MANAGING UNCERTAINTY WITH DAMS*: FROM ASSET SEGMENTATION TO PORTFOLIO MANAGEMENT

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*Diversification Across Macroeconomic Scenarios
Abstract

Recent history has provided an excellent laboratory to test the robustness of investment processes. Despite claims of diversification, most balanced portfolios and pension funds were concentrated on equity risk and, consequently, key investment decisions ultimately consisted in a single binary bet: buy or sell equity. This led to pro-cyclical returns and generated a broad debate on the effectiveness of active management in generating performance in difficult market conditions.

In 2011 AMUNDI Italy decided to revise the asset allocation process starting with a reinterpretation of portfolio diversification in terms of Diversification Across Macroeconomic Scenarios (DAMS). The main ambitions of DAMS are: (i) to explain complex patterns of large investment universes in terms of a limited number of factors and (ii) to catch up the market risk premium without being exposed to specific macroeconomic dynamics and asset idiosyncratic risk. In a previous study we illustrated the DAMS principle and implications in terms of asset segmentation. The aim of this paper is to move towards a new framework for multi-asset portfolio management, what we call DAMS second generation. DAMS first generation is enriched with new concepts and tools that enable us (i) to infer market expectations on relevant macroeconomic factors (growth and inflation) and global risk premium, and (ii) to properly manage portfolios via strategic and tactical asset allocation.

Keywords: asset allocation, diversification, risk-parity, factor model, inflation hedge, macroeconomic factors, rising/falling scenarios, asset polarization, multi-asset portfolio
Introduction

In the industry, strategic asset allocation is usually achieved by means of the Markowitz model (1952). As reported in the literature, the mean-variance framework suffers from many drawbacks, in particular significant dependence on errors in input parameters (Merton, 1980) and the lack of diversification. In Pola (2014) we provided some evidence that, in a reasonable range for the volatility of diversified allocations (from 0 to 10% annualized figures), efficient portfolios exhibit only half of the available diversification. Some advances¹ in strategic asset allocation have been achieved through Bayesian approaches (Black-Litterman, 1991), Robust Asset Allocation (Meucci, 2007) and entropy techniques (Pola, 2014).

Since the beginning of the new millennium, financial markets have experienced several crises. The traditional 60/40 allocation (equity/bond) has delivered poor results. We identified three main reasons for this:

- **Risk allocation.** Most of the portfolio risk was concentrated on equities.
- **Portfolio management.** Investment decisions were ultimately focused on equities: despite the claim of diversification, portfolio decisions consisted mostly in timing the equity market.
- **Macroeconomic scenario exposure.** The 60/40 allocation is implicitly biased towards a disinflationary growth scenario. Even though rates declined following the disinflationary trend in developed economies, growth in the same area was disappointing, thus penalizing equity investments, and consequently asset allocations that were concentrated on equity risk.

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¹ Instability due to parameter uncertainty in the Markowitz model has been addressed through Bayesian approaches (Black-Litterman, 1991) and Robust Asset Allocation (Meucci, 2007). Portfolio concentration on few assets can be alleviated by entropy techniques: as shown in Pola (2014), entropy metrics allow us to swap a negligible amount of the portfolio’s expected return with a huge increase in portfolio diversification.
Poor performance in the 60/40 allocation raises questions as to the ability of investment professionals to forecast asset returns and the effect of incorrect assumptions on expected return in the traditional mean-variance framework (Jobson and Korkie, 1980; Best and Grauer, 1991; Chopra and Ziemba, 1993). In de Laguiche and Pola (2012) we argued that today it is more difficult to forecast the asset risk premium\(^2\).

The industry’s response to the rising uncertainty in financial markets was to move towards forecast-free portfolio construction schemes (Russo, 2013; Choueifaty and Coignard, 2008; Clarke et al, 2013, Martellini, 2008; Maillard et al, 2010). These approaches rely on a risk model and, therefore, suffer from estimation and model risk. In Pola (2014) and in Pola and Zerrad (2014b) we show that the estimation error of diversification measures is very large in some cases and mostly due to errors in correlation. Moreover we show how correlation is strongly affected by (hidden) macroeconomic factors, consequently the above-mentioned forecast-free investment processes are implicitly affected by macroeconomic shifts. Indeed the main problem with traditional risk-based approaches is that the portfolio’s implicit macroeconomic bias is not properly managed.

This observation led us to move beyond traditional statistically-based risk-parity portfolios towards an investment philosophy that allows us to better understand the true drivers of asset return. The world is continuously evolving: investment philosophy should be adaptive to changes in the asset risk-return properties. In 2011 AMUNDI Italy decided to revise the asset allocation process, starting from a very simple principle: asset returns are mainly affected by changes in expectations of macroeconomic and stress factors. Indeed, stocks move not because of low or high growth but mainly because growth is above or below expectations. This intuition led us to develop a new way of looking at portfolio diversification in terms of Diversification Across Macroeconomic Scenarios (DAMS). The main benefits of DAMS are:

- limiting portfolio exposure to unexpected macroeconomic environments (e.g. 2000-2012 falling growth expectations, 1965-1981 rising inflation expectations);
- unfavorable inflation scenarios are also considered and managed;
- it relies on a portfolio construction that is robust to estimation risk;
- it clarifies the (hidden) macroeconomic biases underlying the investor asset allocation in advisory activities.

DAMS represents an opportunity to enlarge the concept of diversification, going to the core and hidden drivers of asset return.

\(^2\) The main reasons for this are: (i) many financial variables are in uncharted territory not seen in many decades, and it is not clear when and if they will return to pre-crisis levels; (ii) the increase in macroeconomic volatility makes it difficult to apply the equilibrium-based approach for estimating asset returns; (iii) the unconventional policy of central banks may disconnect asset prices from their fundamentals.
In Pola (2013a) and Pola (2013b) we introduced the main ideas behind DAMS and we discussed the implications in terms of asset segmentation, strategic asset allocation and portfolio diagnosis in advisory activity. For the sake of simplicity, we refer to the DAMS framework presented in these papers as DAMS 1.0.

In the current work we move our focus to portfolio management. We show how this enlarged concept of diversification is exploited for effectively managing multi-asset portfolios. In particular we set up a new framework for interpreting financial markets in terms of DAMS factors and build an investment process that allows us (i) to take an active position on macroeconomic dynamics and (ii) to select the most appropriate assets to hedge specific scenarios. In the paper we refer to this evolution as DAMS second generation or DAMS 2.0. The main innovations of DAMS 2.0 with respect to DAMS 1.0 are

- we replaced the stress factor with the global risk premium, a wider measure for investor risk appetite;
- we set up tools for reading financial market dynamics throughout the DAMS factors;
- we complement the polarization analysis with the betas to DAMS factors;
- we provide two complementary portfolio construction schemes, a bottom-up and a top-down approach;
- we disentangle the diversification contributions due to DAMS factors and the asset idiosyncratic residuals.

The paper is organized as follows. In section I we critically evaluate the effectiveness of correlation as a tool for building asset allocation. In section II we introduce the main ideas behind DAMS. In section III we review the implications in terms of asset segmentation. In section IV we introduce the DAMS second generation framework. In section V we discuss the characteristics and determinants of the global risk premium. In section VI and 7 we discuss the implications in terms of portfolio management: in section VI we present the way we look at the market according to DAMS, in section VII we illustrate how we build the portfolios. In section VIII we present the applications of DAMS in portfolio diagnosis in asset allocation advisory. Last section concludes with some final remarks. Appendix A offers a guide through the literature on DAMS and Appendix B reports the polarization coefficients of the main markets in the US.

