

## NBIM DISCUSSION NOTE

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### The History of Rebalancing of the Fund

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In this note we dig deeper into the rebalancing question and examine how the Fund's rebalancing rules have impacted overall risks and returns.

We find that the rules for rebalancing have served the fund well and contributed to both lower risk and higher returns compared to a drifting mix portfolio.

We also find that the Fund's current rebalancing regime has provided both higher returns and higher Sharpe ratio compared to a calendar based regime with fixed quarterly rebalancing. Finally, we find that the current procedure with partial rebalancing, where inflows to the Fund leads to changes in the actual index, appears not to have had the same positive impact on the net Sharpe of the Fund despite its cost reducing effect.

## The evolution of the strategic index

The Fund's rules for rebalancing describe when and how the actual benchmark shall be adjusted towards the strategic benchmark. In order to analyse the rebalancing regime for GPFG we need to account for changes to the strategic benchmark over this period. We will focus on changes to the asset mix as well as changes to the regional composition of the strategic benchmark. Changes to the underlying benchmarks such as the 2001 decision to introduce small cap equities and investment grade bonds will not be discussed.

The first transfer to the Fund was made late 1996. At this point the Fund was managed as part of the Norges Bank's FXs reserves which in mid the 90s was invested in government bonds. The currency composition of the FX Reserves, and thereby of the Fund, mirrored Norwegian import weights heavily tilted towards Europe with a 75 percent weight. The corresponding weights for America and Asia (Japan only) were 17 and 8 percent respectively.

In 1998 it was decided to introduce a 40 percent allocation to equities in the strategic benchmark for the Fund. As of that date, the Fund was no longer managed as part of the FX Reserves but as a separate fund. In conjunction with the introduction of equities to the asset mix a new regional allocation was established for the Fund. The regional allocation to Europe was reduced to 50 percent, while allocations to America and Asia were increased to 30 and 20 percent respectively. The regional composition was identical for both asset classes.

The regional composition of the Fund remained the same until 2002 when it was decided to implement different weighting schemes for fixed income and equities. The fixed income index regional weight in Asia was reduced from 20 to 10 after Japanese government bonds were downgraded. The reduction in Asia was evenly split between the two other regions taking the fixed income weights in Europe and America to 55 and 35 percent respectively. The same year it was decided to reduce the number of regions in the equity index from 3 to 2 by merging Asia and America into one region and introduce market weighting within the combined fixed 50 percent allocation to the new region. These weights remained unchanged until 2006.

In 2006, new regional weights for both fixed income and equities were introduced. On the fixed income side the strategic allocation to Asia was reduced another 5 percentage points mirrored by an identical increase in the strategic fixed income weight in Europe. For the equity benchmark it was decided to move back to fixed weights between Asia and America at set these to 15 and 35 percent respectively, leaving the allocation to European equities unchanged at 50 percent.

The regional composition of both the fixed income index and the equity index has not been changed since 2006, despite the decision to increase the strategic allocation to equities from 40 to 60 percent in 2007.

## The evolution of the rebalancing regime

The history of rebalancing dates back to 1998 when equities was introduced as an asset class in the Fund. From 1998 to December 2001 the Fund was rebalanced back to the six strategic weights every quarter in conjunctions with transfers to the Fund.

During 2001 it was decided to move from quarterly to monthly transfers and a new rebalancing regime was introduced, with a calendar based partial rebalancing and conditional full rebalancing. The partial rebalancing brings the regional weights in the actual index in direction of the strategic weights. Full rebalancing brings the regional weights in the actual index back to the strategic weights if the condition for full rebalancing is triggered. The rebalancing regime has not been altered since 2001, but has been temporarily put aside or adjusted during transition periods such as the period when the equity share in the strategic index was adjusted from 40 to 60 percent.

## Empirical evaluation

Below we examine how different decisions regarding the actual index for the Fund have impacted the risk and return of the Fund. The actual index is anchored in the strategic index, where the rebalancing regime is the mechanism by which the deviations between the strategic and the actual benchmark portfolio are regulated. Hence, the dynamic in the actual index is impacted both by changes in the strategic index as well as by changes in the rebalancing regime.

Below we compare the actual index for the fund with a drifting market portfolio, which is constructed by investing according to a strategic asset allocation at inception and then left alone thereafter. The composition of this portfolio would then drift according to the movements in the market. Both the strategic index as well as the rebalancing regime itself has changed during the lifetime of the fund. Hence, differences in risk and return characteristics between the actual index and the drifting market portfolio may emanate from decisions regarding the strategic index as well as decisions regarding the rebalancing regime.

