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EDHEC-Risk Institute Research Insights

The most pressing issues facing investment professionals

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Introduction

I am very pleased to introduce this second issue of the Edhec-Risk Institute supplement to *AsianInvestor*. The aim of the supplement is again to provide research-based analysis of some of the most pressing issues facing investment professionals today.

Our first article looks at the need for lifecycle pension products in East Asia. In research supported by AXA Investment Managers, we argue that neither individuals nor public pension systems in the region have faced the reality of the long-term liabilities created by population ageing and longer retirement periods. Lifecycle investing, both at the individual and collective levels, should be the cornerstone of pension investment management in the area.

In a second article drawn from our Asian research on pensions we examine the lifecycle deficits at the macro level, while stressing the importance of finding micro (asset management) solutions to preserve consumption levels and living standards in ageing societies. Asset management techniques that allow better targeting of liabilities at the relevant horizon, while relying on optimal diversification and implementing adequate risk control, will be key to improving individual and collective outcomes

The third article is drawn from a "call for reaction" that Edhec-Risk Institute sent out to finance practitioners to canvass responses to the institute's research on the shortcomings of corporate bond indices. The respondents broadly shared the concerns raised in the original research. In particular, fewer than half of the respondents were satisfied or very satisfied with corporate bond indices, confirming the failure of corporate bond indices to meet investors' needs.

Questions are also raised about market-cap-weighted equity indices which, while they unquestionably remain a good representation of the market average, tend to be poorly diversified portfolios that are not good proxies for the tangency portfolio. In our next article, with a focus on the Japanese equity universe, we look at various alternative equity indices, or smart-beta indices, and see how they can be diversified. Controlling the risks of these indices is uppermost in the minds of the researchers.

Finally, we look at the risk exposures of minimum-volatility equity index strategies. Since the financial crisis of 2008, minimum-volatility strategies have been highly popular. However, the exposure of smart-beta strategies to systematic risk needs to be analysed by investors if they want to make an informed decision concerning the use of any smart-beta strategy. In our article, we examine this question and include an illustration from Japan, with a special focus on the Fukushima disaster.

We would again like to extend our thanks to our friends at *AsianInvestor*, in particular Rebekka Kristin and Pierre Tachot, for their help in producing the supplement. We wish you all an enjoyable and informative read.

Noël Amenc
Professor of finance, Edhec Business School, and director, Edhec-Risk Institute

Recognising the need for lifecycle pension products in East Asia

The region is not facing up to long-term liabilities created by population ageing and longer retirements. Lifecycle investing must be addressed if otherwise ruinous consequences are to be avoided.

By Frederic Blanc-Brude

In a recent paper, produced as part of the AXA Investment Managers research chair at Edhec-Risk Institute on Regulation and Institutional Investment, we review the latest empirical evidence with regards to the accumulation of pension assets in East Asia (Blanc-Brude, Cocquemas, and Georgieva 2013).

We highlight an apparent puzzle: East Asia has the highest savings rates in the world and its population is ageing rapidly, but very little of these savings are invested in dedicated pension plans designed to meet post-retirement income objectives.

Faced with a very dynamic demographic profile and fast-increasing longevity, the pension systems of East Asia should be focusing on the financing of the long-term consumption objectives of future retirees. In short, lifecycle investing, both at the individual (defined contribution plans) and collective levels (defined benefit plans, be they public or private) should be the cardinal stone of pension investment management in East Asia.

Instead, we observe an almost complete absence of adequate solutions in the region and argue that this is due to an absence of both demand for, and supply of, lifecycle investment solutions. This situation must change rapidly to avoid going further down the road to fiscal and individual ruin. Academic research suggests that implementable solutions exist, but they are likely to require significant foresight and wisdom on the part of the policy maker and the regulator.