I - Correlation is unreliable in quantifying diversification among assets

According to common sense, correlated assets do not offer diversification because they tend to move synchronously. This statement is misleading; in this section we discuss weakness of correlation as an input for asset allocation by means
of three arguments that are macroeconomic, statistical and based on portfolio construction considerations.

The first argument against correlation as an ingredient of the asset allocation process is that correlation itself is not stationary in time: sometimes it moves from negative to positive figures or vice versa; hence assets that do not offer diversification today may be diversified in the future following a movement in the correlation pattern. In Pola (2014) we show that macroeconomic shifts can help us to interpret the phenomenology of correlation. Chart 1 allows us to relate the historical correlation (10-yr trailing windows; quarterly observations) between nominal bonds and equities in the US with the YoY inflation rate:

- from 1881 to 1964 inflation was highly unstable, ranging from -15% to +20%, the correlation between bonds and equities was unstable as well;
- from 1964 to 1998 inflation moved to very high levels in the first part (until 1981), then it calmed down, though it remained at positive levels; in the same period correlation also moved into clearly positive territory;
- from 1998 to 2013 inflation declined to stable low figures and the correlation became negative.

**1- Bond-equity correlation versus inflation rate (US 1881-2013)**

**Historical correlation (10 yr trailing windows)**

**YoY inflation rate**

Source: Amundi Research
This empirical evidence suggests that rising inflation reduces the diversification between bonds and equities, making them positively correlated. The main conclusion is: instead of suffering from instability in correlation, it is wiser to move towards a macroeconomic factor approach that allows us to properly manage macroeconomic shifts and, hence, changes in the asset risk-return properties.

A second argument comes from statistical considerations: what is related to synchronous performance is dependency among assets and not correlation. In Pola (2013c) by measuring the Kullback-Leibler (KL) pseudo-distance (Cover and Thomas, 1991), we were able to show clearly the inconsistency between correlation and synchronous performance. In chart 2 we report the analysis between nominal bonds and equity in the US from December 1953 to December 2013. All the spots in the green box refer to observations on 3-yr trailing windows, according to which equity and nominal bond are independent (95% confidence level (CL)) whereas the correlation coefficient indicates a significant positive relationship between them (95% confidence level). These observations would have led to a wrong assessment of diversification between nominal bonds and equity, and consequently to a wrong asset allocation according to the mean-variance framework and some risk-based strategies.

2- Inconsistency between asset correlation and asset synchronous performance

Source: Amundi Research
Thirdly in Pola (2014) we showed that uncertainties in correlation may produce large errors in the portfolio construction of some risk-based approaches. By analyzing many entropy-based diversification measures and the diversification ratio through out-of-sample backtesting and Monte Carlo experiments, we concluded that in traditional forecast-free approaches portfolio rebalancing is triggered, most of the time, by noise in time-series (“bad portfolio turnover”) and not from a real structural change in the asset risk-return properties (“good portfolio turnover”): estimation risk is sufficiently large as to prevent us from using some diversification metrics for portfolio construction. In the same work we argued that for the practical management of risk-based strategies the risk model is crucial to alleviate the effects of bad portfolio turnover.

From the three above-mentioned considerations, it is clear that building asset allocation on correlation might lead to unstable portfolios. This convinced us to rethink the asset allocation process from a different perspective.

II - The DAMS principle

The economic scenario methods reinterpret asset dynamics in terms of macroeconomic, fundamental and market stress factors. Traditional factor approaches consist in analyzing portfolio returns according to regression-based tools that relate asset returns to factor dynamics: the implicit assumption is that asset returns can be explained in terms of the levels of factors (e.g. inflation and growth rate). Indeed as documented by many research papers and white papers from asset managers (Winkelmann et al., 2012), this approach is poorly supported by empirical data. Moving from the levels of factors to differences in levels, the picture changes significantly.

The main idea behind DAMS is that:

asset price dynamics can be largely explained in terms of changes in expectations of macroeconomic variables (inflation and growth) and market stress.

Growth and inflation are crucial because the value of an investment is mainly affected by the volume of economic activity (growth) and its pricing (inflation). We added the market stress because sometimes it plays a major role in determining asset prices.

Macroeconomic factor approaches in the literature also include other variables, e.g. unemployment rate, consumption, production, interest rates, credit spread, convexity, default risk, equity style factors, implicit volatility, and liquidity. We argue that:

3 In order to test this finding, in Pola (2014) we regress the S&P 500 returns from December 1954 to March 2014 with respect to quarter variations of real GDP and the Consumer Price Index as regressors: we found a very weak relationship ($R^2 = 2.18\%$).
• many of these variables are redundant\textsuperscript{4}, and
• more importantly the ambition of DAMS is to explain complex patterns of 
  large investment universes in terms of a limited number of factors.

Our parsimonious choice to limit the number of factors, we believe, is one of the 
main strengths of the DAMS framework. Moreover this choice is supported by 
empirical evidence that DAMS factors are able to explain most of the asset return 
variance (see section VIII for some empirical evidence).

The main innovation of DAMS with respect to traditional factor-based 
approaches is the belief that variations in factors are more relevant than the 
levels themselves. Indeed we move from the first derivatives (e.g. inflation rate) 
to the second derivatives: acceleration and (resp.) deceleration are represented in 
terms of rising and (resp.) falling scenarios\textsuperscript{5}. Within the DAMS framework, the atoms 
of asset allocations are rising/falling inflation, rising/falling growth, and rising/falling 
stress scenarios.

Chart 3 reports the alternating rising/falling regimes in US inflation since 1950. The 
chart clearly shows that even though the CPI rose markedly from 1950 to 2012, 
rising and falling scenarios were about equally likely.

As detailed in Pola (2013b), while statistical approaches (e.g. Principal Component 
Analysis) permit one to determine perfectly uncorrelated factors, the economic 
scenario methods cannot guarantee this property: in this case orthogonality 
should be verified on empirical data. We carried out the study in the US, quantifying 
independence among rising/falling scenarios under the Kullback-Leibler metric\textsuperscript{6}.

\textsuperscript{4} For example in Pola (2013b) by measuring the Kullback-Leibler pseudo-distance, we 
demonstrated that GDP is largely redundant with the ISM Manufacturing PMI.

\textsuperscript{5} See appendix D in Pola (2013b) for a formal definition of rising/falling scenarios.

\textsuperscript{6} We refer the interested reader to section II and appendix B of Pola (2013b) for more technical 
details about the application of the Kullback-Leibler pseudo-distance to test orthogonality 
of rising/falling scenarios.
We concluded that:

- Orthogonality does hold as a first approximation.
- Deviations from the orthogonality can be partly explained in terms of the historical sample taken for the analysis (1953-2012): in order for the estimation to be reliable, the sample period should be neutral in terms of macro dynamics; the inflationary period in the ‘70s and ‘80s may have had a strong impact on the estimation\(^7\).

We prefer to work with quasi-orthogonal factors that are easily related to macroeconomic factors and stress rather than using perfectly orthogonal axes (statistical-based) that are unstable over time and, sometimes, difficult to interpret. In contrast we should point out that independence might hold only as a first approximation: possible deviations from orthogonality should be taken into account in the portfolio construction, as second-order corrections to the main frame.

We conclude this section with a remark on the factors and their relationship with the different economic areas and markets. We believe that in a more and more globalized market and economy, the key factors should also have a globalized nature; for this reason we prefer to look at factors that represent global inflation, global growth and the global market stress. We are aware that in this way local dynamics are not taken into account, however it is wiser to design the main frame of strategic asset allocation in terms of global factors and, then, to treat local specificities by taking active decisions based on that, or conversely by diversifying them away (e.g. by means of entropy techniques as shown in Pola (2014)) in case of low conviction.

