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MARKET TIMING AND PERFORMANCE ATTRIBUTION IN THE ECB RESERVE MANAGEMENT FRAMEWORK

by Francesco Potente* and Antonio Scalia*

Abstract

We study the performance of a group of foreign exchange reserve managers that are responsible for investing the ECB's official reserves in US dollars, for a value of around $43 billion, using a new dataset which includes detailed portfolio holdings from 2006 to 2010. The ECB reserve managers display a positive ability at security selection overall. Two portfolio managers show market timing ability after adjusting for the non-linearity of the benchmark returns. For one portfolio manager, market timing ability is significantly related to the efficient use of public information. To pin down market timing, we develop a performance attribution model which identifies the contribution of the key portfolio managers' strategies (duration, curve, and spread). We find that, among the active layers, the spread contribution seems the most significant; curve and duration bets, with some exceptions, have generally provided little value added. Our analysis supports the view that portfolio managers adopt diversified investment styles. This may explain the non-negligible result of the aggregate reserve portfolio, averaging 10 basis points on an annual basis, net of transaction costs. The more diversified the investment styles are, the more likely it is that portfolio managers make independent bets, which in turn may positively affect the risk-adjusted return of the aggregate portfolio.

JEL Classification: E58, G11, G15.
Keywords: Foreign exchange reserve management, bond portfolios.

Contents

* Bank of Italy, DG Markets and Payment Systems.

1. Introduction[1]

This paper presents a study on the performance of a group of foreign exchange reserve managers that carry out the investment of the ECB's official reserves in US dollars, worth around 43 billion dollars[2], using a new dataset which includes detailed portfolio holdings from 2006 to 2010.

Foreign exchange reserves worldwide are worth 11.6 US trillion dollars[3] and are mainly invested in government bonds and other liquid instruments. For comparison the global net assets of bond and money market funds is worth 12.6 US trillion dollars[4]. While the management and performance of private bond portfolio managers is the subject of a vast empirical literature, relatively little is known on the investment of foreign exchange reserves, owing mainly to confidentiality reasons.

The recent surveys on central bank reserve management mainly deal with strategy issues, like the use of an ALM approach, and with governance issues (e.g. Borio, Ebbesen, Galati and Heath, 2008; Borio, Galati and Heath, 2008; Johnson-Calari, Grava and Roberts, 2007; Nugée, 2012). The composition of US dollar official holdings has been examined in some detail (McCauley and Rigaudy, 2011). Not surprisingly, due to the prevalence of institutional reasons for the management of official reserves, their investment performance is rarely the subject of publicly available research (exceptions include Hu, 2010 and Vesilind and Kuus, 2005).

Empirically bond mutual fund managers do not appear to consistently generate extra-performance net of transaction costs and management costs. In terms of data quality, the empirical studies of bond fund performance face two issues: first, while portfolio holdings would be best suited to infer the (ex ante) managers' bets, this information is usually not available and researchers generally resort to (ex post) return-based tests; second, the appropriate benchmark index is often not designated ex ante, and some assumptions must be made on its nature. According to these studies: (i) on average bond fund managers exhibit negative or neutral timing ability (Blake, Elton and Gruber, 1993; Elton, Gruber and Blake,

[1] Helpful comments by Christophe Beuve, Gioia Cellai, Maurizio Ghirga, Giuseppe Grande, Johannes Kramer, Franco Panfili, Tommaso Perez, Dario Ottaviani, Antonio Rossetti, Andrea Santorelli, Roberto Violi, Francesco Daini and seminar participants at the ECB and Banca d'Italia are gratefully acknowledged.

[2] At the end of 2010.

[3] At the end of 2014 (IMF COFER statistics: http://data.imf.org/?sk=E6A5F467-C14B-4AA8-9F6D- 5A09EC4E62A4).

[4] At the end of 2014 (International Investment Funds Association: http://www.iifa.ca/documents/1439147874_IIFA%202015%20Q1%20Public%20Statistics%20Report.pdf).

1995; Boney, Comer and Kelly, 2009); (ii) conditional performance adjusted for risk is slightly negative (Lam, 1999; Ferson, Henry and Kisgen, 2006); (iii) adjusting for non-linear effects, there is no evidence of positive performance after costs (Chen, Ferson and Peters, 2010). The studies which employ measures of bond portfolio holdings show a similar picture with some nuances. In particular: Moneta (2013) finds that on average portfolio managers display neutral timing ability, with only a subgroup of funds exhibiting successful timing ability; Cici and Gibson (2012) show that conditional performance adjusted for risk is slightly negative; Huang and Wang (2014) find that fund managers specializing in Treasury securities show better market timing ability in comparison with managers investing in portfolios including mortgage-backed and agency securities; however, after controlling for public information, ability becomes neutral.

The ECB reserves in dollars must be invested in highly liquid fixed income instruments and are actively managed. In the sample period the owner of the reserves delegated their investment to a group of managers located at eight national central banks (NCBs) of the Eurosystem, namely those of Belgium, France, Germany, Greece, Ireland, Italy, Luxembourg, and Spain[5]. In the analysis that follows they are treated anonymously and denoted by a random code ranging from M1 to M8.

The assets under management reflect the share of each NCB in the ECB's capital. The ECB sets a common benchmark, thus generating competition among managers (Koivu, Monar and Nyholm, 2009; Manzanares and Schwartzlose, 2009). Every month their individual performance is computed and made known by the ECB to all managers. Once a year a general report on the investment activities and risks is transmitted to the Governing Council of the ECB, including the individual performance figures and rankings.

Some factors make the investment contest of the ECB's reserve managers extremely challenging (Scalia and Sahel, 2012). First, while private bond funds often lack formal benchmarks, in our case the benchmark is tailor-made by the ECB to reflect its risk-return preferences and is actively managed, since the ECB may revise it based on the flow of new information on a monthly basis. Second, the investment set is relatively small and risk limits are quite severe in comparison with the private sector. Third, reserve managers monitor each

[5] The ECB's official reserves include also assets denominated in Japanese yen and gold. The other Eurosystem's NCBs were involved in the active management of the yen reserve portfolio. We refer to each central bank's desk involved in the management of the ECB reserves as a 'portfolio manager'. In practice a small team usually works on the ECB reserves desk, comprising e.g. one manager and one or two dealers, in some cases devoting part of their work time to the ECB reserves and the remainder to the management of the foreign exchange portfolio owned by the national central bank.

other's performance and ranking at monthly frequency. In practice the ECB's reserve managers compete for a handful of basis points of performance in a tight competition. With reduced risk-taking opportunities, the timing ability of reserve managers plays a key role in securing extra-returns.

We aim to make two types of contribution. First, we provide a return-based analysis on market timing using our dataset on the individual portfolios of the ECB US dollar reserves. Second, we develop a simple and intuitive performance attribution technique based on portfolio holdings, that seeks to assign the extra-performance (positive or negative) to the four main strategies used by bond portfolio managers: duration trade, curve trade and spread trade, all related to market timing ability; and security selection, also referred to as selectivity.

Our empirical approach combines the two main thrusts of performance analysis. In the first part we use the traditional 'top-down' method, whereby we try to detect the presence of extra-performance using the Treynor-Mazuy (1966; henceforth TM) regressions based on portfolio excess returns and controlling for the non-linearity of the benchmark returns as in Chen, Ferson and Peters (2010). In the second part we develop a 'bottom-up' approach to attribute the extra-performance to the managers' specific strategies based on our performance attribution model, which employs portfolio holdings as well as the 'true' benchmark holdings.

We use weekly return data for the eight portfolios and the benchmark, plus the individual asset holdings in the second part. We have a specific interest in time periods shorter than one month. Since the active benchmark is revised on a monthly basis, under the hypothesis that portfolio managers have market timing and selectivity skills, these should be revealed at very short time intervals.

We find that, first, the bond portfolio managers investing the ECB reserves in US dollars on aggregate outperform the active benchmark by around 10 basis points on a yearly basis net of transaction costs. This amounts to 39 million euro per year, which is conceivably above management costs. The positive performance is confirmed on a risk-adjusted basis: the yearly information ratio of the aggregated portfolio is equal to 1.6, while the alpha estimate which might be related to selectivity is positive and significant at the 13 percent significance level. Second, only a subgroup of managers show positive market timing in the US dollar bond market against the active benchmark, partly as a consequence of the correct use of public information. The last finding seems in line with some recent studies on market timing ability (Moneta, 2013; Huang and Wang, 2014).

The analysis based on the model of performance attribution shows that on aggregate the main source of extra-performance is related to security selection, followed by spread timing. This approach allows us to pinpoint the presence of different investment styles.

Overall our results indicate that reserve managers adopt different investment styles and make a diversified use of the risk budget, revealing the presence of a high number of independent bets on the aggregate portfolio. Our findings seem consistent with the 'law of active management' (Grinold, 1989), according to which a high number of independent bets improves the information ratio of the aggregate portfolio. These results seem noteworthy, in consideration of the tightness of the portfolio contest.

Section 2 presents the data and the results on market timing. Section 3 shows the performance attribution model and the related findings. Section 4 concludes.

2. Market timing

The net asset value of the ECB US dollar benchmark and aggregate portfolio during 2006-2010 is shown in Fig. 1. The return on the portfolio has exceeded the benchmark return in each year, and at the end of the period the portfolio cumulative return was about 46 basis points above that of the benchmark.

The above figures are net of transaction costs, which are accounted for in the portfolio management system at each trade. The money equivalent of the yearly average extra-performance is about 39 million euro. This figure is arguably well above management costs (staff salaries, IT equipment, overhead) that is involved in the ECB reserve management framework, hence we have a case of positive net outperformance.

2.1 Regression model

We follow the market timing model of Chen, Ferson and Peters (2010; henceforth CFP), which accounts for the existence of a benchmark portfolio and the presence of nonlinearity in the benchmark returns. Let us start with the return-based TM regression:

$$r_{pt} = a_p + b_p f_t + \Lambda_p f_t^2 + u_t$$

where r_{pt} denotes the portfolio return at time t in excess of the short term treasury bill, i.e. the risk-free rate, which represents a safe alternative to (bond) investment. In the original TM regression, testing for equity market timing requires f_t to be the excess return of the stock market index. Following CFP, we let instead f_t denote the change in the systematic factors that affect bond markets at time t, like interest rate levels and spreads. As argued by TM, if $\Lambda_p > 0$ then portfolio managers display market timing ability. CFP demonstrate that the same property holds in the bond portfolio framework, where f_t are the systematic bond factor changes.

In the ensuing analysis we include the four key factors for bond portfolios: the short term rate, the slope of the yield curve, convexity, and the swap spread. Since these variables are not excess returns, the interpretation of the sign for the timing coefficient may not be straightforward. However market timing still implies that the squared factors display a positive coefficient.

The CFP empirical model introduces a correction for the possibility that interim trading adds to the nonlinearity of returns, plus a correction for stale pricing. In our environment the case for interim trading is negligible, because we use weekly data instead of monthly data. The case for stale pricing is also weak, because the securities are among the most liquid government and quasi-government issues. We are thus left with (i) 'true' non-linearity in market factors of individual securities and (ii) common dependence of portfolio and benchmark returns on public information. The first factor yields the following regression system:

$$r_{Bt} = a_B + b_B(f_t) + u_{Bt} \tag{1}$$

$$r_{pt} = a_p + b_p\left[b_B(f_t)\right] + \Lambda_p\left[b_B(f_t)^2\right] + u_t \tag{2}$$

where r_{Bt} is the excess return on the active benchmark, $b_B(f_t)$ is a nonlinear function of the common factors and r_{pt} is the portfolio excess return. In particular, $b_B(f_t)$ is a quadratic function obtained just considering among explanatory variables - in addition to the simple factors - also the squared factors without taking into account the cross products[6]. Equation (2) is the market-timing regression that incorporates the nonlinear benchmark. Absent timing, i.e. if $\Lambda_p = 0$, the nonlinearity of the portfolio return is determined by the nonlinearity of the benchmark return scaled by the b_p term. Conversely, a successful market timer would generate a convex return relative to the benchmark, with $\Lambda_p > 0$.