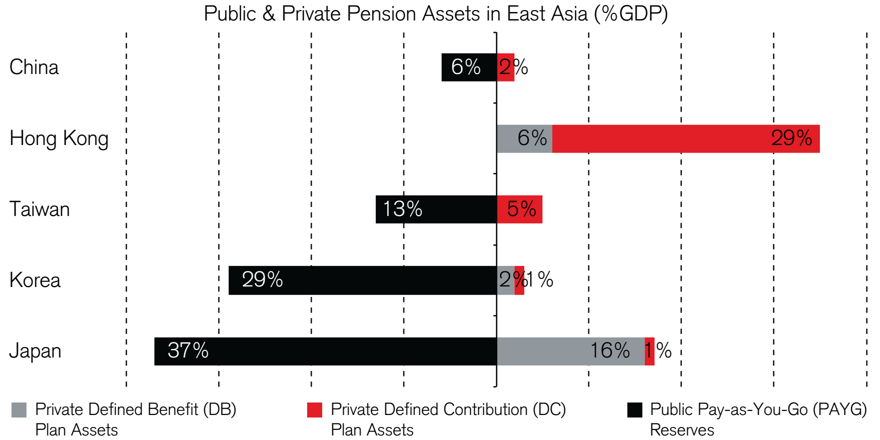
Where are East Asia's pension assets?

Economies undergoing the initial stages of their demographic transition – during which the number of producers (the workforce) increases faster than the number of consumers (the population) – should experience an increase in their savings rate, as empirical research confirms to be the case in East Asia (Horioka and Terada-Hagiwara 2011; Cole and Wright 1997).

However, while we should also expect fast-ageing populations[1] to invest their savings in dedicated post-retirement investment vehicles, such as voluntary pension schemes or individual retirement products, no such trend is visible in the region.

As figure 1 illustrates, the net financial assets of the household sector represent a relatively high proportion of GDP, but private pension assets have remained typically small in size. Furthermore, an examination of the financial balance sheet of the household sector in East Asia reveals that a very large proportion (50%-70%) of household savings is held in deposits and cash.

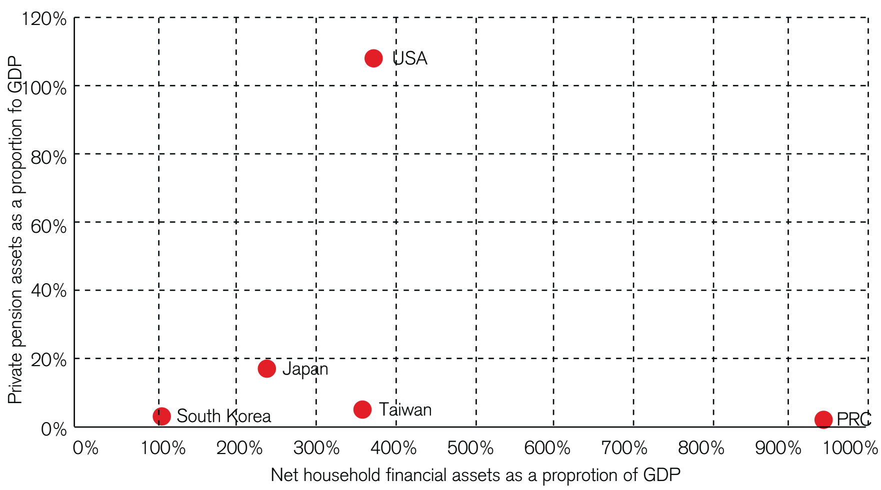
Figure 1: Private pension assets and net household financial assets (%GDP)



Source: Flow of funds data, Blanc-Brude et al. (2013), Gan (2012)