**III - Asset segmentation according to DAMS**

In order for the approach to be effective for asset allocation it is crucial to establish the relationship between asset return and factor dynamics. In chart 4 we report the conditional performance analysis of the US Treasury excess returns over the T-bill 3-months with respect to the rising/falling scenarios: we first divided the bond quarter returns into the factor rising and the falling samples and then we computed the average of each set. The chart reports the conditional average for each rising/falling scenario and the unconditional average as well.

The chart shows that nominal bonds polarize clearly to falling inflation, falling growth, and rising stress scenarios. However dispersion within each sub-sample is not negligible (not shown here; see Pola, 2013b).

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\(^7\) As shown in de Laguiche and Pola (2012), the last century has been characterized by inflationary periods, while by conducting a deeper historical analysis in the US and Sweden it has been proved that inflation and deflation were more balanced.
The above-mentioned naïf approach gives us some indications, however we need to move through a more robust statistical method. **In order to get a more accurate measurement of asset sensitivity to the DAMS factors, we developed a new statistical tool: the polarization coefficient.** The polarization coefficient\(^8\) varies in the interval \([-1, 1]\), and it quantifies the attitude of the asset to polarize towards rising or falling scenarios:

- a figure close to +1 indicates high sensitivity to rising scenarios (e.g. equity and growth),
- a figure close to -1 stands for high sensitivity to falling scenarios (e.g. nominal bonds and inflation);
- figures with an absolute value below 0.70 are not particularly relevant.

The absolute value of the polarization coefficients corresponds to the probability of assets to polarize to specific scenarios; the sign of polarization coefficients indicates preference for rising (+1) or falling (-1) scenarios\(^9\). It is worth stressing that despite the analogy, the polarization coefficients are different from standard correlation coefficients.

An effective way to represent asset polarization is to scatter plot them in a cube expressing polarization to inflation, growth and market stress. In Pola (2013b) we conducted an extensive study in the US: we analyzed 139 assets/strategies including domestic and international traditional assets (nominal bonds, inflation-

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8 We refer the interested reader to appendix D of Pola (2013b) for a formal presentation of the formalism. The polarization coefficients are computed according to a parametric approach (based on the difference in means of asset returns in the rising and falling scenarios sub-samples) and a non-parametric method (bootstrap-based) to ensure robustness of the analysis.

9 For example the polarization coefficients (parametric evaluation; for more details see Pola, 2013b) for the nominal bond in chart 4 are -99.88%, -99.65%, and 99.67% respectively for inflation, growth, and stress. These figures indicate a high probability of polarizing (greater than 99%) and preferences of nominal bonds for falling inflation, falling growth and rising stress.
linked bonds, credit, equity, fx-rates), alternative investments (commodity, hedge fund strategies, trend following, CTAs) and dynamic strategies\(^\text{10}\).

In chart 5 we report the main assets in the inflation-growth polarization plan, which is obtained by integrating away the stress dimension. Each spot in the plan represents an asset class: the closer they are to the border, the more sensitive they are to variations of inflation and growth; conversely the closer they are to the center, the more insensitive they are to macroeconomic dynamics. **The plot shows that assets react significantly when stimulated by inflation and growth factors.** Indeed 91% of assets present at least one factor with a polarization coefficient greater than (in absolute terms) 0.70 (significant relationship), and 62% of the sample has at least one polarization coefficient greater than 0.90 (very significant relationship).

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<th>5- The inflation-growth polarization plan</th>
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We briefly summarize below the main findings:

- nominal bonds are an excellent hedge to falling inflation, falling growth, and rising stress;

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\(^{10}\) **In appendix B we report the polarization coefficients for the main markets in the US.**
• inflation-linked bonds are an excellent hedge against rising inflation; the all maturity index reacts moderately to falling growth scenarios, whereas the 1-5 bucket is rather independent of growth; their polarization to market-stress is weak;

• credit markets present an inhomogeneous pattern; corporate IG tracks the behavior of nominal bonds with respect to inflation and growth, but independent of market stress; corporate HY are rather independent of inflation, moderately related to rising growth, and strongly related to falling stress scenarios; Emerging Market Debt in local currency (EMDL) tracks behavior of commodities, whereas Emerging Market Debt in hard currency (EMDH) is rather independent on inflation and growth;

• equities are an excellent hedge for rising growth and falling stress scenarios, to a lesser extent for falling inflation environments11;

• commodity CRB is an excellent hedge in case of rising inflation, rising growth, and falling stress; gold presents similar biases but its signals are weaker; agriculture is rather independent of growth and stress;

• volatility tracks the behavior of nominal bonds;

• most fx-rates polarize to rising inflation, rising growth, and falling stress;

• hedge fund strategies present an inhomogeneous pattern; most exhibit a behavior similar to commodities; they rarely hedge against market stress, the only exceptions are offered by macro systematic diversified and short bias strategies;

• trend following and CTAs mostly track nominal bonds, thus hedging in case of rising stress.

In Pola (2013b) we conducted some additional tests to verify the robustness of the analysis. The most relevant results are:

• We investigated whether asset return and factor dynamics were synchronous or if there were any significant time-lags; our study confirmed that asset return discounts factor dynamics and, hence, they respond synchronously with respect to rising and falling scenarios.

• We studied the polarization with monthly-based and quarterly-based time-series: the analysis showed that, in some cases, the results are not entirely consistent, signaling that for certain assets the dependency between macro factors and return is tuned to a shorter time frame.

• We documented some differences in the evaluation of the polarization coefficients according to parametric and non-parametric approaches in assets that are significantly leptokurtic or asymmetric in return distribution.

11 As discussed in Pola (2013a) stocks and equity strategies can be segmented into six clusters, including commodity-like stocks and nominal-bond-like beta-neutral strategies.
• We verified robustness with respect to a different segmentation of macroeconomic scenarios; we introduced a neutral scenario for non-significant rising and falling scenarios and we found consistent results with the rising/falling settings.

Asset segmentation according to DAMS has important consequences for asset allocation: understanding the relationship between asset return and macroeconomic and stress factors is crucial in order to avoid negative impacts coming e.g. from long-term downward shifting in growth or upward shifting in inflation, which could seriously damage portfolio long-term performance.

IV - Moving towards DAMS second generation

Previous literature on DAMS\(^\text{12}\) mainly focused on the implications of the DAMS principle in terms of (i) asset segmentation, (ii) strategic asset allocation and (iii) portfolio diagnosis in asset allocation advisory. In this section we describe the evolution of DAMS to a second generation framework that is designed for real management of multi-asset portfolios\(^\text{13}\). For the sake of simplicity we refer in the following to DAMS 1.0 as the approach reviewed in sections 2 and 3, and to DAMS 2.0 or DAMS second generation as the new framework.

DAMS 1.0 was mainly characterized by:

• three factors, inflation, growth and market stress;

• the polarization coefficient, as the main tool to assess asset (and portfolio) sensitivity towards macroeconomic and stress scenarios.

The main goal of DAMS 2.0 is to enrich DAMS 1.0 with tools that allows us (i) to assess what financial markets are “expecting” in terms of macro variables and (ii) to build multi-asset portfolios in line with strategic and tactical views.

