.

[17] A soft target is advisable as, when non-linear instruments (risks) are included in the universe of assets, risk measurement will depend on the underlying assumptions made in the risk model – i.e. prepayment speed – and therefore risk estimation may differ between the manager's model and the one used internally. We have called this the "Relativity of Risk Issue".

[18] Risk allocation could be performed completely by the reserves manager by creating risk specific mandates (an only MBS mandate for example). In this case the maximization of the diversification benefit is performed by the reserves manager entirely. Another alternative is to allow the manager to allocate the entire risk budget by giving him the possibility to expose the portfolio to all risks. Banco de la República implemented an intermediate strategy by taking into consideration the specific abilities of the managers, i.e. asset rotation or global.

[19] At present the evaluation cycle has a frequency of 3 years, although portfolios are continuously monitored (daily).

$$r_i = a_i + b_{i1}F_1 + b_{i2}F_2 + \cdots + b_{iK}F_K + e_i$$

$$= a_i + \sum_{k=1}^{K} b_{ik}F_k + e_i$$

Where a_i is the expected return of asset *i* or *the risk free rate*, b_{ik} are *factor loadings*, i.e. asset *i* sensitivity to factor *k* and e_i is the unexplained part of the returns.

Under non-arbitrage conditions financial assets prices implicitly include the same price of risk for each factor. Thus, supposing a 3-factor model, the price of risk or the returns expected by exposing the portfolio to these risks (given by λ_k, the return by each unit of risk exposure to factor K) are constant through all assets and the product $\lambda_k b_{ik}$ are the "factor risk premiums" for each of the K factors.

$$E\left[r_i\right] = \lambda_0 + \lambda_1 b_{i1} + \lambda_2 b_{i2} + \lambda_3 b_{i3}$$

$$= r_f + \lambda_1 b_{i1} + \lambda_2 b_{i2} + \lambda_3 b_{i3}$$

The expected return is then a function of the price λ_k of each risk that arises from the surprises that are generated by the *k* factors and the asset exposure b_{ik} to each of these factors.

Figure 5 – Aggregated Risk factors
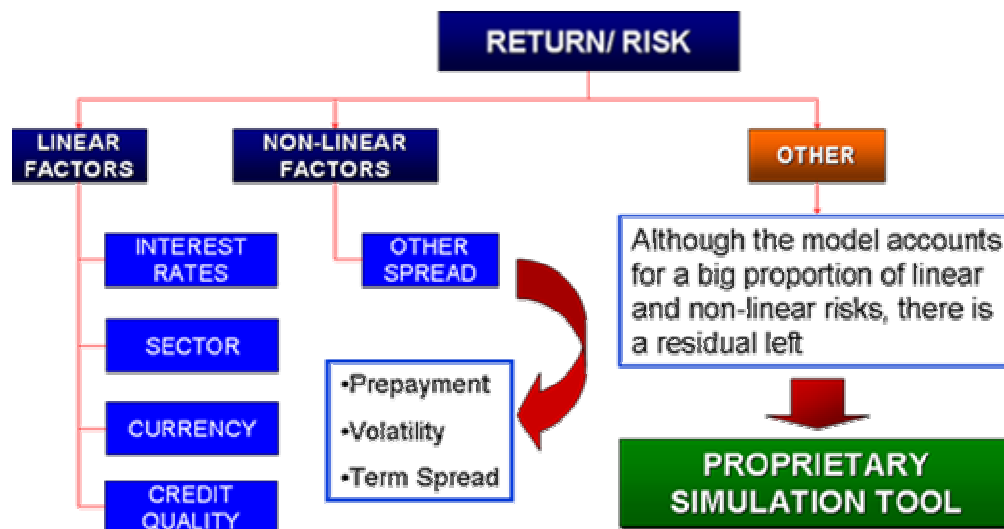
Although the multifactor risk model covers most non-linearity, a proprietary simulation tool was designed to test sets of guidelines, as well as to simulate possible future returns outcomes for the portfolios and benchmarks – see figure 5.

3.2.2. Simulation Analysis

3.2.2.1 Sets theory in portfolio construction

Portfolio and guidelines construction can be performed easily under sets theory representation. In particular, the intersection between assets, risks, guidelines, measurement (observer) functions and the resulting exposure to the risk factors given the explicit definition of the aversion functions – both for the asset allocation and the active management can readily be understood.