We construct two drifting market portfolios. The first one is a portfolio that is invested at inception according to the strategic weights for GPFG as they were in January 1998. The second drifting portfolio is initially invested according to the strategic weights as they currently stand. Hence the former portfolio starts out with an equity share of 40 percent, whereas the latter portfolio is initially invested in 60 percent equities.

Table 1: Comparing with Drifting Market Portfolio

	Actual Benchmark Actual Rebal Regime	Drifting Mix 40% Eq Share Initially	Drifting Mix 60% Eq Share Initially
Ave Ret	3,9 %	3,5 %	2,9 %
Volatility	8,4 %	11,0 %	13,1 %
Sharpe	0,47	0,31	0,22
Turnover	11,7 %	0,0 %	0,0 %
Ave Ret, Net	3,9 %	3,5 %	2,9 %
Sharpe, Net	0,46	0,31	0,22

Table 1 illustrates that the actual index for GPFP, including all changes in the strategic index as well as the changes in the rebalancing regime, has been superior to a drifting portfolio. In Chart 1 we have plotted the equity share in the strategic and actual benchmark for GPFG, along with the drifting mix initially invested in the strategic weights as of January 1998. The equity share in the drifting mix initially invested in the current strategic weights would exhibit the same pattern as the one shown in chart 1, but obviously start out at a higher level. Chart 2 illustrates the cumulated returns of the actual benchmark portfolio in excess of the drifting portfolio initially invested with an equity share of 60 percent.

Chart 1: Equity Share in Benchmark

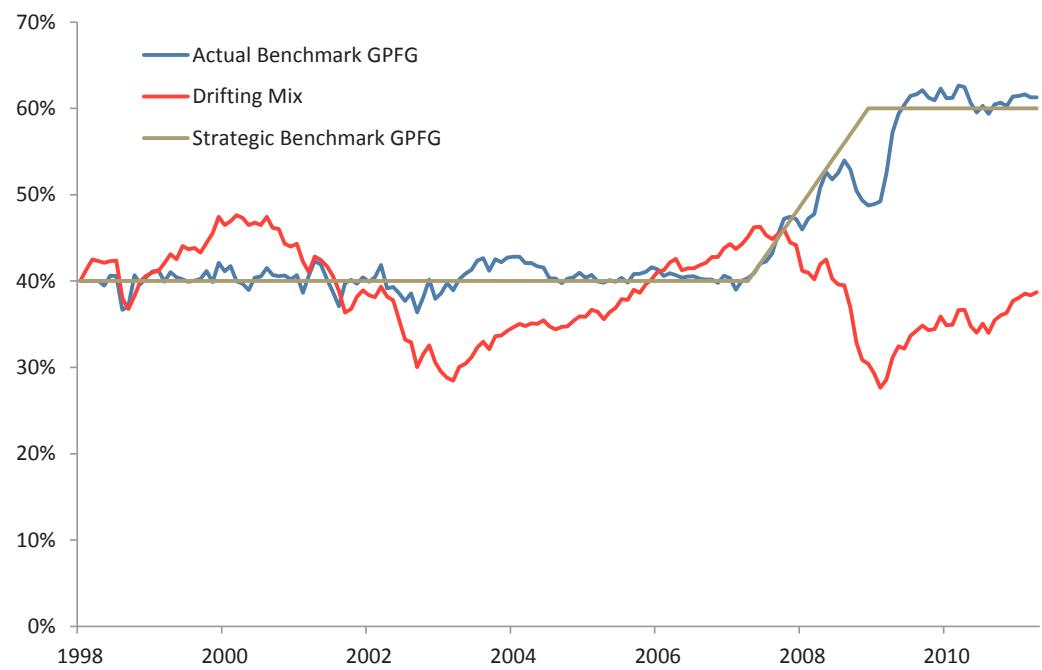
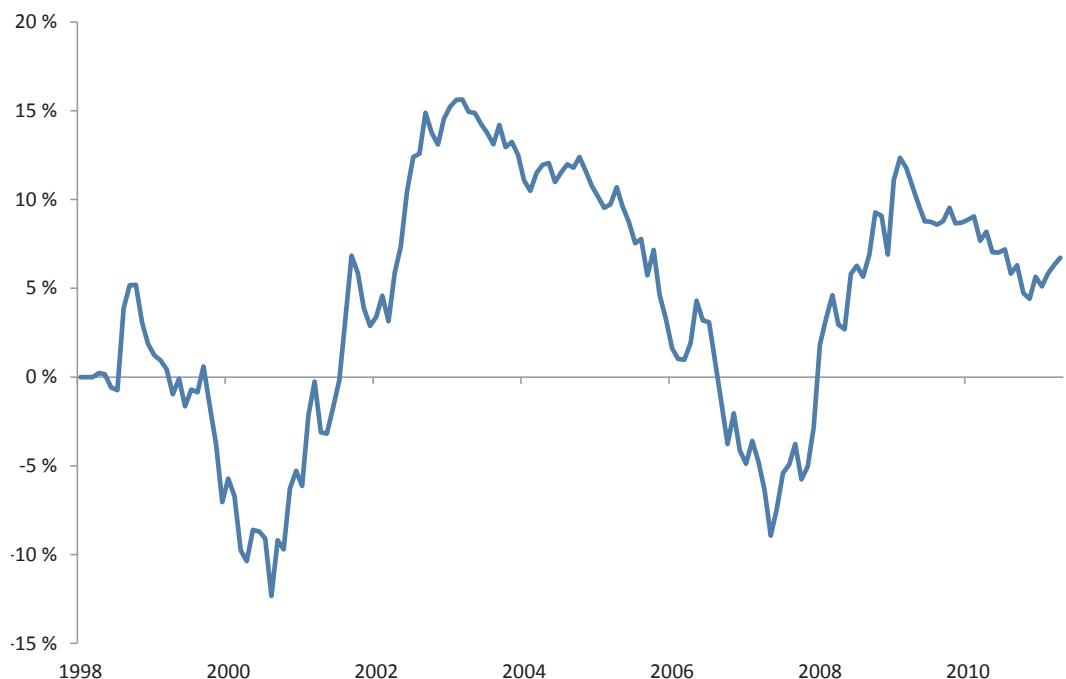