The main innovations in DAMS 2.0 with respect to DAMS 1.0 are:

1. Despite the claims of many index providers, we registered that market stress indicators are often biased towards equity markets; in searching for a more cross-sectional metric we move towards the global risk premium\(^\text{14}\), a more general measure of average appetite for investments. Intuitively we argue that stress is one of the important variables influencing the global risk premium, but not the only one. For example, the implied volatility (the usual indicator for evaluating stress in equity markets) has a clear impact on the equity risk

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12 See Pola (2013a) and Pola (2013b), as reviewed in sections 2 and 3.
13 The DAMS investment process is in place in a range of AMUNDI Milan’s flexible funds since December 2011.
14 As there is not a reliable exogenous indicator for the global risk premium, we prefer to avoid to compute the polarization coefficients. As it will be clearer in the following, sensitivity to risk premium is measured by betas.
premium\textsuperscript{15}, but it is not the only determinant. In chart 6 we compare the implied premium for US equity as computed in Damodaran (2013) with the VIX index: the dynamic of the two variables is not always homogeneous. Therefore, the new set of DAMS factors is composed by growth, inflation and global risk premium.

2. In order to interpret financial markets in terms of DAMS factors, we develop two complementary approaches: (i) portfolio substitutes (proxies) for the factors and (ii) the implicit rising/falling scenario probabilities. While the proxies highlight the temporal dynamic of factors, the implicit probabilities are more appropriate for achieving a hierarchy among factors. Moreover the proxies are more adequate to describe long-term dynamics than the implicit probabilities. The introduction of the proxies for the expectations gives us a unique insight into the macroeconomic dynamics, our signals are directly related to the financial markets with a daily quotation. We are able to quickly detect what the market is discounting and consequently take decisions on portfolio management throughout tactical asset allocation. Potentially we are in the position to exploit anomalies in asset prices and persistency in the behavior of the economy. Macroeconomic figures are lagging indicators of the economic activity and surveys (e.g. PMI) provide only a partial picture. The proxies for the DAMS factors and the implicit probabilities allow us to have more timely and perspective information on the economy than standard economic data can provide.

3. The polarization coefficient is a measure of significance and direction (rising/falling) but it does not quantify the intensity: it is similar to the R\textsuperscript{2} in a traditional regression; following this analogy, the missing information with the polarization coefficient is the beta. We complement the polarization analysis with the betas to DAMS factors.

\textsuperscript{15} For a detailed analysis on equity risk premium we refer the interested reader to Damodaran (2013).
4. In order to effectively manage portfolios we provide two complementary portfolio construction schemes: a bottom-up and a top-down approach. The DAMS portfolio construction is robust with respect to estimation risk (see Pola, 2014) as it does not depend on asset volatility and correlation.

5. The DAMS proxies allow us to disentangle the diversification contributions due to DAMS factors and the asset idiosyncratic residuals.

The main applications of the enriched DAMS framework pertain to three different aspects:

1. **Strategic asset allocation** can be defined according to desired exposure to macro factors and global risk premium; in particular we stress that
   - long term behavior of the economy is uncertain, this risk can be diversified away;
   - conversely, portfolios that hedge a specific economic risk (e.g. inflation risk) can be built;
   - through the portfolio exposure to the global risk premium, an implicit expected return can be inferred; this is crucial for financial planning and ALM or LDI approaches for asset allocation;
   - moreover many investment strategies, including hedge funds, could be replicated using the DAMS proxies.

2. **Tactical asset allocation** can be tilted in response to macroeconomic shifts, in particular
   - proxies for the DAMS factors and the implicit probabilities allow us to quickly interpret the market, and to revisit the allocation in a timely manner;
   - specific risks are taken into account either by taking active portfolio positions (e.g. the recent bull market in Euro peripheral bonds), or diversifying it away in case of low convictions (e.g. the local inflation dynamics are not homogeneous across different countries).

3. **Portfolio diagnosis in asset allocation advisory** can be approached from a different angle; the main innovations with respect to traditional approaches are:
   - implicit portfolio macro exposure is revealed;
   - diversification is decomposed into different risk sources (macro diversification is distinguished from diversification in asset idiosyncratic risk);
   - portfolio is revised through an optimization process that takes into account the target macro exposure and portfolio constraints.

The goal of the next sections is to deepen the concepts and applications of the DAMS 2.0 that have been introduced in this section.
V - A missing factor: the global risk premium

The main assumption in finance is that riskier investments should have higher expected returns than safer investments; this is intuitive and it is central to risk-return models. According to these models, the asset’s expected return can be written as the sum of the risk-free rate and a risk premium. The disagreement remains on how to measure the risk, and how to convert the risk into an expected return.

Typically the risk premium is analyzed separately for each asset class (the equity risk premium is one of the most studied in literature). We question whether there is a global risk premium that is common to most of all assets. Collectively investors are in the position to choose which risk premium they prefer and, in the case of differences between premiums, arbitrages are possible and naturally executed. Because the sources of the risk premium are mainly the same, in this “arbitrage-free” environment, a global risk premium should emerge.

The main characteristics of the global risk premium are:

- The risk premium is the premium required by investors for an average risk investment, and hence, the discount that they apply to expected cash flows with average risk. When risk premiums rise, a higher price for risk is charged by investors and therefore lower prices for the same set of risky expected cash flows are paid.
- The risk premium is not company specific or asset specific but affects the expected return on all risky investments. As a result, the choice of a risk premium may have much larger consequences for value than security-specific risk.
- The risk premium reflects fundamental judgments of riskiness of an economy/market and the price that is attached to that risk. It affects the expected return of every asset and the value that is estimated for that investment.
- It moves over time.
- It is linked to investors’ risk aversion, the amount of liquidity in the system and the state of functioning of the financial system.

The risk premium has also an important implication in terms of defining investment and policy because it is directly linked to the potential investment return from the markets and it also serves as a reference for assessing values for different types of services and products.

16 Many of the ideas presented in this section are inspired by the work of Damodaran in 2013; we believe that concepts illustrated by the author on equity risk premium can be generalized to a cross-sectional risk premium.
17 For a detailed analysis on equity risk premium we refer the interested reader to Damodaran (2013).
There are several determinants of risk premiums, we report the most relevant below:

- **Risk Aversion and Consumption Preferences.** The most critical determinant is investor risk aversion. Risk premiums increase as investors get more risk averse. Even if risk aversion is not homogeneous among investors, the risk premium is determined by the collective risk aversion. While there are numerous variables influencing risk aversion, the most relevant are investor age and their preference for current consumption.

- **Economic Risk.** The health and predictability of the overall economy play the major role, the risk premium should be lower in an economy with, for example, predictable inflation, interest rates and economic growth than in one where these variables are volatile.

- **Liquidity.** High transaction costs and large discounts on estimated value lead investors to pay assets at a lower price, demanding a large risk premium. The cost of illiquidity can vary over time, and significant effects on risk premiums can be produced by small variations. When economies slow down and during periods of crisis, the cost of illiquidity seems to increase.

- **Information.** The quantity (and quality) of information available to investors is one of the determinants that affects the risk premium level. The higher the quality of information provided to investors, the lower the required risk premium should be and vice-versa.

- **Catastrophic Risk.** There is always the potential for catastrophic risk in financial markets, rare events that can cause dramatic losses in wealth, including great economic depressions.

In the next sections we refer to **the discounted risk premium as the price attached to the risk premium**: the relationship between the discounted risk premium and the risk premium is similar to that of price and yield in a bond. It is worth noting that rising (resp. falling) discounted risk premium is related to falling (resp. rising) risk premium.

As for growth and inflation we consider a risk premium that is geographically diversified (global risk premium).
Macroeconomic expectations can be extrapolated from asset returns: market prices already incorporate the information that we need for assessing expectations about the economy. This intuition is supported by the empirical evidence that asset and factor dynamics are synchronous\textsuperscript{18}. With the aim of inferring the market expectations on growth, inflation and global risk premium, we develop two complementary approaches: (i) **portfolio substitutes (proxies) for the factors** and (ii) **the implicit rising/falling scenario probabilities**.