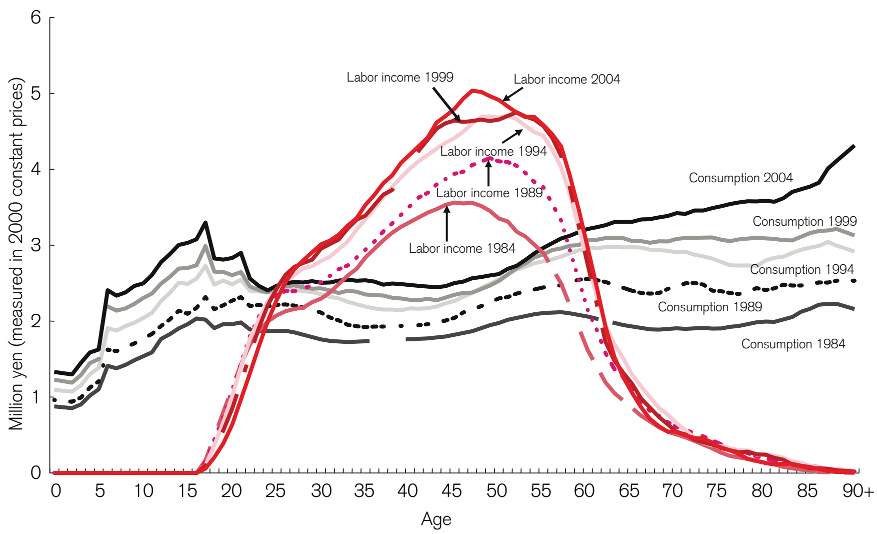
[1]Population ageing occurs with the gradual shift of the age distribution of a population to the right, and is not so much the result of higher longevity than that of below-replacement rate fertility levels. In East Asia, fertility rates have been below replacement levels for several decades and are expected to stay at these levels, leading to the continuous ageing of the population.

Figure2: Public & private pension assets in East Asia (%GDP)



Source: Blanc-Brude et al. (2013)

Figure 3: Per capita public and private consumption and labour income profiles in Japan, 1984 to 2004, constant prices



Source: National Transfer Accounts, Lee and Mason (2011)

Even in Japan, by far the most advanced and financially sophisticated economy in the group studied, households make limited use of private retirement plans and have been holding more than half of their financial assets in cash since the 1970s.

Our review of the different pension systems in existence in the region reveals that the largest pool of pension-related assets consists of the reserves accumulated by public, pay-as-you-go pension systems during the period when the aggregate contributions of a rapidly-increasing workforce exceeds the public pension benefits paid to a relatively small number of retirees.

The pace of demographic change (creating a larger workforce) and of economic development (higher labour productivity leading to higher wages) has resulted in the rapid growth of these surpluses in East Asia. But as demographic trends are reversed and marginal wage growth tails off, these reserves must eventually peak, as they did in Japan in 2004. Other countries in the region are still accumulating public pension reserves but, like Japan, which plans to have exhausted its reserves at the end of this century, they are currently expecting to spend them down almost entirely.

Figure 2 illustrates the size of public pension reserves relative to GDP in comparison with private pension assets, defined as both defined-benefit (DB) and defined-contribution (DC) corporate, occupational and individual plans. Clearly, East Asia's public pension reserves are only "large" because private pension assets are small by international standards (the OECD average is above 70%).

While this may be expected in countries that did not have any funded pension plans until very recently (e.g. mainland China), it is striking to observe that in Japan, which has had private pension plans since the 1960s, low levels of accumulation remain the norm.

Indeed, East Asia's private pension plans have historically been voluntary. Thus, asset growth in private plans, DB or DC, has levelled off rapidly after they were introduced (see Blanc-Brude, Cocquemas, and Georgieva 2013, for a detailed review of the creation of each type of funded pension plan in East Asia). In effect, private accumulation has only been made mandatory very recently in Hong Kong (2000), Taiwan (2004) and Korea (2012). Mainland China and Japan, the two largest economies in the region, still do not have mandatory private pensions.

The road to ruin?

This is likely to end very badly. We know from recent research that population ageing is associated with a very significant increase in aggregate and per capita old-age consumption, especially the consumption of health care and long-term care.

Indeed, the lifecycle hypothesis, according to which individuals alternate periods of borrowing, saving and dis-saving to smooth their lifetime consumption, is partly invalidated by the evidence that retirees increasingly tend to consume more than the workforce if their total public and private consumption levels are taken into account (see Lee and Mason 2011; Ogawa, Matsukura, and Chawla 2011, for a detailed analysis). As we discuss in a separate article in this issue, what is already evident for Japan in figure 3 is also the case in other countries in the region.

Whether such increasingly high post-retirement consumption levels are financed privately or via public transfers, they represent a considerable financial liability that needs to be addressed in the context of investing individual and collective savings.