Define the universe of assets, risks and measurement tools (observer functions), as well as the set of guidelines as:

A : {Universe of assets}

> It constitutes all the assets available to the investor, i.e. emerging markets, equities, sovereign bonds, etc. Choose a subset $a \subseteq A$ of assets that are acceptable for asset allocation and a subset $a' \subseteq A$ of assets that are acceptable for active management. Subsets a and subset a' can be equal, complementary ($a \subseteq a'$) or distinct.

F : {Universe of risks}

> Includes all the universe of risk factors, i.e. prepayment risk, parallel curve shifts risk, country risk, etc. Choose a subset $f \subseteq F$ of risks that are acceptable for asset allocation and a subset $f' \subseteq F$ of risks that are acceptable for active management. Subsets f and subset f' can be equal, complementary ($f \subseteq f'$) or distinct.

G : {Set of guidelines}

> Starting from the sets of assets and risks defined by the Board of Directors (a,a',f,f'), combined with the explicit definition of the risk aversion a set of guidelines for active management is designed ($g \subseteq G$). in terms of market risk they should ensure both the maximum loss probability tolerated and the active management tracking error, searching orthogonality of returns. These may be unique or multiple if many mandates are desired.
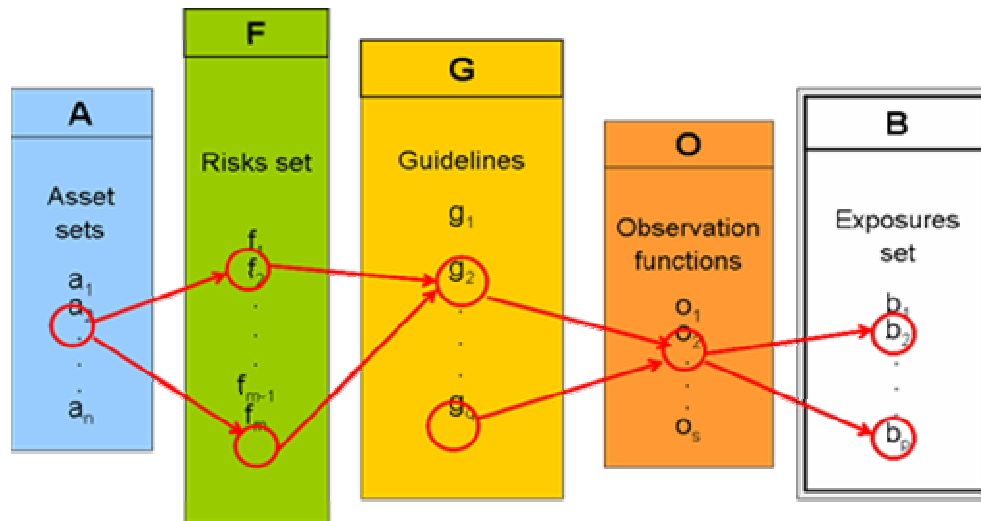
O: {Set of Observer functions}