The main characteristics of the proxies for the discounted risk premium, inflation and growth, are:

- they are calculated from a large investment universe including assets with very different polarization towards growth and inflation;
- portfolio polarization is tuned to the specific factor exposure (e.g. inflation) and neutral with respect to the other factors (e.g. growth and risk premium);
- a diversification policy is applied in order to minimize the asset idiosyncratic risk (e.g. by maximizing the entropy in asset risk contribution; see Pola, 2014);
- proxies are obtained by taking the portfolio cumulative performance (detrended returns);
- to be comparable, proxies have been computed with the same risk level (10% annualized historical volatility).

Confirmations of the quality of our proxies are given by (i) the high significant relationship that we found by regressing asset return with respect to them (see section VIII for some empirical evidence), (ii) the historical de-correlation between them. In chart 7 we plot the proxies on selected historical periods:

- 1994. Expectations in the DAMS factors moved significantly during 1994; at the end of the year the most significant movement was registered by the discounted risk premium; this was related to the Fed’s change in policy;
- 2001 and 2008 were mainly characterized by falling discounted risk premium and falling growth in a scenario of bubbles that brought recession, shocks and market dysfunction;
- 2011 was a good year for asset discounted risk premium, even though growth was disappointing; this was mainly due to the supportive policies by the central banks;
- 2013 was a disinflationary-growth year with disappointing discounted risk premium; this was related to uncertainty on Fed tapering;
- The first half of 2014 has been characterized by rising discounted risk premium.

\textsuperscript{18} This property has been proved in Pola (2013b) and was mentioned in section III.
in a scenario where the Fed reassured investors and the ECB moved towards unconventional measures.

The examples above confirm that the DAMS factors are well connected to the markets.

7- Implied expectations on discounted risk premium, growth and inflation

Source: Amundi Research
In order to ensure the robustness of the previous metric we developed a complementary approach based on a probabilistic model that is induced by the polarization coefficients. The aim of the approach is to answer to the following question: what is the most relevant factor that is driving the market?

Our study on asset segmentation clarified that assets respond to rising and falling scenarios with different patterns. In table 1 we report some hypothetical patterns: + and – refer to a positive or negative excess return over the risk-free rate in a given time window; for example if all assets delivered positive excess return over cash, it is likely that the most relevant factor is the risk premium.

However, financial markets are more complex as all the factors act simultaneously and asset idiosyncratic risk, as well, make the picture even more difficult to interpret. Moreover assets respond to macroeconomic variables and the risk premium with different intensity. These motivations led us to adopt a probabilistic model based on the polarization coefficients for extracting the implicit scenario probability from asset returns, and hence to elaborate a hierarchy of factors to explain asset performance.

We considered 60 markets covering nominal bonds, inflation-linked bonds, credit markets, equities, commodities, volatility and fx-rates; we selected a basket of indices that is internationally diversified. In order to illustrate the methodology, four time windows are analyzed: the first half of 2008, 2013, the second quarter of 2013, the first half of 2014. Chart 8 reports the implicit probability for the rising/falling scenarios.
Results from chart 8 are consistent with those of chart 7: indeed, in this case, we are able to establish a hierarchy between the DAMS factors. The main remarks from the analysis are:

- **H1 2008** was mainly impacted by rising inflation expectations. Indeed the price of Brent in July 2008 was close to 150 USD leading the ECB to erroneously raise official rates; this event was one of the triggers of the recession.

- **2013** was mainly a disinflationary growth year; this favored mainly equities and traditional balanced portfolios that were overweight on equity risk.

- **Q2 2013** was driven almost completely by a marked fall in the discounted risk premium.

- **H1 2014** was characterized by a sharp rebound in the discounted risk premium; this scenario favored the DAMS allocation with respect to traditional portfolios.

The complementary tools presented in this section are crucial in the tactical management of the DAMS investment process, giving the opportunity to exploit potential anomalies on market valuations and persistency in the factor dynamic.
The DAMS portfolio construction can be achieved by two complementary methodologies:

- **a bottom-up approach** consisting in building up sub-portfolios for each scenario (macroscenario-hedge portfolios) and then aggregating them in the portfolio according to the views on specific scenarios (scenario allocation).

- **a top-down scheme** that breaks down the macroscenario-hedge silos and builds the asset allocation by an optimization process that controls the portfolio polarization through explicit non-linear constraints.

The second approach is preferable in the case of advisory activities because of the specific constraints characterizing each investor.

In the bottom-up approach four macroscenario-hedge portfolios are built: one portfolio for “hedging” rising growth expectations, one for falling growth, one for rising inflation expectations and one for falling inflation. We remark that:

- The four portfolios are long only, hence they are long the asset risk premium: the investor view on the global risk premium is implemented by modulating the overall portfolio risk.

- Portfolio construction for each sub-portfolio is risk-based, however we move beyond traditional risk-parity approaches because as demonstrated in Pola (2013b), they may suffer from instabilities in asset correlation and volatility. The risk-based construction of the macroscenario-hedge portfolios does not depend on asset correlation and volatility.

Chart 9 reports the strategic risk allocation for each sub-portfolio. For example, the falling growth portfolio is mainly composed of nominal bonds and inflation-.
linked bonds. Both of them have a clear polarization towards falling growth scenarios but the opposite in terms of inflation. The asset mix reported in chart 9 permits us to minimize the bias towards inflation and asset idiosyncratic risk. Analogously we derived the other three portfolios.

Within this approach we are able to actively manage the portfolio exploiting different sources of alpha, that are essentially three:

- The **scenario allocation** allows us to adapt the portfolio to different economic scenario environments. It is determined by the investor view on global growth and inflation.

- The **macroscenario-hedge allocation** consists in selecting the best assets for hedging each specific scenario. This investment decision incorporates relative value considerations: for example recently there was a great opportunity on Eurozone peripheral bonds as a substitute for bonds from emerging markets.

- The **risk level allocation** is modulated according to investor confidence in the discounted risk premium in the market.

We typically apply a parsimonious approach in the sense that we adapt the portfolio to structural market and economic changes and we dedicate a budget of risk to the different active choices.

The top-down approach in the portfolio construction process is particularly useful in advisory activities in order to (i) meet investor views on macroeconomic dynamics, (ii) ensure a good degree of diversification at the asset level, (iii) maximize the portfolio’s expected return (or risk-adjusted return), (iv) meet the investor risk-budget. The four specifications are handled as follows:

- Investor views on macroeconomic factors are expressed in terms of polarization bands.

- Portfolio diversification at the asset level is ensured by a constraint in terms of the entropy in the asset risk-contribution (see Pola, 2014).

- Portfolio expected return or risk-adjusted return are usually the objective of the optimization process.

- The risk budget is usually controlled in terms of a specific quadratic constraint.

19 Polarization coefficients to growth of the macroscenario-hedge portfolios (falling growth, rising growth, falling inflation, rising inflation) are (resp.), -99.8%, 98.9%, 69.7%, 61.4%; polarization coefficients to inflation correspond to 63.5%, -56.5%, -99.9%, 100.0%.

20 Portfolio exposure to the overall risk premium can be modulated also inside the macroscenario-hedge allocation by selecting securities that present higher, lower or even negative sensitivity to risk premium variations.

21 For example, if the investor is looking for a rising inflation exposure but neutral in terms of growth, appropriate bands for inflation and growth are resp. [0.90, 1] and [-0.70, +0.70]. In practice portfolio polarizations are imposed in terms of non-linear constraints.
The advantage of the top-down approach over the bottom-up one is that it allows us to handle more specific constraints that are regulatory, operational or driven by investment decisions (e.g. modified duration, exposure to credit instruments, equities, and fx-rates).