As a further step, we can condition the timing model (1)-(2) for public information following the approach of Ferson and Schadt (1996) and CFP. In this case equation (2) is replaced with:

$$r_{pt} = a_p + b_p\left[b_B(f_t)\right] + \Lambda_p\left[b_B(f_t)^2\right] + c_p\left[Z_{t-1}b_B(f_t)\right] + u_t \qquad (3)$$

where Z_{t-1} denotes the public information variable at t-1. The interaction term $Z_{t-1}b_B(f_t)$ controls for nonlinearity in the factors due to public information effects.

2.2 Data

We employ the following common factors for bond portfolios: (i) the change in the 3-month T-bill rate (the 'short term rate'); (ii) the change in the 10 to 2 year T-bond yield differential (the curve 'slope'); (iii) the change in the convexity factor $c_t = y_t^3 - \frac{y_t^7 + 2 \cdot y_t^1}{3}$, where y_t^n denotes the n-year T-bond yield at time t; (iv) the change in the 2-year swap spread over the T-bond yield curve.

Summary statistics for the systematic bond factors are shown in Table 1, while Table 2 presents the statistics on net returns. The latter show that the (unweighted) mean weekly excess return r_{pt} equals 0.033, i.e. 3.3 basis points, whereas the benchmark presents an average excess return of 3.2 basis points.

[6] Since four common factors are considered (see also section 2.2), $b_B(f_t)$ can be expressed as $\sum_{i=1}^{4} b_i f_i + \sum_{i=5}^{8} b_i f_i^2$.

2.3 Results

As our first step we estimate equations (1) and (2) simultaneously with the generalized method of moments for each portfolio manager at a time[7]. We include eight variables in the f_t vector: the four factor changes and the four squared factor changes, with a view to capturing in a parsimonious way the non-linearity of benchmark returns. The GMM model will thus yield the estimates of a_B, b_B (eight parameters denoted respectively by $b_1, b_2, ..., b_8$), a_p, b_p, and Λ_p. More specifically, the four parameters $b_5,..,b_8$ multiply the quadratic terms of the factor changes.

Table 3 shows the regression results for each portfolio manager arranged by column. The a_B average estimate is equal to 0.018, i.e. short of 2 basis points of return above the 3-month T-bill return on a weekly basis, and it is significant at the 10% level or better in four cases out of eight, revealing security selection ability on the part of the benchmark portfolio.

The estimates of the (4 x 8 = 32) parameters for the quadratic terms are significant in the majority of cases, showing the presence of non-linearity in benchmark returns relative to the common factors as a whole. Considering them individually, this holds true for the short rate, convexity and the spread. In the case of the slope, the low *z*-value for b_6 indicates that portfolio returns are linear in this factor.

The a_p estimates are on average 0.019 and they are significant for portfolios M2, M4, M5, M6 and M7, indicating that portfolio management tends to add one tenth of a basis point over the benchmark on average every week via the security selection process. To be precise, this figure includes also some residual components that are not distinguishable using weekly returns, namely the effect of intra-weekly positions and the returns associated with money market activity.

The b_p estimates are close or equal to 1 and highly significant, as expected.

The estimates of Λ_p are positive in five cases out of eight. For portfolios M5 and M8, where Λ_p reaches on average 0.08, the coefficient is also significant. This reveals the presence of market timing for those two portfolio managers. Three portfolio managers show a negative lambda estimate, although statistically insignificant. These findings indicate that on an

[7] Simultaneous estimation of eight portfolio returns plus the benchmark return is unmanageable.

aggregate basis portfolio managers show security selection ability, while only a subgroup of them displays market timing ability after adjusting for the nonlinearity of benchmark returns. These results are substantially in line with those obtained by Moneta (2013).

Next we turn to the estimation of the model that controls for the effect of public information, made by equations (1) and (3). In the specification of equation (3), for econometric tractability Z_{t-1} is defined as each bond factor level at a time.

Table 4a presents the results of the model that employs the (lagged) short term rate as the public information variable. The estimated coefficients of equation (1) are broadly in line with those obtained without the public information variable: a_B averages 0.017 and the $b_5,...,b_8$ coefficients are highly significant in the majority of cases, confirming non-linearity of benchmark returns particularly in the short rate and the curve. The security selection ability of portfolio managers seems also confirmed in six cases, as against five in the model without public information.

Interestingly, the lambda coefficient for portfolios M5 and M8 is no longer significant. This indicates that the nonlinearity measured by the lambda coefficient in the previous specification - not controlling for public information - is presumably related to correlation among conditional portfolio betas and benchmark returns due to their common dependence on public information on the short term rate (Chen et al., 2010). In turn, this correlation might be explained by the portfolio managers' reaction to information embedded in short term rate developments. The c_p coefficient is statistically significant in one case only, for portfolio M3, for which lambda is equal to 0.11 and also significant. This shows that, after controlling for the use of information on the short term rate, this portfolio would display true market timing ability. Conversely, that is equivalent to saying that M3 seems to make an adverse use of information on the short term rate because in the 'raw' estimates (from Table 3) the market timing of this portfolio disappears.

The results from Table 4b, conditioning on the use of information on the slope of the yield curve, do not add much to the picture. No lambda is significant, confirming that the market timing ability of M5 and M8 might be partly explained by return convexity induced bycorrelation among conditional portfolios betas and benchmark returns due to their common dependence on the public information on the slope of the yield curve. Even in this case, correlation might be explained by a reaction of portfolio managers to information embedded in yield curve slope developments.

Table 4c presents the results which control for the use of information on the convexity of the curve. We note a positive and significant lambda for portfolio M8, equal to 0.10, which suggests that this portfolio manager's timing is largely independent of the use of information on the curve.

Table 4d gives the results that control for the use of information on the spread. We find only minor variations relative to the base case and to the previous regressions, with one exception. While lambdas are never significant, we obtain a significant c_p coefficient for M6. This goes in parallel with a somewhat larger value of a_p, equal to 0.024 and significant. An explanation might be related to the efficient use of information on the spread by M6, which possibly translates into a higher-than-average security selection ability.

The empirical results of this section show that market timing ability might be related to a correct use of public information, as also pointed out in Huang and Wang (2014). It is also important to recall that the public information variables in Z_{t-1} are introduced one at a time. Had they been introduced together, the significance of a_p and lambda coefficients would have presumably been lower.

3. Performance analysis on a strategy basis

The availability of granular data on portfolio and benchmark holdings allows us to develop an analytical performance attribution method. Compared with econometric models of performance attribution, our approach allows us to better pinpoint the skills of portfolio managers by linking return decomposition to specific portfolio strategies. For example, a manager's ability in terms of duration management could be compensated by the lack of skill in spread management, or vice versa. In such cases the econometric estimate of market timing ability would be the result of two opposite forces, which might offset each other in statistical terms. Performance attribution models also allow to better identify different portfolio manager styles. When these are well diversified the Information ratio of the aggregated portfolio, other things being equal, tends to be higher.

Two main families of performance attribution models have been developed in the literature and in the financial industry: sector-based models and factor-based models. The first group tries to identify the contribution of each strategy via a comparison between the portfolio sector weights and returns and the benchmark sector weights and returns. These models are usually applied to equity funds and identify three types of performance contributions (see e.g. Brinson, Hood and Beebower, 1986): asset allocation, stock selection and interaction. It is inappropriate to adapt this approach to fixed income portfolios in order to identify the contributions of typical fixed income portfolio strategies (e.g. Campisi, 2011).

In factor models the return on each asset is viewed as a function of specific risk factors (duration, convexity, carry, spread component, etc. See e.g. Khoury, Vielleux and Viau, 2003). As a first step, the exposure to each risk factor is computed for each asset included in the portfolio. By aggregating individual asset exposure to each risk factor it is possible to build the overall portfolio exposure to each factor vis-à-vis the benchmark. The specific risk factor contribution to the extra-performance is obtained as the interaction between the exposure to a specific risk factor and the measured change in that risk factor. In general, each risk factor can be considered as the constituent of a specific strategy. For instance, the contribution to extra-return coming from the portfolio manager exposure to the risk factor 'parallel shift' can be viewed as the contribution of duration positions. These models provide a richer description of the performance contribution than sector models. However, the quality of the results of the former may be affected by the presence of a non-negligible residual term as a component of the return.

3.1 Methodology

We develop an alternative approach which tries to preserve the richness of factor models without incurring in the drawback of a large residual term. The approach resembles that of sector models, however we modify the actual portfolio weights in such a way that they can be viewed as the result of exposures to the risk factors related to specific strategies. The proposed model disentangles the contribution of each strategy in order to detect specific portfolio manager skills: (a) duration contribution; (b) curve contribution; (c) spread contribution; and (d) security selection. The proposed framework thus provides a clear interpretation of results from a portfolio manager perspective.

The total extra–return is described by the following expression:

$$r^p = r_d^p + r_c^p + r_a^p + r_s^p$$

where

> r^P is the total portfolio extra-return,
> r_d^P is the duration contribution,
> r_c^P is the curve contribution,
> r_a^P is the spread contribution,
> r_s^P is the security selection contribution.

The duration contribution r_d^P captures the part of extra-return stemming from portfolio duration exposure vis-à-vis the benchmark. The curve contribution r_c^P gives the portfolio manager's skill in weighting the time buckets differently from the benchmark without taking any duration exposure. The selection contribution r_a^P comes from the ability in choosing weights of different asset classes (indexed by *i*; e.g. Treasuries vs Agencies) within a specific time bucket *j*. The security selection contribution r_s^p is due to the ability in picking securities within a specific sector.

We start by building a sequence of virtual portfolios the weights of which represent the relevant strategies. As a first step we build a virtual portfolio A, reflecting all the strategies implemented by the portfolio manager with the exception of security selection choices. By comparing the total return of the actual portfolio with that of portfolio A we can isolate the security selection contribution r_s^p. Second, we build a virtual portfolio B whose weights include only the portfolio manager spread choices. By comparing the benchmark total return with that of the virtual portfolio B we can thus disentangle the spread contribution r_a^p. Third, starting from virtual portfolio B, we rearrange the weights in order to build a virtual portfolio C including also the curve exposure. By comparing the virtual portfolio B return with that of portfolio C we obtain the curve contribution r_c^p. Finally, comparing the portfolio A with portfolio C we obtain the duration contribution. By construction this model presents no residual term.

We introduce the following definitions:

> $w_{ij}^{\ b}$ is the weight of sector *ij* of the benchmark;
>
> $R^b{}_{ij}$ is the return of sector *ij* of the benchmark;
>
> $MD_{ij}^{\ b}$ is the modified duration of sector *ij* in the benchmark;

$pd_{ij}^{\ b}$ is the partial duration (or duration contribution) of the sector *ij* in the benchmark; it is obtained as the product of benchmark weight $w_{ij}^{\ b}$ times the modified duration of sector *ij*, $MD_{ij}^{\ b}$;

$w_{ij}^{\ p}$ is the weight of each sector in the actual portfolio;

$R^{p}{}_{ij}$ is the return of the sector *ij* in the portfolio;

$MD_{ij}^{\ p}$, is the modified duration of sector *ij* in the portfolio;

$pd_{ij}^{\ p}$ is the partial duration of sector *ij* in the portfolio; it is obtained as the product between the actual portfolio weight $w_{ij}^{\ p}$ and the modified duration of sector *ij*, $MD_{ij}^{\ p}$.