> An observer function allows to measure specific characteristics for a given system, process or asset. For instance, for a plain vanilla government bond, duration estimation (an observer function)
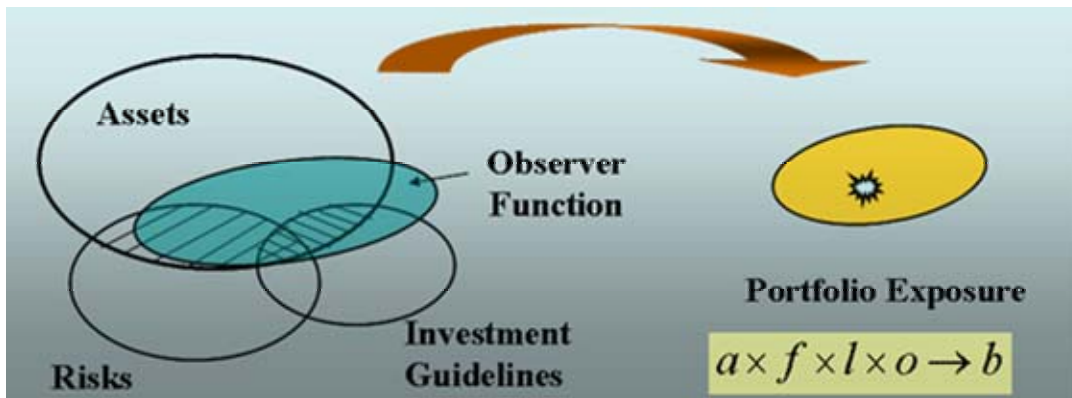
allows the investor to measure the risk exposure to the risk factor of parallel shifts of the curve. Or in an option, Gamma estimation (an observer function) is a measure of the exposure to changes in volatility. The set of observer functions $o \subseteq O$ is decided by the investor and is a function of his sophistication or interest. It is extremely important that adequate sets of observer functions are defined in order to measure all risks in a portfolio as, for example, measuring the risk of a MBS with an observer function set composed only of duration measures will underestimate the risk as this instrument is also exposed to prepayment risk and negative convexity. Thus the observer function set should include a function that measures the prepayment risk factor and the negative convexity factor[20].

The value of the duration estimation is in fact the exposure (the factor loading b_{ik}) of the asset i to the risk factor k, in particular parallel shifts of the curve. Thus from the combination of these sets, the set of exposures to the risk factors can be determined ($a \, x \, f \, x \, g \, x \, o \rightarrow$ b), where $b \subseteq B$ the universe of all possible exposures to the risk factors.

Figure 6. Mapping of assets and risks factors to risk exposures

---

It must be noted at this point that as asset complexity increases, implicit exposure to additional risks factors is taken and the potential differences between one's model and the external manager's model could increase from the use of distinct sets of observer functions.

Under this framework, simulations can easily be performed as any choice of assets, risks and guidelines can be mapped to risk factors' exposures using the proper observer functions, i.e. a portfolio is reduced to a set (a vector) of exposures to each risk factor. If guidelines include potential deviations from the benchmark the complete set of potential exposures can be created as a matrix of all the possible combinations of risk exposures achievable given the guidelines, subsets $\{b_1, b_2, b_3.., b_n\} \subseteq B$.

Simulations are then performed by generating the dynamics of factor returns for each risk factor, i.e. the returns series of the prepayment factor, etc. This is done in 3 ways: use of historical factor returns (how the exposures of the actual portfolio or guidelines would have behaved in the past), statistical (not necessarily normal) distributions are fit to the returns histograms or Montecarlo simulations can be performed[21]. Each risk exposure subset b is dynamically multiplied by the generated returns $r_{j,t}$ in order to generate the portfolio returns $r_{p,t}$ for at each point in time t, $r_{p,t} = b_j.r_{j,t}$.

3.2. Results for Active Management

The risk systems described convert sets of guidelines into portfolio exposures from which expected returns and risks can be measured. Thus, changes in guidelines can readily be evaluated, as well as the integral risk of the portfolios including most non-linearity and all possible outcomes from all the possible portfolios constructed by the managers. Moreover, the correlation between the resulting returns series for the active management guidelines and the benchmarks can be easily computed.

---

[21] These can be run keeping the implicit factor correlation.

Below some results are presented for the prevailing set of aggregate guidelines for Banco de la República.

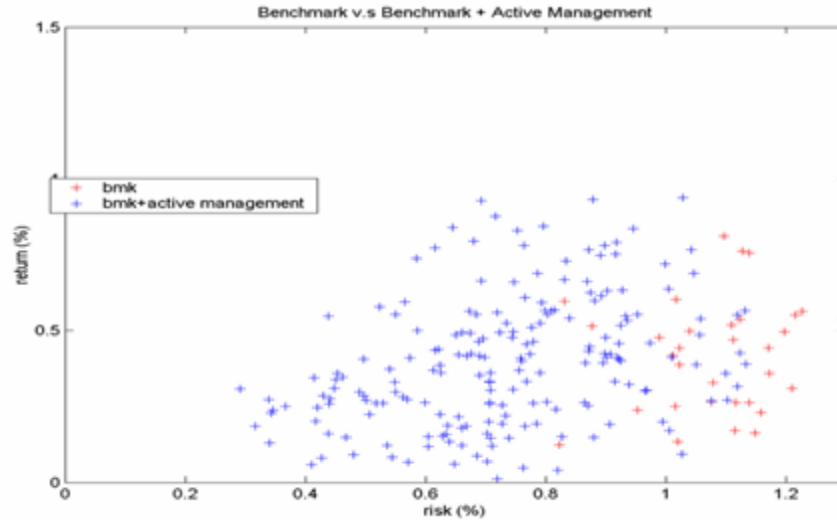Figure 7 – Benchmark and active management