The main characteristics of the DAMS portfolio (neutral versus growth and inflation) with respect to traditional allocations are:

- **The portfolios are usually leveraged especially for high risk-budget levels** (in order to achieve a long-term volatility greater than 5-6% a leverage exposure is required). There is a great debate around the use of leverage in portfolio management. Portfolio leverage allows us to (i) significantly enhance portfolio diversification (see Pola and Zerrad, 2014a), (ii) increase the exposure to the market risk premium and hence increase the expected return, (iii) achieve a lower level of volatility with respect to traditional allocations with similar expected return. Indeed leverage is not used for speculative purposes.

- **Portfolio diversification is, in general, increased with respect to traditional portfolios at different levels:** (i) macroeconomic biases, (ii) geographic and sector level, (iii) asset idiosyncratic risk.

- **Inflation-sensitive assets are not marginal as in traditional allocation:** inflation-linked bonds, commodities, and emerging debt in local currencies are a significant part of the asset allocation.

- **Portfolio duration is quite high:** for a risk level of long-term volatility of 10%, the modified duration is greater than 10 years. Even though the exposure might seem very high, we claim that this level permits us to be neutral with respect to movements in growth expectations, lower levels lead to a systematic dependency on global growth and, consequently on equity markets. We stress that the duration exposure is not built only on nominal bonds: an important contribution comes from inflation-linked bonds and credit. The high duration does not imply a structural dependency on interest rates because it is balanced by other components in the portfolio.

- **The portfolio rebalancing is not triggered** by movements in asset volatility and correlation (bad portfolio turnover) as in traditional risk-parity portfolios, but it is triggered by investment decisions.

- **Allocation on illiquid instruments is marginal:** this allows the portfolio manager to considerably reduce the transaction costs and to easily rebalance the portfolios e.g. in case of unexpected financial stress in the market.

Some of the characteristics above are similar to traditional risk-parity allocations: the main difference with DAMS is that traditional risk-parity approaches do not allow the exposures to macroeconomic scenarios to be managed properly; moreover DAMS portfolio construction does not depend on asset correlation and volatility and, hence, we claim to have a more robust framework.
In order to clarify the benefits of DAMS in designing a strategic asset allocation, we compare the DAMS portfolio (that is set to be neutral with respect to growth and inflation) with the traditional 60/40 allocation\textsuperscript{22}. The DAMS leverage has been set in order the long-term volatility be 7\% (annualized); conversely the volatility of the 60/40 allocation is 10\%. The historical period under consideration is from December 1992 to June 2014. The main results of the back-testing are:

- The performance of the DAMS is 10.30\% (annualized), higher than that of the 60/40 portfolio that is 8.50\%.
- The Sharpe ratio of the DAMS is 1.03, significantly higher than that of the 60/40 allocation, which is 0.53.
- The maximum draw-down of the DAMS over the same period is 24\%, whereas that of the 60/40 is 36\%.

The simulated DAMS portfolio is neutral versus macro factors, but it is long the asset risk premium, which represents the implicit return deliverable by financial markets in the medium/long-term horizon. The risk premium decreased over the last twenty years together with rates for fundamental reasons linked to, among others, savings glut, demography and central bank policies. A reversal of this process might negatively impact a risk premium portfolio as well as all assets and, therefore, all long only portfolios (including traditional allocations such as the 60/40). In contrast, we believe that the most likely picture for the near future is a scenario of lower potential return with respect to the '80s and '90s, hence a complete reversal seems unlikely.

VIII - Portfolio diagnosis

In this section we discuss the implications of DAMS in terms of portfolio diagnosis for asset allocation advisory. In Pola (2014) we introduced a new framework to analyze portfolio diversification. This approach leverages on the DAMS to quantify diversification in macroeconomic factors and on entropy to measure diversification in asset idiosyncratic risk. The methodology can be summed up in three steps:

- first, regress asset return with respect to the proxies of DAMS factors (see section VI),
- second, decompose the portfolio variance into DAMS factors (diagonal and off-diagonal terms), idiosyncratic risk factors (diagonal and off-diagonal terms) and interactions terms,
- third, interpret macro diversification in terms of the DAMS polarization coefficients and diversification in asset idiosyncratic risk by mean of the entropy in asset risk contribution.

\textsuperscript{22} Equity is the MSCI World USD unhedged, bond is the global bond USD hedged.
We will not review the mathematical formulation of the framework\(^23\). In order to illustrate the descriptive power of this approach, we present a practical application to a balanced portfolio\(^24\). We considered a euro-based investor holding a portfolio composed of 25% domestic government bonds, 25% international government bonds (euro-hedged), 25% domestic equity and 25% international equities (euro unhedged). Indirect fx exposures from stocks have been mapped as a currency overlay. In Table 2 we report the capital and the risk allocation. It is evident that despite the portfolio being perfectly balanced between bonds and equities in terms of capital allocation, the portfolio risk is mostly concentrated on equities.

<table>
<thead>
<tr>
<th>Table 2- Portfolio: capital and risk allocation</th>
<th>capital</th>
<th>risk cnb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro</td>
<td>25.0%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Japan</td>
<td>9.1%</td>
<td>-0.4%</td>
</tr>
<tr>
<td>US</td>
<td>13.2%</td>
<td>-2.3%</td>
</tr>
<tr>
<td>UK</td>
<td>2.7%</td>
<td>-0.5%</td>
</tr>
<tr>
<td>Equity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro</td>
<td>25.0%</td>
<td>58.6%</td>
</tr>
<tr>
<td>US</td>
<td>16.5%</td>
<td>30.4%</td>
</tr>
<tr>
<td>Japan</td>
<td>2.5%</td>
<td>3.8%</td>
</tr>
<tr>
<td>UK</td>
<td>2.4%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.3%</td>
<td>2.4%</td>
</tr>
<tr>
<td>Canada</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Australia</td>
<td>1.0%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Fx-overlay (Equity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USD</td>
<td>16.5%</td>
<td>-1.4%</td>
</tr>
<tr>
<td>JPY</td>
<td>2.5%</td>
<td>-1.1%</td>
</tr>
<tr>
<td>GBP</td>
<td>2.4%</td>
<td>0.4%</td>
</tr>
<tr>
<td>CHF</td>
<td>1.3%</td>
<td>-0.2%</td>
</tr>
<tr>
<td>CAD</td>
<td>1.2%</td>
<td>0.6%</td>
</tr>
<tr>
<td>AUD</td>
<td>1.0%</td>
<td>0.7%</td>
</tr>
<tr>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

In order to decompose the portfolio variance between the DAMS factors and the idiosyncratic risk, we move first to regress asset return with respect to the DAMS proxies. Table 3 reports the results of the multiple regressions. The DAMS factors

\(^{22}\) We refer the interested reader to section 10 in Pola (2014).

\(^{24}\) In this section we briefly review a practical case study that has been discussed in section 11 in Pola (2014).
are effective in explaining bond and equity returns\textsuperscript{25}, but on fx rates the $R^2$ is not satisfactory (however we should note that recently the relationship has been more reliable). We stress again that sensitivity to the discounted risk premium is assessed only by the beta: while for growth and inflation it is possible to compute also the polarization coefficients, for the discounted risk premium this is not possible as there is not a convincing exogenous index in the market measuring cross-sectional premiums in the global financial market.