The total extra-return of the portfolio is given by:

$$r^{p} = \sum_{i}^{k}\sum_{j}^{n} w^{p}{}_{ij} R^{p}{}_{ij} - \sum_{i}^{k}\sum_{j}^{n} w^{b}{}_{ij} R^{b}{}_{ij} \qquad (4)$$

where *k* is the number of asset classes and *n* is the number of time buckets.

First, we build a virtual portfolio A which, by construction, has for each sector *ij* the same internal composition, modified duration and return of the benchmark, but the partial durations of the actual portfolio. This virtual portfolio includes all the choices of the reserve manager with the exception of the security selection component. Therefore, if we subtract the overall return of this portfolio from the overall return of the actual portfolio, we obtain the security selection contribution to the overall extra-return.

We compute the weights of the virtual portfolio as:

$$w_{ij}^{\ A} = \frac{pd_{ij}^{\ p}}{MD_{ij}^{\ b}}$$

Since the sum of the rearranged portfolio weights is not necessarily equal to 100%, we assume that we can use a cash account as an additional asset class in order to finance the position (if the sum of weights is larger than 100%) or to invest the cash (if the sum of weights is lower than 100%). We assume that the return on this cash account is equal to the overnight uncollateralized rate $r_{O/N}$. The weight of this cash account is equal to:

$$w_{cash}{}^{A} = 1 - \sum_{ij}^{ij} w_{ij}{}^{A}$$

The overall extra-return can be split into two components

$$r^p = \underbrace{\sum_{i}^{k}\sum_{j}^{n} w^p{}_{ij} R^p{}_{ij} - \left(\sum_{i}^{k}\sum_{j}^{n} w^A{}_{ij} R^b{}_{ij} + w_{cash}{}^{A} r_{O/N} \right)}_{\text{This term represents the security selection component } r_s^p} + \underbrace{\sum_{i}^{k}\sum_{j}^{n} w^A{}_{ij} R^b{}_{ij} + w_{cash}{}^{A} r_{O/N} - \sum_{i}^{k}\sum_{j}^{n} w^b{}_{ij} R^b{}_{ij}}_{\text{This term represents the sum of spread contribution, curve and duration contribution } r_d^p + r_c^p + r_a^p}$$

The asset class selection choices depend on the relative asset weighting (e.g. Treasury vs Spread products) within each time bucket in terms of partial duration; the partial duration for each time bucket of the actual portfolio and the benchmark can be expressed by:

$$PD_j{}^{p} = \sum_{i=1}^{k} pd_{ij}{}^{p} \text{ (portfolio)}$$

$$PD_j{}^{b} = \sum_{i=1}^{k} pd_{ij}{}^{b} \text{ (benchmark)}$$

The relative asset class weight $\alpha_{ij}{}^{p}$ of the actual portfolio in terms of partial duration exposures for each asset class *i* and time bucket *j* is:

$$\alpha_{ij}{}^{p} = \frac{pd_{ij}{}^{p}}{PD_j{}^{p}}$$

Second, we build the weights of a virtual portfolio B, having the same time bucket partial duration exposure as the benchmark, expressed by $PD_j{}^{b}$, but an exposure for each asset class *i*, in relative terms, equal to the one of the actual portfolio, as:

$$w^B_{ij} = \frac{PD_j^b \alpha_{ij}^p}{MD_{ij}^b}$$

Starting from equation (4), we add and subtract the overall return of the virtual portfolio B. Similarly to the virtual portfolio A, the sum of the rearranged portfolio weights is not necessarily equal to 100%; therefore we introduce an additional cash account:

$$w_{cash}^B = 1 - \sum_{ij}^{ij} w_{ij}^B$$

Again, we assume that the return of this cash account is equal to the overnight uncollateralized rate $r_{O/N}$. If we subtract the overall return of the benchmark from the virtual portfolio B return, we obtain the asset class selection contribution to the overall extra-return. The difference between the return of portfolio A and the return of portfolio B represents the sum of curve and duration contribution.

$$\underbrace{\left(\sum_i^k \sum_j^n w^A{}_{ij} R^b{}_{ij} + w_{cash}{}^A r_{O/N}\right) - \left(\sum w^B{}_{ij} R^b{}_{ij} + w_{cash}{}^B r_{O/N}\right)}_{\text{This term represents the sum of curve and duration contribution to the overall extra–performance } r_d^p + r_c^p} + \underbrace{\left(\sum w^B{}_{ij} R^b{}_{ij} + w_{cash}{}^B r_{O/N}\right) - \sum_i^k \sum_j^n w^b{}_{ij} R^b{}_{ij}}_{\text{This term represents the spread contribution to the overall extra-performance } r_a^p}$$

Third, in order to disentangle the contribution stemming from the curve exposure, we assume that the duration exposure is conveyed by the sector with the highest exposure in the same direction of the overall exposure. Therefore:

i) we compute the differential time bucket exposures (portfolio vs benchmark) in terms of partial duration,

For instance, assume that

- the portfolio exposure in terms of partial duration for the different time - buckets is the following

Portfolio

	1 - 3	3 - 5	5 - 7	7 +	
Weights	19%	25%	31%	25%	100%
Modified duration	2	4	6	9	5.49
PD	0.38	1	1.86	2.25	5.49

- the benchmark exposure is the following

Benchmark

	1 - 3	3 - 5	5 - 7	7 +	
Weights	25%	25%	25%	25%	100%
Modified duration	2	4	6	9	5.25
PD	0.5	1	1.5	2.25	5.25

The differential exposure results to be the following

Differential exposure

	1 - 3	3 - 5	5 - 7	7 +	
PD	-0.12	0	0.36	0	0.24

ii) we identify the time bucket $\bar{j}$ with the highest exposure in the same direction as the overall exposure.

In the example, the overall exposure is equal to 0.24 and the bucket with the highest exposure in the same direction as the overall exposure is the 5–7 time bucket.

iii) starting from the portfolio exposure, we assume that we sell or buy the overall exposure by means of the time bucket identified in the previous step in order to re-instate the benchmark overall exposure; we therefore compute:

$$PD^{*}{}_{j}^{p} = PD_{j}^{p} \forall j \neq \bar{j}$$

$$PD^{*}{}_{\bar{j}}^{p} = PD_{\bar{j}}^{p} \pm overall\ \ exposure$$

and, with regards to the time bucket $\bar{j}$, we re-compute the asset class partial durations $pd^{*}{}_{ij} = \alpha_{i\bar{j}} PD_{\bar{j}}^{p} \pm overall\ \ exposure$ in such a way as to preserve the actual portfolio proportion to the overall time bucket partial duration.

In the example, the partial duration of the 5–7 time bucket is adjusted accordingly

Portfolio adjusted - partial durations

	1 - 3	3 - 5	5 - 7	7 +	
Modified duration	2	4	6	9	5.25
PD	0.38	1	1.62	2.25	5.25

Notice that this portfolio has the same overall duration as the benchmark, but a different combination of partial duration exposure among different time bucket; therefore it conveys only a curve exposure.

Differential exposure adj

	1 - 3	3 - 5	5 - 7	7 +	
PD	-0.12	0	0.12	0	0

iv) we compute the weight of the virtual portfolio C including only curve and sector selection exposure in the usual way:

$$w^C_{ij} = \frac{pd^*_{ij}}{MD_{ij} b}$$

also including the cash account:

$$w_{cash}{}^C = 1 - \sum_{ij}^{ij} w_{ij}{}^C$$

In the example, considering only the total time bucket weights and the cash account adjustment, the result is the following:

Portfolio adjusted - weights

	0 - 1	1 - 3	3 - 5	5 - 7	7 +	
Weights	4%	19%	25%	27%	25%	100%
Modified duration	0	2	4	6	9	5.25
PD	0	0.38	1	1.62	2.25	5.25

$$\underbrace{\left(\sum_{i}^{k}\sum_{j}^{n} w^{A}{}_{ij} R^{b}{}_{ij} + w_{cash}{}^{A} r_{O/N}\right) - \left(\sum w^{C}{}_{ij} R^{b}{}_{ij} + w_{cash}{}^{C} r_{O/N}\right)}_{\text{This term represents the duration contribution component } r_d^p} + \underbrace{\left(\sum w^{C}{}_{ij} R^{b}{}_{ij} + w_{cash}{}^{C} r_{O/N}\right) - \left(\sum w^{B}{}_{ij} R^{b}{}_{ij} + w_{cash}{}^{B} r_{O/N}\right)}_{\text{This term can represents the curve contribution } r_c^p}$$

3.2 Results

We applied the above model to a dataset of portfolio manager performances and positions related to the fixed income portfolios of USD reserves managed by the NCBs, described in section 1. Owing to the weekly data frequency, security selection actually reflects not only the activity of ‘pure’ selectivity among different bonds, but it captures also the result of all the other positions (duration, curve and spread) opened and closed in the same week, without altering the weights from one week to another. Furthermore, it includes the component of extra-return which comes from the carry of deposits and repo market activity[8].

We first examine the contribution to the extra-return which accrues from duration management (Fig. 2).
It is interesting to notice that one portfolio manager only (M8) achieved a non-negligible positive result in duration management, while the other portfolio managers obtained negative results (M3, M4, M7) or almost nil (M2, M5). This result supports the idea that the market timing ability coefficient lambda estimated in the econometric section for portfolio manager 8 might be related to this component.

Portfolio managers also show different styles in the use of risk budget, as it can be argued looking at the average and volatility of duration exposure for each portfolio manager (Fig. 3). We observe a relatively low exposure to duration bets, with the exception of a couple of portfolio managers (M3 and M4). However, we note that M4 shows a more active duration management only after 2008. The peaks of duration exposure of the other portfolio managers are of the order of 10 basis points only.

The curve contribution analysis shows a similar picture.

[8] The extra-return which comes from the carry of deposits is included in the security selection and not in the spread contribution, because deposit instruments are not classified as spread products.

Even in this case only M8 achieved a meaningful extra-return in curve management (Fig. 4). Thus, this component might also contribute to the overall ability of manager 8, as detected with the performance attribution approach.

M1 shows a slightly positive performance, with the other portfolio managers performing close to zero (M2, M3 and M4) or negatively (M6, M7 and M5). Fig. 5 illustrates a more diversified usage of the risk budget in curve bets than it appears in duration bets. In particular, some portfolio managers seem not to play curve bets (M2 and M3), other managers maintain only moderate curve exposures (M1, M4, M7 and M5) while M8 (with exposure peaks at around 50 basis points) and M6 (with maximum exposure at around 30 basis points) show a very active curve management.

The spread exposure proved to be the most important active layer in terms of results and exposures along the considered period.