Figure 7 shows some simulation results for: (1.) the benchmark and (2.) a set of portfolios that reflect the benchmark and the active management exposures arising from the guidelines. It is shown that the set of portfolios that include the active management tend to present higher returns, lower risk or a combination of both. This reflects: (i.) the benefits of including more asset classes to the portfolio and (ii.) that active management tends to cluster in the lower risk or higher return space, i.e. although active management could result in higher risk than the benchmark as new risk factors are allowed in the portfolio, this does not seem to be the case.

Using 500 potential sets of exposures (portfolios that can be constructed applying the active management guidelines[22]) and simulating returns for 32 years, the following histogram is obtained:

---

[22] Includes only active management strategies.

Figure 8 – Long Term Average annual excess return distribution

Average annual excess return distribution
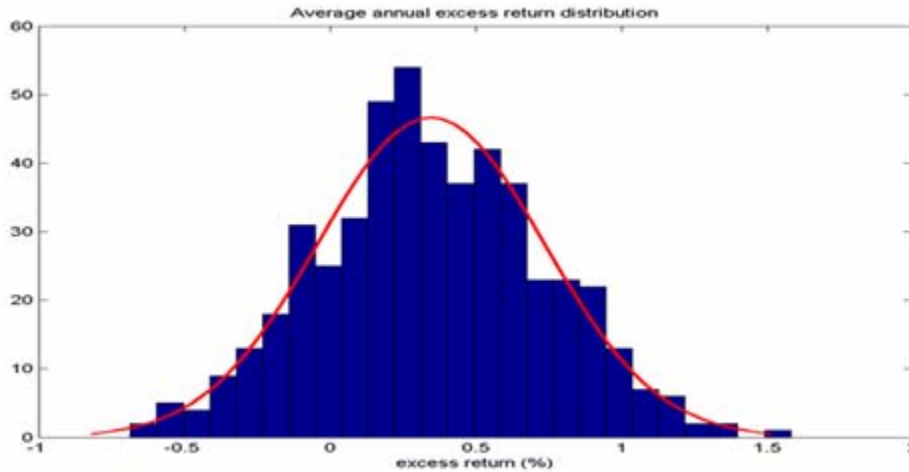
The resulting distribution has a positive skewness. On average on the long term, active management strategies allowed in the investment guidelines generate 30-40 basis points excess return to the portfolio per year with an implicit information ratio close to 1. The positive skewness is similar for a one-year horizon – see figure 9.

Figure 9 – Average annual excess return distribution

Annual Excess Return Distribution
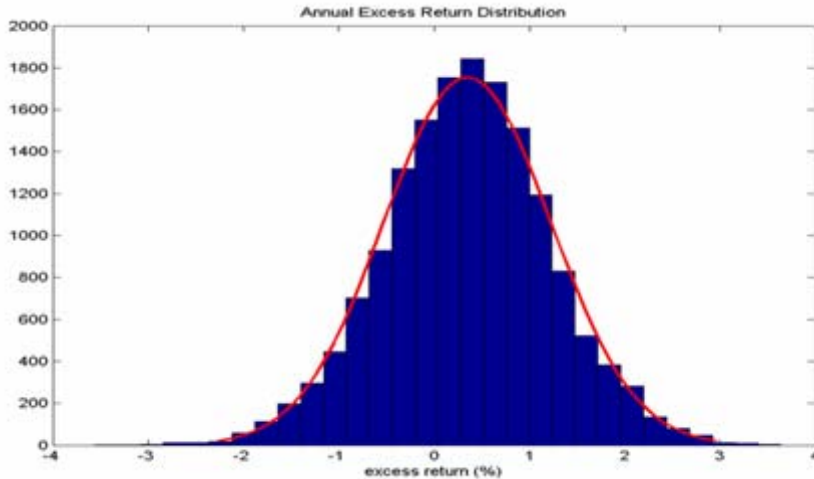
However, the expected volatility in the one-year horizon increases so that the implicit information ratio is near to 0.5. On average, active management strategies allowed in the investment guidelines generate a tracking error of 0.7%-0.8% per year – see figure 10[23].