\textbf{Table 3- Results of the regression analysis of asset return vs. DAMS factors}

<table>
<thead>
<tr>
<th>Assets</th>
<th>Beta growth</th>
<th>Beta inflation</th>
<th>Beta discounted risk premium</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro</td>
<td>-0.250</td>
<td>-0.094</td>
<td>0.173</td>
<td>56%</td>
</tr>
<tr>
<td>Japan</td>
<td>-0.082</td>
<td>-0.016</td>
<td>0.022</td>
<td>7%</td>
</tr>
<tr>
<td>US</td>
<td>-0.383</td>
<td>-0.127</td>
<td>0.214</td>
<td>74%</td>
</tr>
<tr>
<td>UK</td>
<td>-0.433</td>
<td>-0.122</td>
<td>0.216</td>
<td>70%</td>
</tr>
<tr>
<td>Equity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro</td>
<td>1.145</td>
<td>-0.393</td>
<td>0.978</td>
<td>68%</td>
</tr>
<tr>
<td>US</td>
<td>0.961</td>
<td>-0.562</td>
<td>0.974</td>
<td>86%</td>
</tr>
<tr>
<td>Japan</td>
<td>0.840</td>
<td>-0.114</td>
<td>0.711</td>
<td>32%</td>
</tr>
<tr>
<td>UK</td>
<td>0.878</td>
<td>-0.342</td>
<td>0.846</td>
<td>63%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.824</td>
<td>-0.426</td>
<td>0.753</td>
<td>49%</td>
</tr>
<tr>
<td>Canada</td>
<td>0.959</td>
<td>-0.164</td>
<td>0.933</td>
<td>61%</td>
</tr>
<tr>
<td>Australia</td>
<td>0.611</td>
<td>-0.138</td>
<td>0.751</td>
<td>45%</td>
</tr>
<tr>
<td>Fx-overlay (Equity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USD</td>
<td>-0.175</td>
<td>-0.208</td>
<td>-0.283</td>
<td>13%</td>
</tr>
<tr>
<td>JPY</td>
<td>-0.393</td>
<td>-0.154</td>
<td>-0.268</td>
<td>13%</td>
</tr>
<tr>
<td>GBP</td>
<td>0.012</td>
<td>-0.051</td>
<td>-0.022</td>
<td>1%</td>
</tr>
<tr>
<td>CHF</td>
<td>-0.149</td>
<td>0.001</td>
<td>-0.067</td>
<td>8%</td>
</tr>
<tr>
<td>CAD</td>
<td>0.199</td>
<td>-0.052</td>
<td>0.086</td>
<td>5%</td>
</tr>
<tr>
<td>AUD</td>
<td>0.374</td>
<td>0.063</td>
<td>0.296</td>
<td>16%</td>
</tr>
</tbody>
</table>

\textsuperscript{25} The only exception is the Japanese bond; this can be explained by the peculiarity of the Japanese economy in the last decades and the consequent extreme economic and monetary policies taken recently by the Bank of Japan.
As described in details in Pola (2014), portfolio variance can be decomposed as follows:

\[ \sigma^2 = \Gamma_{\text{factor}}^{\text{diag}} + \Gamma_{\text{factor}}^{\text{off-diag}} + \Omega_{\text{idrisk}}^{\text{diag}} + \Omega_{\text{idrisk}}^{\text{off-diag}} + \Phi_{\text{idrisk-factor}}^{\text{off-diag}}, \]

where the \( \Gamma \) terms refer to the DAMS factors, the \( \Omega \) terms to asset specific risk, and \( \Phi \) to the interactions between idiosyncratic risk and macro factors. In order for the formalism to be well posed, the off-diagonal \( \Gamma \) and \( \Phi \) terms should be small. In fact:

- as DAMS factors are quasi-orthogonal, the off-diagonal \( \Gamma \) should be small;
- as asset specific risk is supposed to be de-correlated from factors, \( \Phi \) should be negligible.

In table 4 we report the contributions as a percentage of the full portfolio variance. The main results are:

- the DAMS framework is able to explain about 75% of the portfolio variance;
- idiosyncratic risk is small but not negligible (20%);
- interaction between factors and idiosyncratic risk is 5%. We argue that this can be explained in part by the exponential smoothing technique\(^{26}\) used to estimate the ex-ante risk that creates some distortions in the time series. In contrast, the standard regression technique is based on pure historical estimation;
- the \( \Omega \) off-diagonal term states that idiosyncratic risks are not perfectly de-correlated;
- the \( \Gamma \) off-diagonal term is very small and it comes from the imperfect orthogonality of DAMS factors; as discussed in section III, the Kullback-Leibler analysis showed that orthogonality among DAMS factors holds as a first approximation.

The DAMS factors explain about 75% of the portfolio variance: this result demonstrates that in this case study factor diversification is more relevant than diversification in asset idiosyncratic risk.

| Table 4 - Risk allocation in the factor plus idiosyncratic risk framework |
|-----------------------------|-----------------|
| idiosyncratic risk          | Risk contribution (%) |
| deaf                       | diagonal \( \Omega \) | 13.1% |
| deaf                       | off-diagonal \( \Omega \) | 6.9% |
| factors                    | diagonal \( \Gamma \) | 70.8% |
| deaf                       | off-diagonal \( \Gamma \) | 4.0% |
| interaction                | off-diagonal \( \Phi \) | 5.2% |

26 See Pola (2014) for details on the exponential smoothing settings to estimate the ex-ante risk figures in this specific case study.
We will now discuss diversification in macroeconomic factors and in asset idiosyncratic risk. The risk explained by the diagonal terms of DAMS factors is decomposed by 9.3% for inflation, 22.1% for growth and 39.4% for the global risk premium. The portfolio beta to inflation, growth and the global risk premium correspond (resp.) to -0.296, +0.350, and +0.501. Indeed the portfolio is exposed to falling inflation, rising growth and rising discounted risk premium. Results on inflation and growth are confirmed by computing the portfolio polarization coefficients\(^{27}\): we found very significant figures, -98.9% for inflation and 84.3% for growth. From a geometric point of view the portfolio is positioned in the top left corner of the inflation-growth polarization plan (see chart 5). Indeed the portfolio is poorly diversified according to DAMS, as it is exposed to a specific macroeconomic scenario: the portfolio is significantly biased towards falling inflation and rising growth. The result is not surprising given that almost all of the portfolio risk can be explained in terms of equity risk. The portfolio is well positioned to benefit from disinflationary growth scenarios. The main risk comes from unexpected rising inflation and from a slowdown of the economy. This picture is similar to all traditional equity-bond portfolios with heavy risk exposure to equity.

Idiosyncratic risk accounts for about 20% of the portfolio variance. By using entropy techniques we were able to show in Pola (2014) that idiosyncratic risk is poorly diversified. In particular the largest idiosyncratic risk contributions come from Euro equity, USD/EUR fx rate, and euro bonds. By computing (the exponential of) the entropy in asset risk contribution, we found 5.3, which is a modest figure given 17 possible risk sources within the asset universe\(^{28}\).

The main messages from the asset allocation diagnosis through DAMS and entropy techniques are:

- portfolio risk is almost all concentrated on equities;
- the portfolio is poorly diversified across macroeconomic scenarios; the main adverse macroeconomic scenario is unexpected rising inflation and a slowdown of the economy;
- the portfolio is well-positioned to benefit from disinflationary growth scenarios;
- idiosyncratic risk is not negligible (20%) and poorly diversified due to lack of geographic diversification;

We believe that the main contribution of DAMS in asset allocation advisory is to highlight clearly the implicit macroeconomic biases of the asset allocation.

\(^{27}\) Aggregated portfolio polarization can be calculated either by applying the parametric and non-parametric approaches already discussed in section III (in this case applied to a back-test of the portfolio), or by aggregating single asset polarization according to a closed analytical formula.

\(^{28}\) If idiosyncratic risk were fully diversified, the exponential of the entropy would be 17, which corresponds to the number of assets in the investment universe (see table 2).
Conclusion

The main benefit of DAMS is to provide a framework for limiting the portfolio’s dependence on the macroeconomic environment. This is particularly appropriate today because the world is changing rapidly and its future is not easily foreseeable: financial markets are facing a long period of rebalancing of power and deleveraging from an excessive amount of debt involving all the major economies; the final effects and results of this process are not clear today and surprises are always possible.