Almost all portfolio managers achieved positive results in spread management, with the exception of M8 which was substantially aligned with the benchmark (Fig. 6). In general, an important source of spread extra-performance is related to the carry component. This component represents the yield pick–up earned by replacing government securities with spread products. The yield pick-up has been very high during the financial crisis of 2007–2008, when swap spreads in the two year tenor peaked at about 165 basis points. However, portfolio managers seem to have achieved these results not only by maintaining a long exposure to spread products, but also by actively trading spreads on both sides, long and short. The best performer in spread management is M6, which obtained an extra-performance of around 40 basis points. This manager also showed a very active style, by changing intensity in the usage of the risk budget (Fig. 7); M4, M7 and M5 show a result of around 20 basis points, while the other managers obtained a slightly positive extra-performance (M1 and M3) or close to nil (M2 and M8). Again, different styles can be traced: low active spread players (M2, M3 and M4), moderate active spread players (M1, M7 and M8) and strong spread players (M5 and M6) can be clearly identified (Fig. 7).

The most important source of extra-performance proves to be security selection (Fig. 8).

The best performer is M6, which achieves an extra-return close to 60 basis points, followed by M7 (around 50 basis points) and M5 (40 basis points); M2 and M4 achieve around 20 basis points, while the results of M1 and M3 are close to zero. The only manager which reports a negative result is M8 (-20 basis points).

All the managers contribute to the extra-performance with a positive result, while showing different skills or different ways to pursue extra–performance. Some portfolio managers prove to be more successful in duration bets, while others obtain better results in curve management, or playing the spread component, or exploiting the carry opportunities. Fig. 3, 5 and 7 clearly show a different usage of the risk budget among portfolio managers and a different attitude in changing it over time.

Portfolio managers styles prove to be different also in terms of some important indicators which may help to better qualify the attitude towards risk and the specific ability of portfolio managers to preserve capital. To illustrate this point we selected a small group of indicators: 1) the information ratio, measuring risk adjusted performance; 2) the tracking error, giving the dispersion of extra-returns; 3) the hit ratio, i.e. the percentage of winning bets over total bets; 4) the max drawdown, measuring the largest cumulative loss from peak to trough over a period of time.

The ranking across these performance qualifiers sheds some light about the preferences of portfolio managers towards returns (high information ratio) or capital preservation (low drawdown risk). The hit ratio helps understand if the extra-return reflects a combination of a large number of winning bets (with low profits) and a small number of losing bets (with a higher loss) or a combination of a few winning bets (with high profits) with many losing bets (with low losses). The tracking error provides a useful indication on the confidence interval of returns around the mean, which may help to distinguish whether the results depend on solid skills.

The tables show a low degree of overlap among the ranking of portfolio managers across performance qualifiers and active layers, thus supporting the idea of heterogeneous investment styles. The time horizon for active bets chosen by portfolio managers qualifies the investment style, discriminating between portfolio managers that prefer a low number of bets with a longer time horizon from those oriented toward a higher number of bets with a shorter time horizon.

Finally, Table 9 shows the average time horizon, in terms of weeks, for each single strategy across portfolio managers[9].

[9] The average time horizon is obtained by counting the number of inversions of sign of partial duration exposures related to each single strategy.

Portfolio managers are more resilient in changing positions of spread trades. This is in line with the idea that managers seek to fully exploit the carry component of spread products, which involves a preference for long spread positions and a bias towards a longer time horizon of spread strategies.

The average holding period for curve strategies is shorter, and it goes between 4 and 8 weeks, showing mixed preferences in terms of holding period among portfolio managers.

The time horizon for duration strategies is even shorter than that of curve strategies. The duration positions show a time horizon of slightly over one month, thus showing that the monthly rebalancing represents a kind of 'catalyst' for duration bets.

The latter figures confirm the idea that portfolio managers adopt different investment styles. The more diversified the investment style of portfolio managers is, according to each active layer, the more likely it is that on the aggregate portfolio a higher number of independent bets are carried out. According to the 'law of active management' (Grinold, 1989), other things equal, the higher the number of independent bets, the higher the information ratio of the aggregated portfolio. In particular, the information ratio is defined as :

$$\mathrm{IR} = \mathrm{IC} * \sqrt{BR}$$

where IC is the Information coefficient, a measure of the level of skill, or the ability to forecast each asset residual return. It is defined as the correlation between the forecasts and the returns; BR represents the Breadth, or the number of independent bets in the managed portfolio. According to this formula, one way to improve the information ratio might be given by an increase in the number of independent bets, assuming a comparable level of skills. More independent positions among portfolio managers in terms of duration, curve and timing may actually lead to a decrease in the absolute and relative risk of the aggregated portfolio, while the aggregate return can be expected to increase, hence improving the risk-return profile of the aggregate portfolio.

4. Conclusions

The ECB reserve managers display a significant weekly α in excess of the benchmark α, revealing security selection ability. Two portfolio managers show market timing ability after adjusting for the non-linearity of the benchmark returns. For one portfolio manager market timing ability is significantly related to the efficient use of public information.

The econometric analysis does not enable to pin down market timing to actual portfolio manager strategies (duration, curve, spread). For this reason we developed a simple performance attribution model which has some advantages in comparison with existing factor models: it identifies the contribution of the key portfolio managers' strategies; it offers a clear interpretation of results from a portfolio manager perspective; and it presents no residual term.

The application of this model to the group of reserve managers confirms their security selection skills. Among the active layers (duration, curve and spread), the spread contribution seems the most relevant; curve and duration bets, with some exceptions, have generally provided modest value added. The analysis of the usage of risk budget and the ranking across 'performance qualifiers' support the view that portfolio managers adopt diversified investment styles. This may explain the non-negligible result of the aggregate reserve portfolio, averaging 10 basis points on an annual basis net of transaction costs. The more diversified the investment styles are, the more likely it is that portfolio managers play independent bets, which in turn may positively affect the risk-adjusted return of the aggregate portfolio.

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Table and Figures

Table 1 - Common factors *(percentage points; weekly data)*

	f1 Δ(rate)	f2 Δ(slope)	f3 Δ(curve)	f4 Δ(spread)	f5 $Δ(rate)^2$	f6 $Δ(slope)^2$	f7 $Δ(curve)^2$	f8 $Δ(spread)^2$
mean	-0.015	0.010	0.000	-0.001	0.020	0.008	0.003	0.004
min	-1.000	-0.320	-0.277	-0.260	0.000	0.000	0.000	0.000
max	0.590	0.260	0.257	0.250	1.000	0.102	0.077	0.068
std dev	0.141	0.087	0.053	0.060	0.086	0.015	0.007	0.009

Table 2 - Excess returns *(percentage points; weekly data)*

	benchmark	M1	M2	M3	M4	M5	M6	M7	M8
mean	0.032	0.033	0.033	0.032	0.031	0.033	0.033	0.035	0.034
min	-0.986	-1.003	-0.986	-1.015	-0.989	-0.988	-1.012	-1.016	-0.978
max	0.661	0.690	0.719	0.670	0.653	0.693	0.704	0.710	0.689
std dev	0.190	0.190	0.190	0.193	0.187	0.189	0.190	0.195	0.188

Table 3 - Market timing regressions - Equations 1 and 2

	M1			**M2**			**M3**			**M4**			**M5**			**M6**			**M7**			**M8**		
	Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*	
ab	0.016	*1.49*		0.018	*1.63*	*	0.017	*1.57*		0.017	*1.56*		0.018	*1.66*	*	0.019	*1.76*	*	0.019	*1.68*	*	0.017	*1.53*	
b1	-0.298	*-3.18*	***	-0.269	*-2.92*	***	-0.278	*-2.96*	***	-0.287	*-3.04*	***	-0.306	*-3.32*	***	-0.229	*-2.55*	***	-0.280	*-3.02*	***	-0.292	*-3.12*	***
b2	-0.400	*-3.34*	***	-0.377	*-3.20*	***	-0.357	*-2.97*	***	-0.408	*-3.41*	***	-0.418	*-3.50*	***	-0.472	*-4.13*	***	-0.400	*-3.40*	***	-0.384	*-3.23*	***
b3	-2.176	*-10.89*	***	-2.134	*-10.71*	***	-2.179	*-10.88*	***	-2.177	*-10.88*	***	-2.141	*-10.77*	***	-2.083	*-10.55*	***	-2.136	*-10.72*	***	-2.175	*-10.89*	***
b4	-0.842	*-4.98*	***	-0.877	*-5.26*	***	-0.848	*-5.00*	***	-0.784	*-4.62*	***	-0.797	*-4.76*	***	-0.723	*-4.46*	***	-0.854	*-5.12*	***	-0.854	*-5.06*	***
b5	-0.388	*-2.62*	***	-0.421	*-2.86*	***	-0.405	*-2.69*	***	-0.437	*-2.89*	***	-0.499	*-3.50*	***	-0.442	*-3.04*	***	-0.432	*-2.91*	***	-0.407	*-2.74*	***
b6	0.403	*0.57*		0.302	*0.44*		0.324	*0.46*		0.425	*0.60*		0.520	*0.74*		0.386	*0.57*		0.191	*0.28*		0.441	*0.63*	
b7	4.138	*2.88*	***	4.761	*3.28*	***	4.883	*3.30*	***	4.473	*3.04*	***	3.524	*2.55*	***	4.555	*3.21*	***	4.817	*3.31*	***	4.490	*3.13*	***
b8	1.994	*1.73*	*	1.542	*1.33*		1.379	*1.17*		1.806	*1.54*		2.372	*2.09*	**	1.733	*1.55*		1.648	*1.42*		1.596	*1.39*	
ap	0.018	*1.60*		0.019	*1.67*	*	0.018	*1.62*		0.018	*1.63*	*	0.019	*1.75*	*	0.022	*1.92*	*	0.021	*1.91*	*	0.017	*1.56*	
bp	0.988	*69.58*	***	1.026	*113.91*	***	0.987	*85.14*	***	0.997	*85.38*	***	0.985	*91.55*	***	1.054	*69.36*	***	1.004	*84.81*	***	0.983	*67.48*	***
lambda	0.077	*1.55*		-0.018	*-0.68*		-0.007	*-0.20*		0.028	*0.75*		0.078	*1.88*	*	0.011	*0.24*		-0.005	*-0.14*		0.083	*1.64*	*