---

[23] The reader must keep in mind that the tracking error objective is 100 b.p.

Figure 10 – Annual tracking error distribution
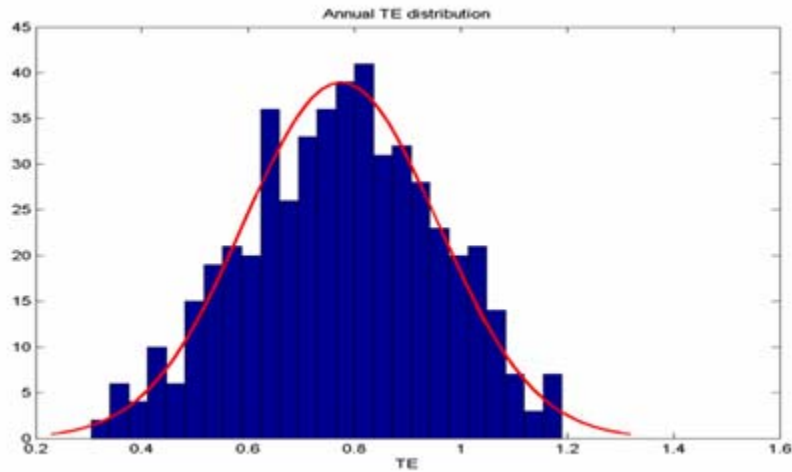
Finally, the correlation between active management exposures and benchmark returns is presented in figure 11. It can be observed that most correlations are clustered near 0 and the 95% confidence interval includes low correlations between -0.35 and 0.34.

Figure 11 – Correlation distribution between benchmark and active management
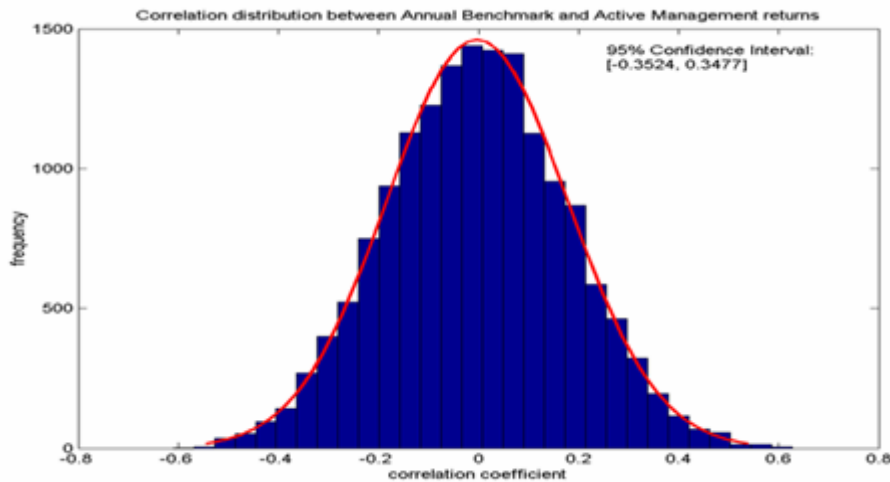

From these results it can be inferred that an active management program based on a macro-risk budgeting process, in which the universe of risks taken in the benchmark can differ from the ones allowed in active management, can yield higher returns while exposing the portfolio to lower absolute overall risk if guidelines are designed in order to obtain excess returns that are mostly independent of benchmark returns.

It must be complemented however with a minimum threshold of returns over the benchmark that is formally related to the fees schedule. Banco de la República

has designed a mixed fixed and performance fees schedule. Figure 12 shows an example of such a system of fees.