The main risk an investor should avoid is to find himself drifting unconsciously downside because of an unexpected decrease in growth (2000-2012) or an increase in inflation (1965-1981), for example: macro trends may last for decades and the wrong portfolio positioning may seriously damage portfolio return in the long run.

DAMS deepens the relationship between macro factors and asset return, unveils the (hidden) macro dynamics by extracting reliable proxies and implicit probabilities of relevant factors, and finally enables macroeconomic changes in financial markets to be properly managed.

**We believe that the enriched DAMS framework offers an effective and original approach for managing multi-asset portfolios with several applications:** strategic asset allocation can be defined according to desired exposure to macro factors and global risk premium, and tactical asset allocation can be tilted to manage macroeconomic shifts. Lastly, the joint application of DAMS and entropy techniques provides a sound framework for advisory activity.
Appendix A
A guide to the literature

This section offers a guide to the published literature on DAMS within AMUNDI publications and external journals.

Pola (2013a) is a short letter that introduces the DAMS principle and consequences in terms of asset segmentation. In this publication the DAMS factors were inflation, growth and market stress. Moreover we investigated three applications of DAMS:

- we provided a clustering analysis on US equity sectors, styles and beta-neutral strategies, showing that under the DAMS metric equities can be clustered into six sets according to their similarity to the DAMS factors (clusters include equity-like, commodity-like and nominal-bond-like stocks/strategies);
- we showed an application of the top-down DAMS portfolio construction approach to build an inflationary-growth diversified portfolio that is rather neutral with respect to market stress;
- by leveraging the concept of dual assets under the DAMS metric, we were able to demonstrate that commodity macro behavior can be achieved by a portfolio that is long on equities and inflation-linked bonds, and short nominal bonds.

Pola (2013b) is the main reference for the DAMS principle and asset segmentation. In particular the paper:

- introduces the DAMS principle;
- includes details on macroeconomic and stress indices, and discusses why it is not possible to conduct the analysis on inflation swaps and expectation indicators on growth (e.g. ZEW indicators);
- explains the way we define rising/falling scenarios from macroeconomic and stress time-series for quarterly-based and monthly-based analysis;
- quantifies the degree of orthogonality of the DAMS rising/falling scenarios under the Kullback-Leibler pseudo-distance, and relates part of the departure from orthogonality to the sample specificity of the historical time window considered in the analysis (in particular we argued that the inflationary period in the ’70s and ’80s should have had a strong impact in our evaluation);
- introduces the polarization coefficients (parametric and non-parametric approaches) to measure the sensitivity of asset return to rising/falling scenarios;
- includes a comprehensive study on asset segmentation in the US involving 139 assets (traditional, alternative, and dynamic asset allocation strategies);
the analysis has been conducted for quarterly and monthly time-series and according to the parametric and the non-parametric methodologies for computing the polarization coefficients;

• illustrates how to build a proxy for commodities in terms of nominal bonds, equities, and inflation-linked bonds;

• includes a review of the Kullback-Leibler pseudo-distance to evaluate dependency between random variables;

• additional analyses to ensure the robustness of the approach: (i) we provided some evidence in favor of the synchrony between asset and factor dynamics; (ii) we studied robustness of the polarization coefficients with respect to introducing a neutral state for the DAMS factor that expresses weak rising and falling scenarios.

Pola (2013c) is a paper on portfolio diversification. In this work we introduce a scalar indicator expressing the overall degree of diversification in terms of DAMS factors of a given asset allocation. From a geometric point of view, the indicator measures the distance of the portfolio position in the polarization cube from the centre: the closer to the centre, the more diversified the allocation and the higher the index; conversely the closer to the corners, the less diversified the portfolio and the smaller the indicator. Moreover in the paper we report some statistical considerations against the use of correlation to measure asset dependency, as briefly reviewed in section 1.

In Pola (2014) we introduce a unified framework to analyze portfolio diversification in terms of factor diversification (as measured by the DAMS polarization), and asset idiosyncratic risk (as quantified by the entropy in asset risk contribution). Moreover we illustrate the main ideas on the application of DAMS for advisory activities. We consider a balanced portfolio of a euro-based investor. We are able to decompose portfolio diversification in terms of DAMS factors and idiosyncratic risk: the main conclusion is that the portfolio is poorly diversified in terms of DAMS and asset idiosyncratic risk as it is heavily exposed to the specific risk of euro-based assets.

Appendix B
Polarization coefficients of the main asset classes in the US

The table below shows the polarization coefficients of the main financial markets in the US with respect to the US factors. Estimations have been obtained according to the parametric approach; time series are quarterly. For more details, refer to Pola (2013b).
Table B1. Polarization coefficients of the main markets in the US

<table>
<thead>
<tr>
<th>Bloomberg code</th>
<th>CPI</th>
<th>GROWTH</th>
<th>STRESS</th>
</tr>
</thead>
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<tr>
<td>All-maturity nominal bond</td>
<td>luattruu</td>
<td>-100%</td>
<td>-100%</td>
</tr>
<tr>
<td>Inflation-linked 1-5</td>
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<td>61%</td>
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<td>All-maturity inflation-linked</td>
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<td>-86%</td>
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<td>IG credit</td>
<td>c0a0</td>
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</tr>
<tr>
<td>HY Credit</td>
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<td>55%</td>
<td>90%</td>
</tr>
<tr>
<td>Emg Debt Hard cncy</td>
<td>igov</td>
<td>59%</td>
<td>54%</td>
</tr>
<tr>
<td>Emg Debt Local cncy</td>
<td>jgeneruug</td>
<td>91%</td>
<td>100%</td>
</tr>
<tr>
<td>S&amp;P 500</td>
<td>spx</td>
<td>-87%</td>
<td>98%</td>
</tr>
<tr>
<td>S&amp;P 500 info tech</td>
<td>s5inf</td>
<td>87%</td>
<td>98%</td>
</tr>
<tr>
<td>S&amp;P 500 financials</td>
<td>s5finl</td>
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<td>84%</td>
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<tr>
<td>S&amp;P 500 health care</td>
<td>s5hth</td>
<td>-76%</td>
<td>76%</td>
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<tr>
<td>S&amp;P 500 cons discret</td>
<td>s5cond</td>
<td>54%</td>
<td>98%</td>
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<tr>
<td>S&amp;P 500 energy</td>
<td>s5ensrs</td>
<td>91%</td>
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<tr>
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<td>-82%</td>
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<tr>
<td>DJ us real estate</td>
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<td>92%</td>
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<td>S&amp;P 500 small cap</td>
<td>sml</td>
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<td>99%</td>
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<td>98%</td>
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<tr>
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<td>94%</td>
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<tr>
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<td>65%</td>
</tr>
<tr>
<td>CAD-USD x-rate</td>
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<td>100%</td>
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<tr>
<td>AUD-USD x-rate</td>
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<td>100%</td>
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<td>NZD-USD x-rate</td>
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<td>98%</td>
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<td>CHF-USD x-rate</td>
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<td>62%</td>
<td>84%</td>
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<tr>
<td>NOK-USD x-rate</td>
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<td>89%</td>
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<td>96%</td>
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<td>zarusd</td>
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Acknowledgement

We would like to thank Claudio Casadei and Fabrizio Quarta for their fundamental contribution and joint work in defining and building the DAMS framework and its portfolio management implementation, and Sylvie de Laguiche, Éric Tazé-Bernard and Philippe Ithurbide for very stimulating discussions and valuable comments that improved the manuscript.

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