Table 4a - Regressions with public information - Short term rate

	M1			M2			M3			M4			M5			M6			M7			M8		
	Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*	
Ab	0.017	*1.50*		0.018	*1.60*		0.016	*1.49*		0.017	*1.56*		0.017	*1.55*		0.019	*1.68*	*	0.019	*1.71*	*	0.017	*1.54*	
b1	-0.287	*-3.04*	***	-0.276	*-2.94*	***	-0.271	*-3.21*	***	-0.285	*-3.02*	***	-0.287	*-3.07*	***	-0.246	*-2.68*	***	-0.273	*-2.95*	***	-0.296	*-3.16*	***
b2	-0.404	*-3.36*	***	-0.382	*-3.22*	***	-0.450	*-3.85*	***	-0.405	*-3.37*	***	-0.399	*-3.32*	***	-0.451	*-3.85*	***	-0.388	*-3.33*	***	-0.393	*-3.28*	***
b3	-2.173	*-10.85*	***	-2.155	*-10.79*	***	-2.176	*-11.01*	***	-2.178	*-10.87*	***	-2.171	*-10.85*	***	-2.120	*-10.67*	***	-2.144	*-10.80*	***	-2.178	*-10.89*	***
b4	-0.816	*-4.80*	***	-0.845	*-5.04*	***	-0.716	*-4.36*	***	-0.792	*-4.66*	***	-0.807	*-4.75*	***	-0.752	*-4.54*	***	-0.831	*-5.05*	***	-0.840	*-4.97*	***
b5	-0.410	*-2.71*	***	-0.425	*-2.85*	***	-0.374	*-2.65*	***	-0.430	*-2.84*	***	-0.430	*-2.86*	***	-0.431	*-2.92*	***	-0.440	*-3.01*	***	-0.416	*-2.79*	***
b6	0.440	*0.62*		0.333	*0.48*		0.451	*0.68*		0.420	*0.59*		0.374	*0.53*		0.410	*0.60*		0.167	*0.25*		0.449	*0.63*	
b7	4.486	*3.03*	***	4.760	*3.28*	***	4.592	*3.55*	***	4.546	*3.07*	***	4.656	*3.16*	***	4.522	*3.11*	***	4.978	*3.57*	***	4.495	*3.09*	***
b8	1.773	*1.51*		1.586	*1.37*		1.844	*1.64*	*	1.708	*1.45*		1.762	*1.50*		1.717	*1.50*		1.591	*1.41*		1.591	*1.37*	
Ap	0.018	*1.63*	*	0.018	*1.64*	*	0.016	*1.48*		0.018	*1.63*	*	0.019	*1.69*	*	0.021	*1.83*	*	0.022	*1.97*	**	0.017	*1.56*	
bp	1.004	*18.54*	***	1.039	*26.80*	***	0.895	*25.08*	***	0.999	*21.42*	***	1.028	*21.66*	***	1.044	*20.13*	***	1.068	*19.13*	***	0.975	*18.94*	***
lambda	0.043	*0.47*		-0.035	*-0.56*		0.110	*1.82*	*	0.025	*0.32*		-0.011	*-0.14*		0.028	*0.32*		-0.091	*-1.01*		0.094	*1.03*	
cp	0.008	*0.25*		0.008	*0.37*		-0.053	*-2.60*	***	0.001	*0.03*		0.024	*0.88*		-0.004	*-0.14*		0.039	*1.23*		-0.005	*-0.17*	

Table 4b - Regressions with public information - Slope

	M1			M2			M3			M4			M5			M6			M7			M8		
	Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*	
ab	0.017	*1.54*		0.017	*1.57*		0.018	*1.58*		0.017	*1.57*		0.017	*1.57*		0.018	*1.59*		0.018	*1.58*		0.017	*1.56*	
b1	-0.286	*-3.04*	***	-0.284	*-2.99*	***	-0.282	*-2.98*	***	-0.285	*-3.01*	***	-0.285	*-3.01*	***	-0.278	*-2.95*	***	-0.284	*-3.01*	***	-0.288	*-3.04*	***
b2	-0.402	*-3.34*	***	-0.397	*-3.29*	***	-0.395	*-3.28*	***	-0.400	*-3.31*	***	-0.400	*-3.31*	***	-0.409	*-3.40*	***	-0.399	*-3.31*	***	-0.397	*-3.29*	***
b3	-2.172	*-10.84*	***	-2.177	*-10.84*	***	-2.183	*-10.87*	***	-2.179	*-10.86*	***	-2.177	*-10.84*	***	-2.171	*-10.82*	***	-2.175	*-10.84*	***	-2.180	*-10.86*	***
b4	-0.822	*-4.83*	***	-0.812	*-4.77*	***	-0.805	*-4.72*	***	-0.806	*-4.73*	***	-0.809	*-4.74*	***	-0.797	*-4.70*	***	-0.813	*-4.78*	***	-0.813	*-4.77*	***
b5	-0.413	*-2.74*	***	-0.419	*-2.76*	***	-0.414	*-2.73*	***	-0.421	*-2.78*	***	-0.424	*-2.79*	***	-0.423	*-2.79*	***	-0.421	*-2.78*	***	-0.420	*-2.77*	***
b6	0.416	*0.59*		0.407	*0.57*		0.401	*0.56*		0.421	*0.59*		0.424	*0.60*		0.412	*0.58*		0.391	*0.55*		0.416	*0.58*	
b7	4.544	*3.11*	***	4.613	*3.11*	***	4.631	*3.12*	***	4.576	*3.09*	***	4.536	*3.06*	***	4.595	*3.11*	***	4.620	*3.11*	***	4.598	*3.11*	***
b8	1.673	*1.43*		1.577	*1.33*		1.516	*1.28*		1.599	*1.35*		1.625	*1.37*		1.603	*1.36*		1.588	*1.34*		1.585	*1.34*	
ap	0.018	*1.57*		0.018	*1.52*		0.017	*1.52*		0.018	*1.54*		0.019	*1.60*		0.020	*1.64*	*	0.020	*1.71*	*	0.017	*1.48*	
bp	1.108	*5.07*	***	1.022	*3.59*	***	1.078	*4.31*	***	1.059	*4.22*	***	1.027	*4.07*	***	1.032	*3.57*	***	1.015	*3.89*	***	1.017	*3.49*	***
lambda	0.133	*0.75*		-0.020	*-0.09*		0.054	*0.27*		0.066	*0.33*		0.066	*0.32*		0.025	*0.11*		0.005	*0.02*		0.101	*0.43*	
cp	0.073	*0.54*		-0.002	*-0.01*		0.058	*0.38*		0.039	*0.25*		0.024	*0.15*		-0.008	*-0.04*		0.008	*0.05*		0.021	*0.12*	

Table 4c - Regressions with public information - Curve

	M1			M2			M3			M4			M5			M6			M7			M8		
	Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*	
ab	0.016	*1.44*		0.018	*1.67*	*	0.017	*1.54*		0.017	*1.52*		0.018	*1.59*		0.019	*1.72*	*	0.018	*1.69*	*	0.018	*1.59*	
b1	-0.300	*-3.20*	***	-0.265	*-2.86*	***	-0.280	*-2.98*	***	-0.293	*-3.11*	***	-0.294	*-3.19*	***	-0.228	*-2.55*	***	-0.288	*-3.09*	***	-0.307	*-3.31*	***
b2	-0.399	*-3.33*	***	-0.380	*-3.22*	***	-0.362	*-3.02*	***	-0.415	*-3.47*	***	-0.416	*-3.48*	***	-0.462	*-4.02*	***	-0.434	*-3.73*	***	-0.404	*-3.41*	***
b3	-2.176	*-10.89*	***	-2.130	*-10.70*	***	-2.180	*-10.89*	***	-2.180	*-10.90*	***	-2.143	*-10.76*	***	-2.101	*-10.60*	***	-2.121	*-10.72*	***	-2.174	*-10.90*	***
b4	-0.847	*-5.01*	***	-0.872	*-5.24*	***	-0.854	*-5.04*	***	-0.793	*-4.69*	***	-0.853	*-5.12*	***	-0.723	*-4.43*	***	-0.838	*-5.11*	***	-0.840	*-4.99*	***
b5	-0.379	*-2.54*	***	-0.428	*-2.91*	***	-0.387	*-2.57*	***	-0.417	*-2.76*	***	-0.437	*-2.99*	***	-0.431	*-2.98*	***	-0.456	*-3.11*	***	-0.436	*-2.94*	***
b6	0.457	*0.65*		0.302	*0.44*		0.326	*0.46*		0.447	*0.63*		0.442	*0.63*		0.388	*0.58*		0.491	*0.72*		0.432	*0.62*	
b7	4.187	*2.89*	***	4.704	*3.26*	***	4.847	*3.27*	***	4.584	*3.12*	***	4.253	*2.92*	***	4.447	*3.11*	***	4.725	*3.39*	***	4.380	*3.09*	***
b8	1.920	*1.66*	*	1.523	*1.32*		1.392	*1.18*		1.693	*1.44*		1.848	*1.59*		1.832	*1.63*	*	1.340	*1.16*		1.675	*1.46*	
ap	0.017	*1.54*		0.019	*1.71*	*	0.017	*1.60*		0.017	*1.57*		0.019	*1.68*	*	0.021	*1.91*	*	0.020	*1.88*	*	0.018	*1.63*	*
bp	0.988	*68.53*	***	1.027	*112.90*	***	0.986	*81.56*	***	0.999	*83.52*	***	0.993	*93.07*	***	1.048	*66.99*	***	1.010	*81.85*	***	0.981	*65.51*	***
lambda	0.073	*1.42*		-0.024	*-0.82*		-0.002	*-0.06*		0.018	*0.46*		0.022	*0.60*		0.038	*0.75*		-0.039	*-0.97*		0.103	*1.74*	*
cp	-0.035	*-0.31*		-0.038	*-0.56*		0.052	*0.55*		-0.080	*-0.88*		-0.195	*-2.30*	**	0.149	*1.35*		-0.206	*-2.20*	**	0.112	*0.97*	

Table 4d - Regressions with public information - Spread

	M1			M2			M3			M4			M5			M6			M7			M8		
	Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*		Coef.	*z*	
ab	0.017	*1.50*		0.017	*1.56*		0.018	*1.62*		0.017	*1.55*		0.018	*1.60*		0.021	*1.91*	*	0.018	*1.63*	*	0.017	*1.56*	
b1	-0.290	*-3.08*	***	-0.272	*-3.00*	***	-0.283	*-3.08*	***	-0.286	*-3.05*	***	-0.297	*-3.20*	***	-0.229	*-2.66*	***	-0.281	*-3.01*	***	-0.317	*-3.42*	***
b2	-0.407	*-3.40*	***	-0.372	*-3.16*	***	-0.353	*-2.97*	***	-0.413	*-3.46*	***	-0.419	*-3.49*	***	-0.465	*-4.11*	***	-0.404	*-3.42*	***	-0.391	*-3.31*	***
b3	-2.169	*-10.84*	***	-2.142	*-10.78*	***	-2.174	*-10.90*	***	-2.179	*-10.89*	***	-2.160	*-10.83*	***	-2.091	*-10.68*	***	-2.157	*-10.79*	***	-2.189	*-10.97*	***
b4	-0.833	*-4.91*	***	-0.869	*-5.29*	***	-0.883	*-5.30*	***	-0.792	*-4.69*	***	-0.808	*-4.82*	***	-0.724	*-4.68*	***	-0.828	*-4.93*	***	-0.802	*-4.81*	***
b5	-0.398	*-2.65*	***	-0.414	*-2.88*	***	-0.385	*-2.63*	***	-0.417	*-2.78*	***	-0.455	*-3.11*	***	-0.448	*-3.28*	***	-0.422	*-2.81*	***	-0.438	*-2.95*	***
b6	0.431	*0.61*		0.305	*0.45*		0.204	*0.30*		0.434	*0.61*		0.527	*0.75*		0.336	*0.53*		0.240	*0.34*		0.132	*0.19*	
b7	4.241	*2.92*	***	4.882	*3.40*	***	4.849	*3.33*	***	4.418	*3.03*	***	3.839	*2.70*	***	4.558	*3.26*	***	4.612	*3.16*	***	4.837	*3.31*	***
b8	1.916	*1.65*	*	1.606	*1.44*		1.382	*1.22*		1.772	*1.51*		2.058	*1.79*	*	1.466	*1.47*		1.819	*1.55*		1.996	*1.79*	*
ap	0.018	*1.61*		0.018	*1.64*	*	0.019	*1.72*	*	0.017	*1.59*		0.019	*1.68*	*	0.024	*2.19*	**	0.020	*1.83*	*	0.018	*1.66*	*
bp	0.992	*22.43*	***	0.995	*27.08*	***	0.948	*22.00*	***	1.027	*25.85*	***	1.010	*26.69*	***	0.954	*18.05*	***	1.022	*25.93*	***	0.930	*17.99*	***
lambda	0.071	*0.97*		-0.055	*-0.98*		-0.057	*-0.87*		0.064	*1.01*		0.090	*1.41*		-0.086	*-1.13*		0.022	*0.37*		0.005	*0.05*	
cp	0.004	*0.05*		-0.049	*-0.89*		-0.063	*-0.96*		0.049	*0.81*		0.037	*0.66*		-0.153	-1.94	**	0.032	*0.54*		-0.092	*-1.16*	