Chart 2: Performance of actual benchmark for GPFG in excess of drifting market portfolio



We now narrow the analysis in order to isolate the impact of the choices that have been made with respect to the rebalancing regime. This means that we are comparing the actual rebalancing regime as it has developed over time with alternative specifications of the rebalancing regime, using the same underlying strategic index in all alternatives.

The Fund started out with a rebalancing regime where a full rebalancing was conducted at each quarter-end. Below we compare the actual index with a benchmark portfolio following a calendar-based rebalancing regime with full rebalancing each quarter. We also look at the impact of partial rebalancing. This means that we are comparing four alternatives; the actual rebalancing regime, with and without partial rebalancing, and a quarterly rebalancing regime, with and without partial rebalancing. Table 2 summarizes the results.

Our results show that the actual rebalancing regime has given a higher return and a higher Sharpe-ratio compared to a regime with quarterly rebalancing. Hence, the changes in the rebalancing regime that have taken place during the lifetime of the fund have served the fund well. We also see that the decision to introduce partial rebalancing has reduced the net Sharpe for the fund, in spite its cost reducing effect. Our interpretation is that this is related to the presence of momentum effects at asset class level. Such momentum effects imply that frequent buying of an underperforming asset class will reduce the return of the fund. However, partial rebalancing has contributed to smaller deviations from the strategic index. The mean absolute deviation (MAD) between the equity share in the actual index and the strategic index is lower for rebalancing regimes with partial rebalancing. Whether it is optimal to incur lower returns in exchange for an actual index which is closer to the strategic benchmark depends on the asset owners preferences.

We also see that a quarterly rebalancing regime implies that the equity share in the actual index stays closer to the equity share in the strategic index compared to the actual rebalancing regime. But a closer tracking of the equity share in the strategic index comes at a cost, both in terms of higher turnover and lower gross returns. The latter is related to the momentum and reversal effects at asset class level.

Table 2: Comparing Rebalancing Regimes

	<b>Actual Rebals Regime</b>	<b>Actual Rebals Regime w/o Partial</b>	<b>Quarterly Rebals with Partial</b>	<b>Quarterly Rebals w/o Partial</b>
Ave Ret	3,9 %	4,0 %	3,7 %	3,8 %
Volatility	8,4 %	8,5 %	8,6 %	8,6 %
Sharpe	0,47	0,47	0,42	0,44
Turnover	11,7 %	17,7 %	12,2 %	23,2 %
Ave Ret, Net	3,9 %	4,0 %	3,6 %	3,7 %
Sharpe, Net	0,46	0,47	0,42	0,43
MAD	1,5 %	1,8 %	0,6 %	0,9 %

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