Figure 12 – Performance Fees Schedule

Reference Performance Fee Schedule
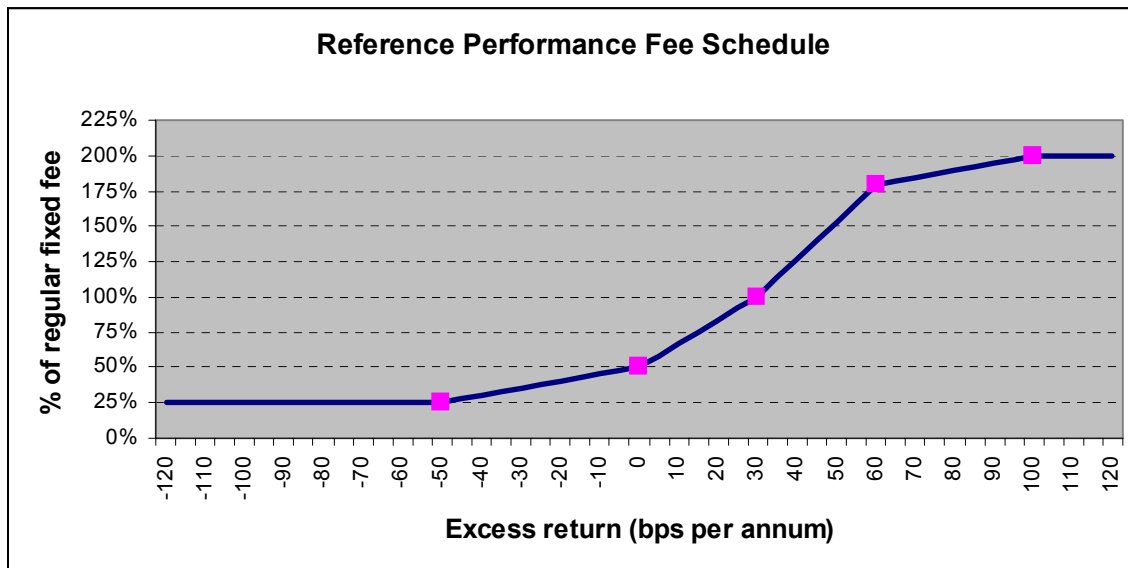
For excess returns lower than -50 basis points per year against the index, the fee will equal a fixed value that corresponds to a portion of the fixed fee normally charge by the manager for a portfolio with the characteristics of the one to be delegated. For intermediate excess returns the scale depends both on the generated and the expected excess returns for the manager. For an excess return after some level, say 60 basis points, the performance fee stabilizes in order to diminish the incentives for risk taking by the manager. Recall that this combined with a coherent tracking error soft target.

4. Conclusions

This document provides insight on the asset allocation process and the active management programs designed by Banco de la República for the management of the international reserves. It was shown that an explicit definition of the market and liquidity risk aversion by the highest level of decision-making, the Reserves Committee, as well as the universe of assets and risks acceptable facilitates the asset allocation and the active management processes in a context of macro risk budgeting.

The construction of active management guidelines is a complex process that must take into account the objectives of excess return generation, as well as the increase in risk exposure to obtain it. An alternative that allows to minimize the expected risk while increasing returns is to create an active management program that generates excess returns orthogonal (independent) of benchmark

returns and that is in turn consistent with the tolerated active management tracking error. Figure 13 summarizes the objectives, constraints and policies.