One may be tempted to argue that countries such as Japan may have already accumulated enough savings to pay for their passage into a period of plentiful retirement. But this remains an elusive argument without any explicit measurement and management of the long-term liabilities created by retirement for current and future retirees and workers. Even if that was the case, the opportunity cost of leaving vast amounts of accumulated savings sitting in bank deposits for the next several decades is likely to be very high for the economy as a whole, and thus for the next generation of retirees as well.

The current situation needs to change urgently, and a substantial share of East Asia's savings can and should be used to maximise the likelihood of meeting long-term public and private consumption objectives in retirement.

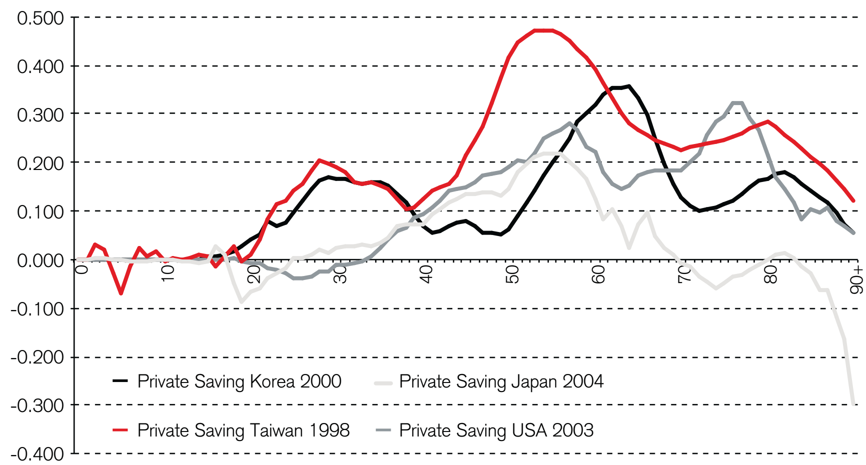
The absence of demand for lifecycle solutions...

Incentives to demand investment solutions that help target long-term liabilities are also lacking in East Asia. Indeed, while the combined long-term liability of retirees and the workforce is shown to grow dramatically with population ageing, the current generation of retirees has not been involved in financing the majority of what was effectively its long-term consumption objective.

Since it did not have to invest its savings to meet such objectives, it never had to demand lifecycle investment products. Instead, as we discussed above, the majority of household financial savings are still held in cash.

Such is the size of inter-generational transfers that, contrary to the standard lifecycle hypothesis, the current generation of retirees has not had to dis-save during retirement. On the contrary, as figure 4 shows, as a generation, current retirees in East Asia can afford to continue to accumulate (i.e. have positive net savings) long after their retirement date.

Figure 4: Per capita private saving flows, normalised by the average of labour income for individuals between 30 and 49 years of age, relevant years



Source: Lee and Mason (2011)

reserves is also typically aggravated by the political use of these funds to absorb large quantities of public debt or sterilisation bonds.

...and the lack of interest in supplying them

If the demand for lifecycle investment products has so far remained muted because the current generation of retirees has had no immediate need for them, the limited supply of adequate retirement products in East Asia may also explain why the region's household savings are not being invested to generate post-retirement income streams.

post-retirement of the latter.

DC plans are also deficient: instead of coming with default options that would channel member funds into adequate retirement solutions, they typically offer a dazzling variety of investment products.

Thus, where DC plan members can choose investment options, as is the case in Hong Kong or Korea, they may keep assets in cash or equivalent (e.g. Korea) or, on the contrary, pursue short-term speculative objectives by investing in substantial equity positions (e.g. Hong Kong). Whether this behaviour results from domestic savings cultures or reflect the biases in offerings and their presentation, they are not adapted to meeting long-term consumption objectives.

Target-date funds, when they exist, are only one of many options for DC plan members and, above all, are not designed properly: they are blind to members' differences in risk tolerance other than those related to the investment horizon and their deterministic glide paths fail to take into account the dynamic nature of long-term liabilities or the role of market conditions in the evolution of the plan's asset allocation.

'Public pension reserve management is a victim of the same absence of incentives to target long-term liabilities.'

Likewise, public pension reserve management is a victim of the same absence of incentives to target long-term liabilities. The rapid accumulation of vast pension (and social security) reserves, in parallel with the rise of aggregate household savings during the same period, leads to a form of "monetary illusion", pushing the question of the liabilities of the public pension system and its sustainability far into the future.