Table 5 - Duration extra–performance indicators

	M1	M2	M3	M4	M5	M6	M7	M8
DURATION								
Information ratio (yearly basis)	0.02	-0.30	-0.35	-0.87	-0.36	-0.20	-0.56	0.40
Ranking	**2**	**4**	**5**	**8**	**6**	**3**	**7**	**1**
Tracking error (yearly basis)	0.03%	0.03%	0.10%	0.06%	0.03%	0.04%	0.05%	0.08%
Ranking	**1**	**2**	**8**	**6**	**3**	**4**	**5**	**7**
Hit Ratio	45%	51%	49%	48%	47%	50%	56%	49%
Ranking	**8**	**2**	**4**	**6**	**7**	**3**	**1**	**4**
Max Drawdown	-0.09%	-0.09%	-0.30%	-0.30%	-0.11%	-0.09%	-0.14%	-0.09%
Ranking	**4**	**1**	**8**	**7**	**5**	**2**	**6**	**3**

Table 6 - Curve extra–performance indicators

	M1	M2	M3	M4	M5	M6	M7	*M8*
CURVE								
Information ratio (yearly basis)	0.35	0.05	-0.18	0.09	-0.71	-0.33	-0.27	*0.36*
Ranking	**2**	**4**	**5**	**3**	**8**	**7**	**6**	***1***
Tracking error (yearly basis)	0.04%	0.02%	0.01%	0.03%	0.03%	0.10%	0.04%	*0.15%*
Ranking	**5**	**2**	**1**	**4**	**3**	**7**	**6**	***8***
Hit Ratio	51%	53%	51%	50%	48%	49%	49%	*54%*
Ranking	**3**	**2**	**3**	**5**	**8**	**7**	**6**	***1***
Max Drawdown	-0.09%	-0.04%	-0.04%	-0.09%	-0.14%	-0.34%	-0.08%	*-0.18%*
Ranking	**5**	**2**	**1**	**4**	**6**	**8**	**3**	***7***

Table 7 - Spread extra–performance indicators

	M1	M2	M3	M4	M5	M6	M7	M8
SPREAD								
Information ratio (yearly basis)	0.55	0.47	0.40	0.77	0.57	0.50	0.36	-0.01
Ranking	**3**	**5**	**6**	**1**	**2**	**4**	**7**	**8**
Tracking error (yearly basis)	0.14%	0.03%	0.03%	0.06%	0.06%	0.16%	0.12%	0.18%
Ranking	**6**	**1**	**2**	**4**	**3**	**7**	**5**	**8**
Hit Ratio	57%	61%	57%	54%	55%	55%	61%	53%
Ranking	**3**	**2**	**4**	**7**	**6**	**5**	**1**	**8**
Max Drawdown	-0.28%	-0.07%	-0.06%	-0.17%	-0.08%	-0.33%	-0.33%	-0.27%
Ranking	**6**	**2**	**1**	**4**	**3**	**7**	**8**	**5**

Table 8 - Security selection extra-performance indicators

	M1	M2	M3	M4	M5	M6	M7	M8
SECURITY SELECTION								
Information ratio (yearly basis)	0.04	0.77	0.18	0.68	1.13	0.76	1.21	-0.32
Ranking	**7**	**3**	**6**	**5**	**2**	**4**	**1**	**8**
Tracking error (yearly basis)	0.11%	0.05%	0.07%	0.07%	0.08%	0.16%	0.09%	0.13%
Ranking	**6**	**1**	**2**	**3**	**4**	**8**	**5**	**7**
Hit Ratio	52%	55%	60%	51%	55%	55%	54%	44%
Ranking	**6**	**2**	**1**	**7**	**2**	**2**	**5**	**8**
Max Drawdown	-0.19%	-0.09%	-0.09%	-0.25%	-0.07%	-0.23%	-0.09%	-0.28%
Ranking	**5**	**3**	**2**	**7**	**1**	**6**	**4**	**8**