Figure 13 – Summary Investment Objectives, constraints and policy
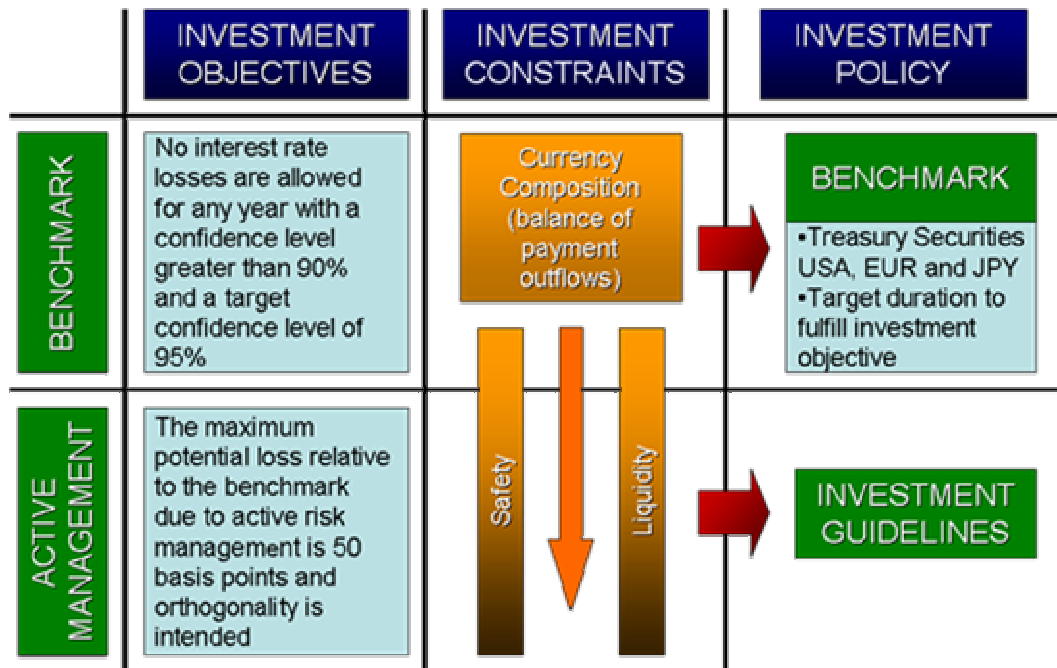
It was also shown that Banco de la República's active management was designed to have positive skewness and very low correlation with benchmark returns, whilst creating the proper incentives for the managers to actively use the risk budget with tracking error and capped performance fees that are consistent with the expected returns against the benchmark.

In addition, distinct mandates and management styles enhance further the diversification and allow managers to use risk-budgeting based decision processes to maximize diversification benefits. The potential variability in the diversification benefit is buffered by the intermediate tranche (passive portfolio) with the diversification benefit only changing slightly; say from 52% for the stable tranche to 51% for the overall reserves portfolios. The size of the intermediate tranche is defined such that added to the working capital they cover one-year intervention needs with a confidence interval of 99%.

Figure 14 presents a diagram that summarizes the liquidity and risk policies. Recall that an additional policy to liquidate the stable tranche when necessary complements both policies.

Figure 14 – Liquidity and Market Risk Policies
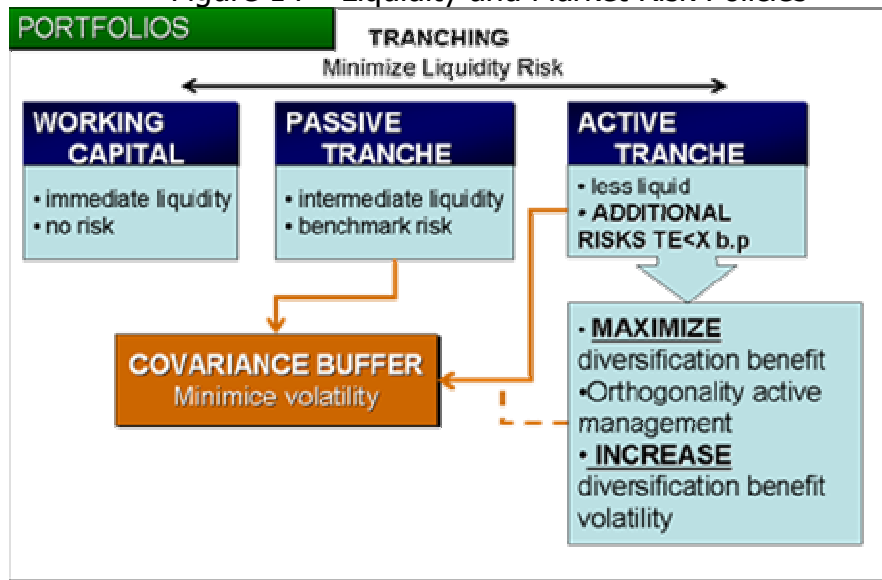
Finally, for consistency, the decision process for the internally managed active portfolio is also based on the risk budgeting approach.