Table 9 - Active positions - average time horizon *(weeks)*

	M1	M2	M3	M4	M5	M6	M7	M8
DURATION	4	10	5	5	6	6	6	6
CURVE	11	6	4	6	7	10	7	9
SPREAD	24	13	2	15	24	22	13	18

Fig. 1 – Cumulative returns, ECB's USD reserves, 2006-2010

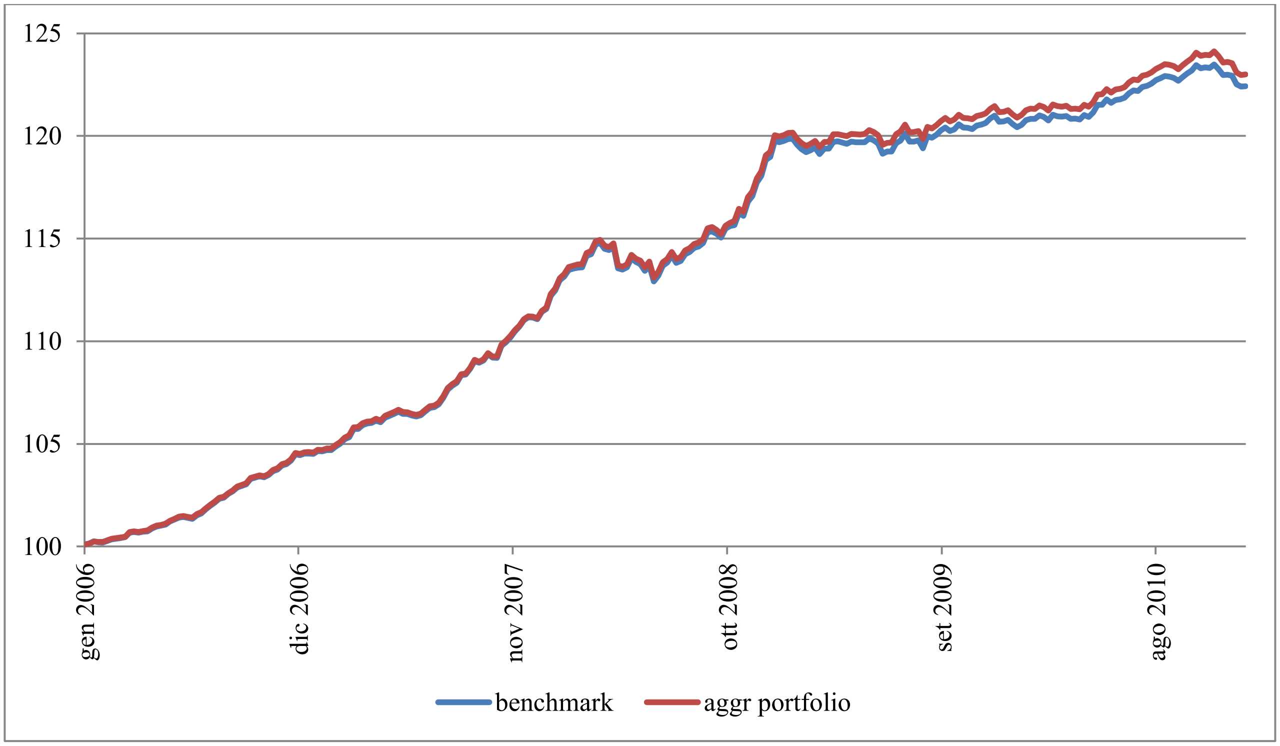


Fig. 2 - Duration contribution to extra-performance

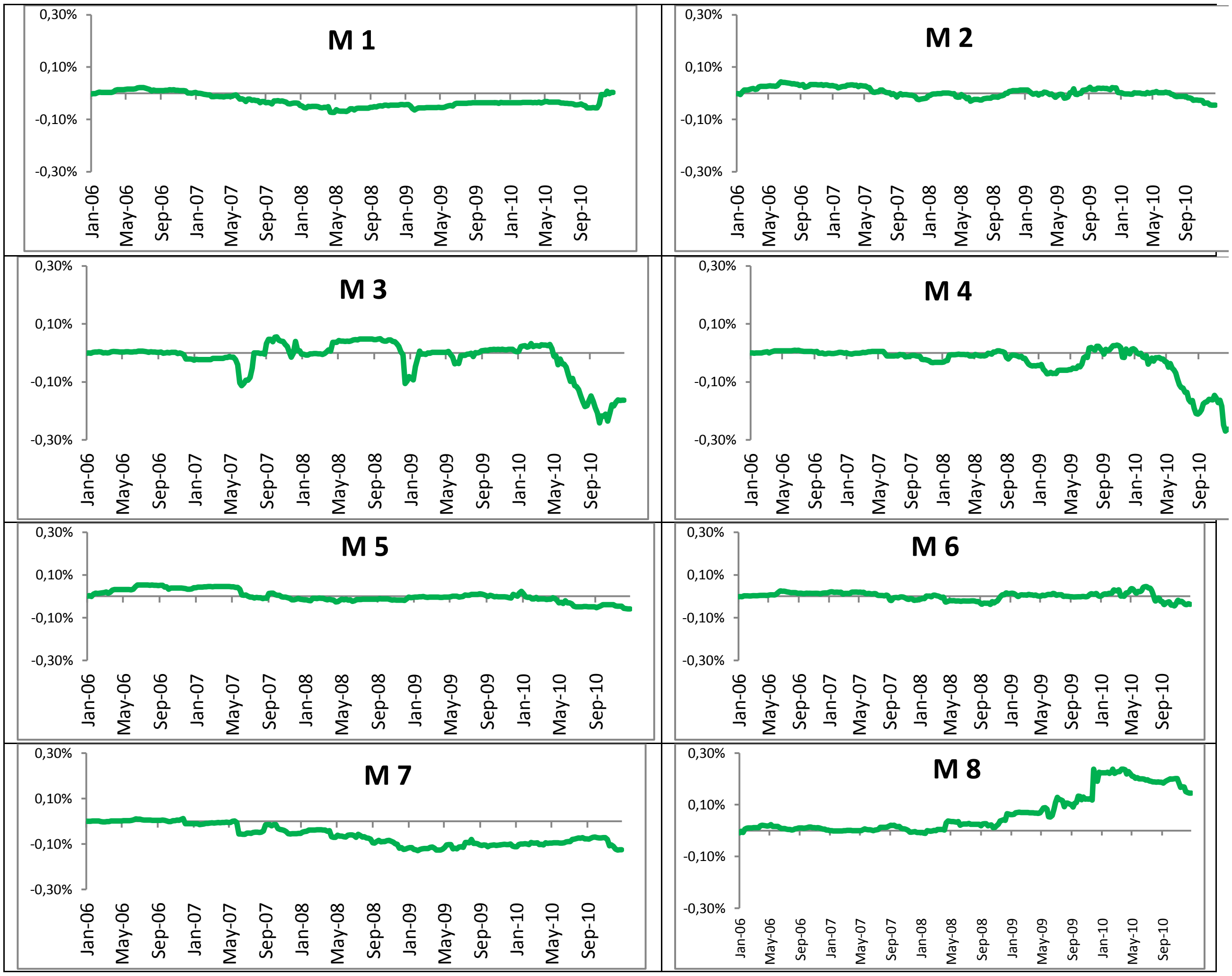


Fig. 3 - Duration exposure

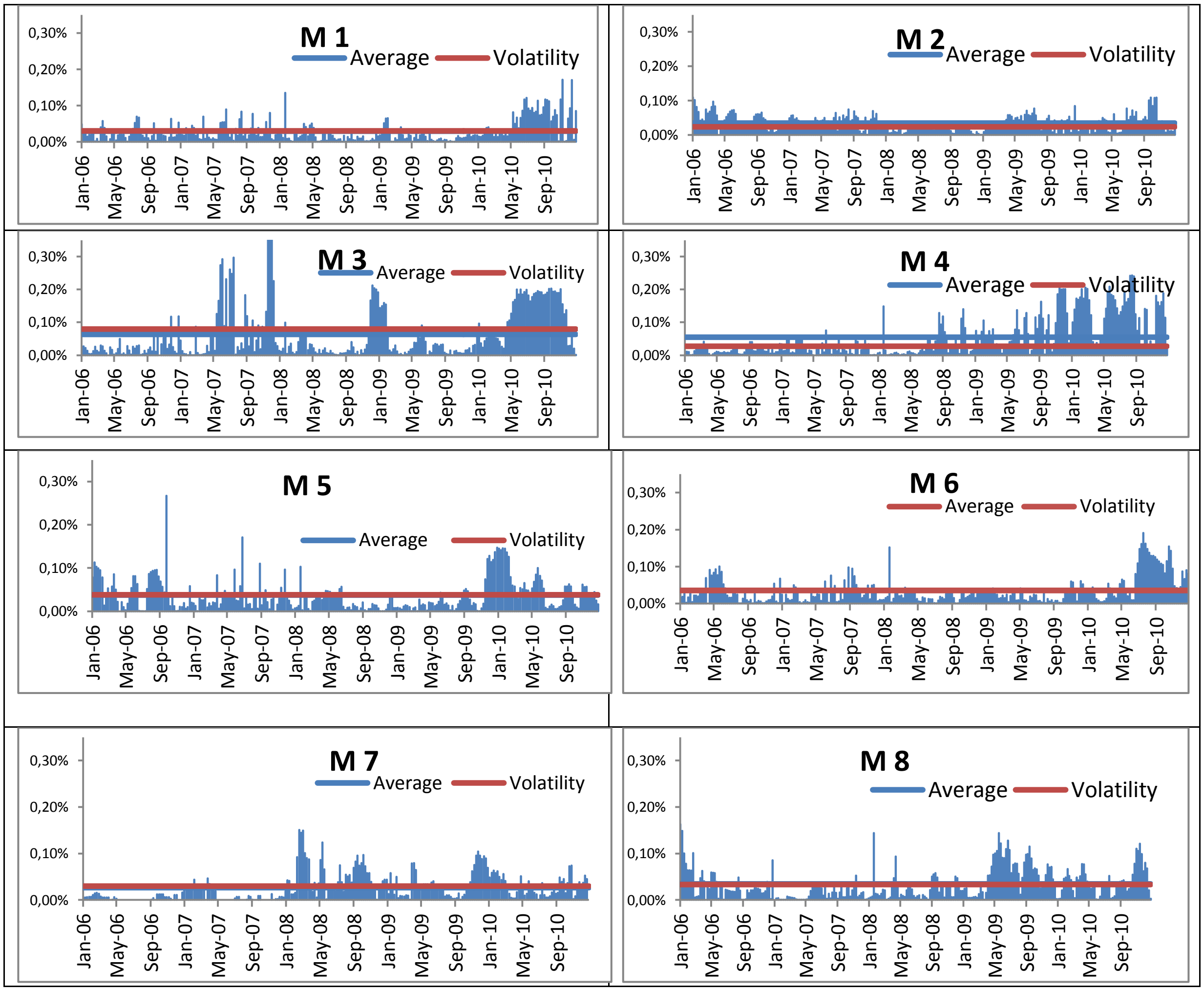


Fig. 4 - Curve contribution to extra-performance

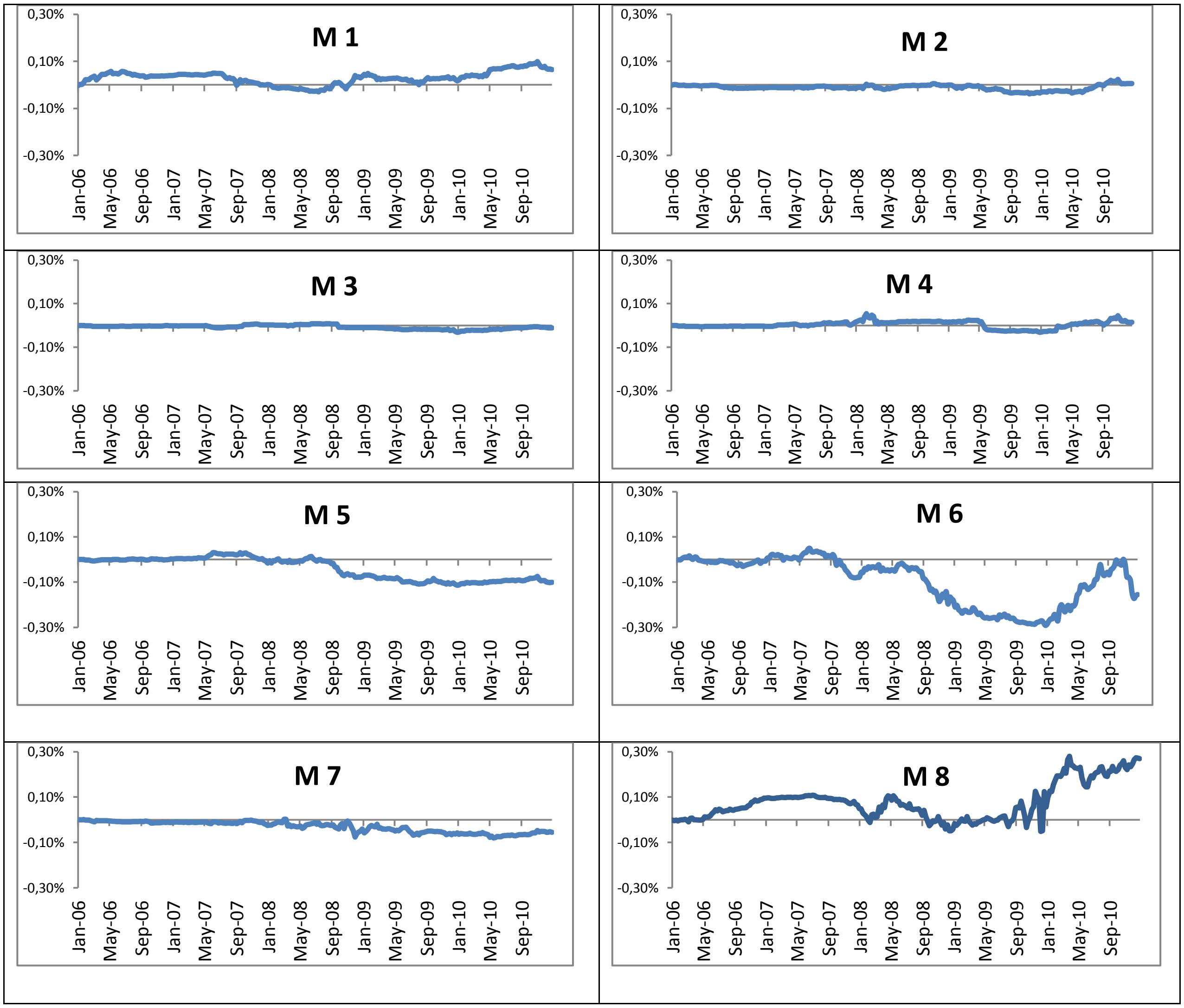


Fig. 5 - Curve exposure

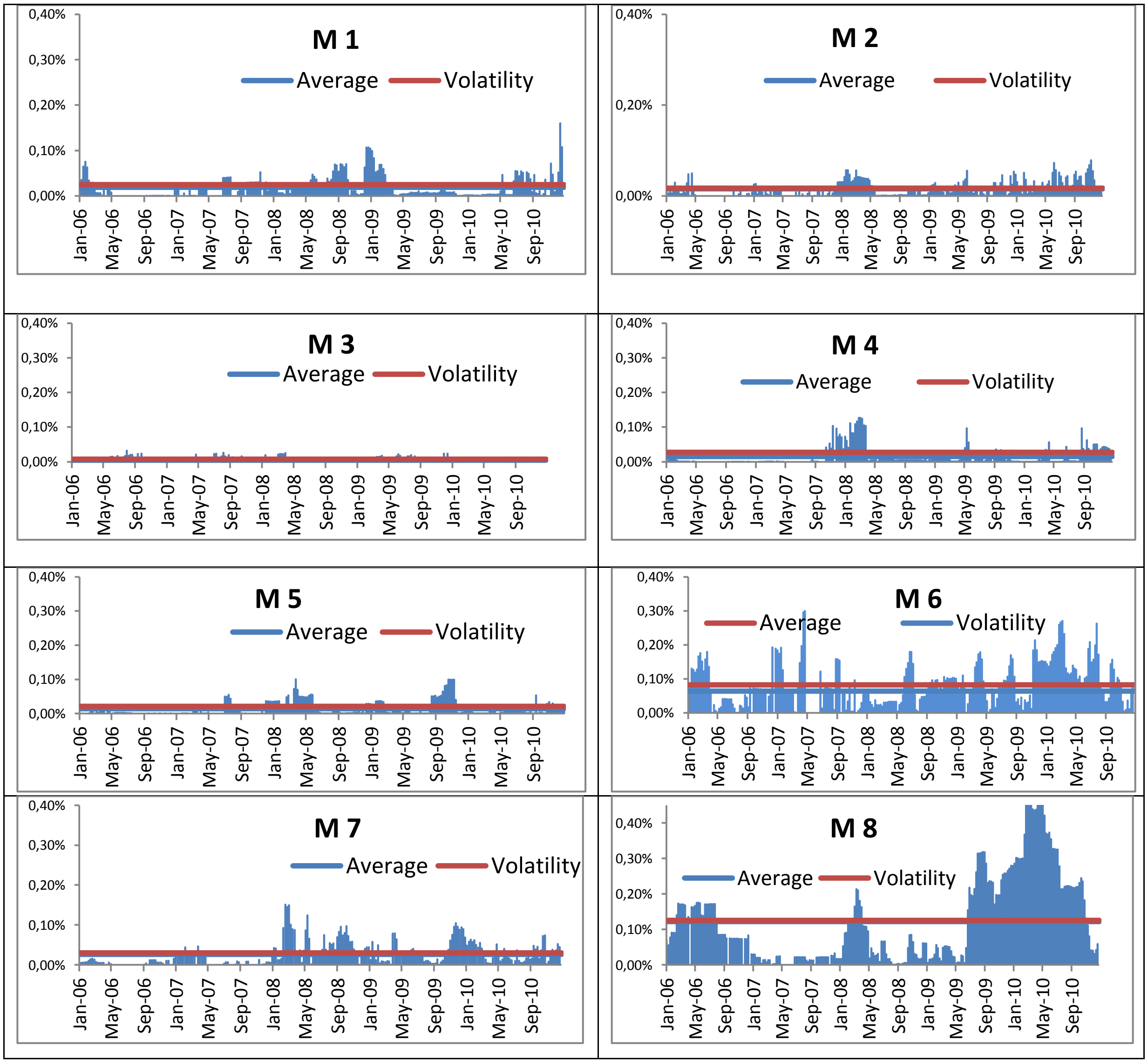


Fig. 6 - Spread contribution to extra-performance

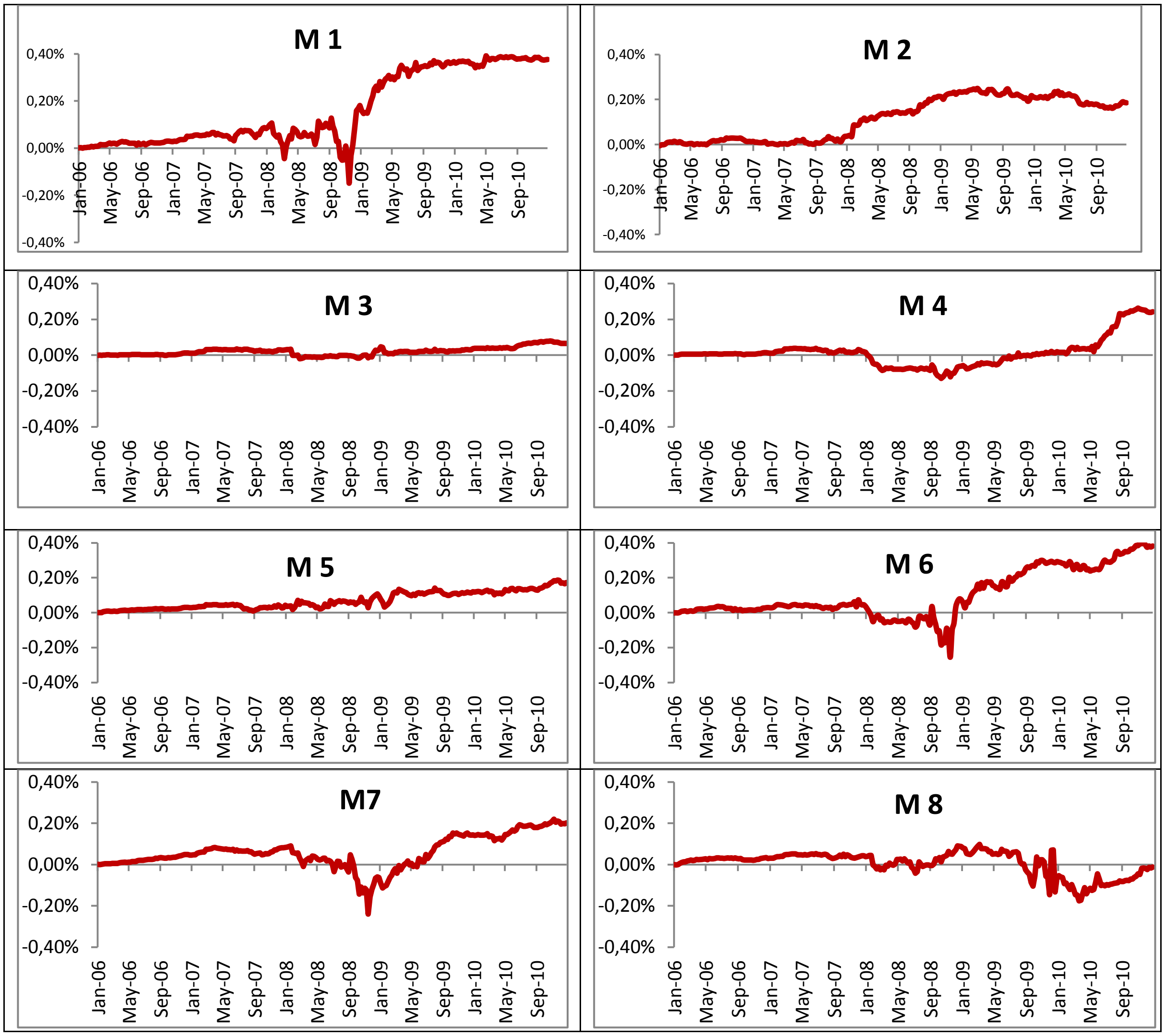


Fig. 7 - Spread exposure

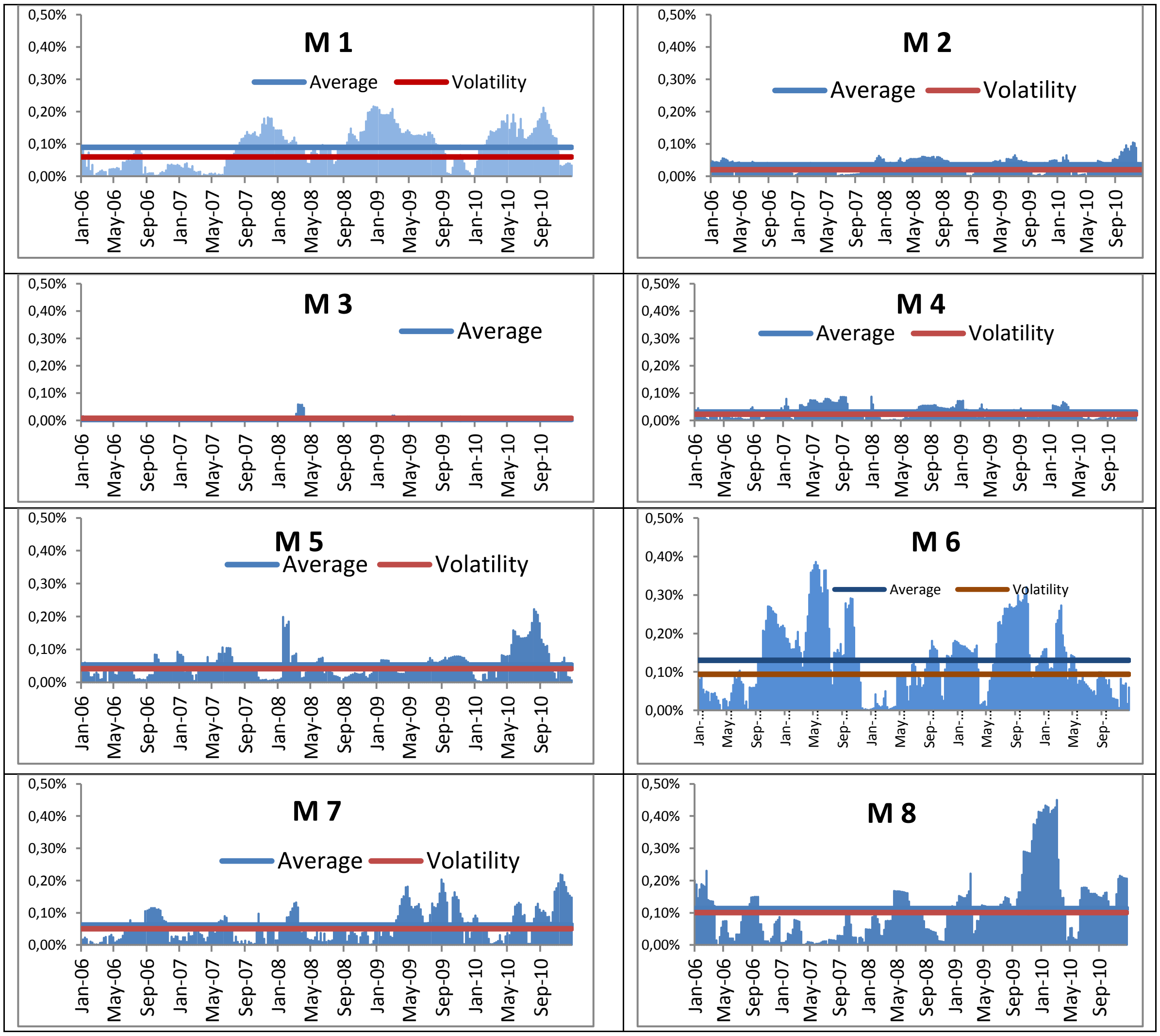
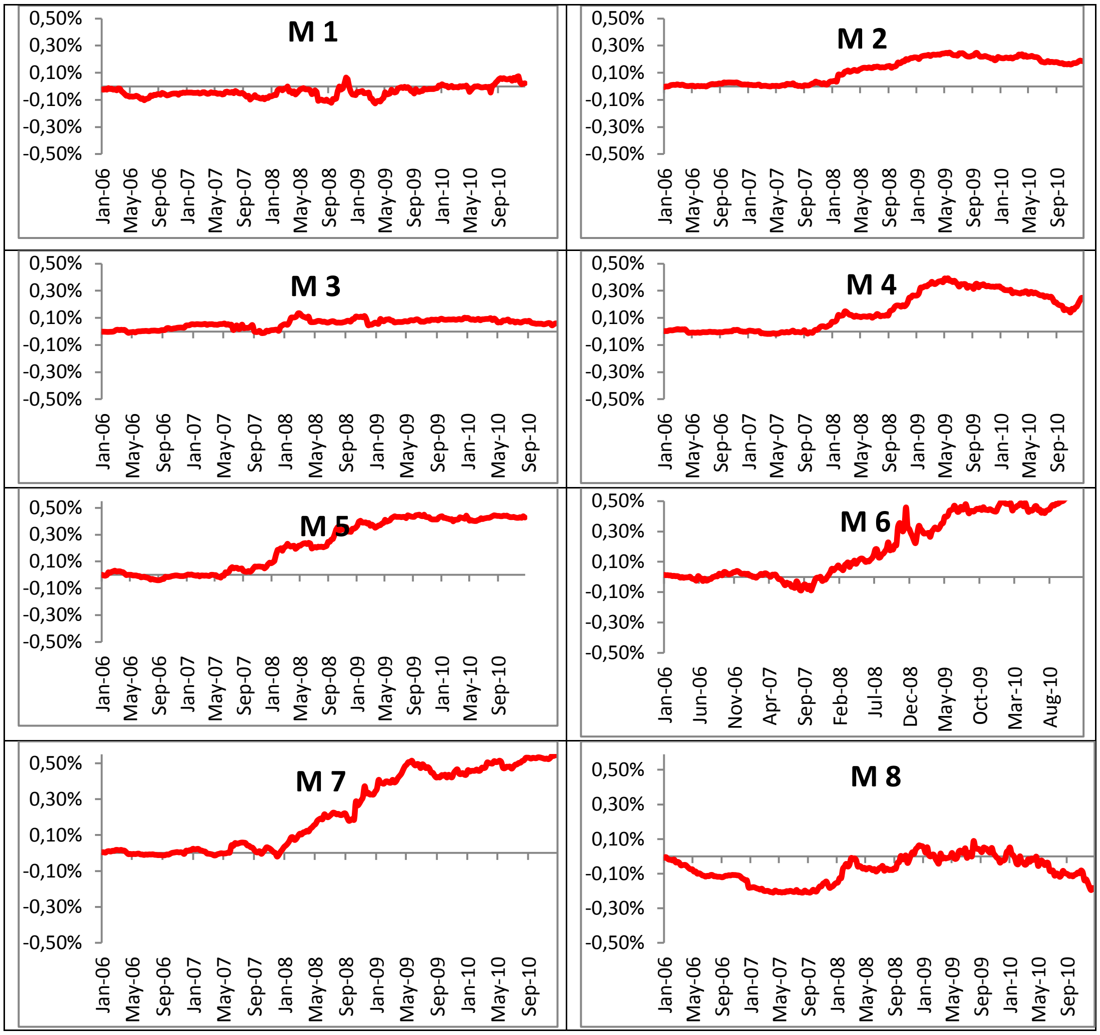


Fig. 8 - Security selection contribution to extra-performance



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