Hence, pension reserve funds have historically invested most of their assets in cash and government bonds, even though this is now changing (e.g. Korea). This absence of meaningful asset-liability management of public pension

Even when corporate or occupational plans have been made mandatory, incentives for employers or employees to contribute more than the required minimum are often lacking or insufficient.

Crucially, the immense majority of such plans are avatars of the age-old retirement allowance system, which is still in existence in the region i.e. they only pay a lump sum when employees leave their position or retire but fail to provide any post-retirement income.

Thus, East Asia's private DB schemes really are crude forms of 'hybrid' plans, sharing risk between plan sponsors and members, since the former are not exposed to longevity or indexation risk

Facing the challenge of lifecycle investing in East Asia

So far neither individuals nor public pension systems have faced the reality of the long-term liabilities created by population ageing and longer retirement periods.

Nevertheless, the challenge of lifecycle investing must be taken seriously and addressed, if otherwise ruinous consequences are to be avoided. Hence, the relevance of implementing approaches that offer to design investment solutions maximising the likelihood of meeting a given objective function while respecting a set of constraints, for financial and fiscal stability at the macro-economic level.

Edhec-Risk Institute has devoted significant attention to advancing techniques for the management of pension schemes and the design of retirement solutions (see for example Martellini and Milhau 2010; Martellini and Milhau 2010a; Martellini and Milhau 2010b; Martellini, Milhau, and Tarelli 2012; Martellini and Milhau 2012). Some of these ideas are already at work in retirement schemes around the world.

For funded pension systems to deliver levels of wealth in real terms that are commensurate with post-retirement consumption objectives, this literature highlights three fundamental dimensions of pension solutions:

- Pensions are long-term liabilities, which are in fact dynamic and depend on several time-varying factors. Pension solutions should therefore be designed in order to maximise the likelihood of meeting those liabilities at the horizon.
- As they approach retirement, plan members should be exposed to less risk. The strategy, notably the amount of risk-taking, should be dynamic depending on the current wealth and future expected performance, and should explicitly consider the investment horizon.
- Such a strategy also needs to be implemented while managing risk levels: along with long-term risk tolerance, there need to be short-term constraints too, which take into account the existence of a sponsor when there is one. These constraints can either be self-imposed (e.g. maximum drawdown) or defined by the regulator (e.g. funding ratio).

This approach can be applied to public and private, centralised and de-centralised systems – importantly, Edhec-Risk Institute research has demonstrated that it can be mass-customised in a parsimonious manner to adequately serve the diverse needs of a wide range of retail investors or scheme members without renouncing the benefits of pooling (see for example Martellini and Milhau 2010b).

Solutions: the opportunity created by public reserves

The existence of large public pension reserves in East Asia provides governments with a unique opportunity to support public pension systems and minimise the impact of population ageing.

Pension reserves are not necessarily meant to be spent entirely and pension reserve management does not have to limit itself to trying to slow down the rate of decline of the reserve as much as possible. This would be just as short-sighted as hoping that the present allocation of existing savings will suffice to generate post-retirement income covering the cost of population ageing.

Reserve funds can be turned into powerful policy instruments dedicated to solving the pension crisis if the three dimensions of a fully-fledged long-term strategy for the management of pension assets described above are taken into account.

Demographic transitions create predictable evolutions of public pension liabilities, driving a form of collective lifecycle which can be tackled with time-consistent public policies.

Solutions: implementing DC 2.0 for private pensions

Regulators should also ensure that mandatory and incentivised voluntary private schemes adopt state-of-the-art techniques for pension management and retirement provision.

Private pension schemes must be developed and optimised and voluntary contributions into these schemes and adequate individual retirement solutions must be incentivised.

In the case of individual DC accounts in particular, the regulator has a responsibility to highlight the type of products that can help individuals meet their post-retirement objectives, thus creating incentives for financial providers to offer such solutions instead of run-of-the-mill investment products, which can only be regarded as relevant in the context of retirement if individual investors are assumed to have the resources to treat them as building blocks to be assembled and dynamically rebalanced over time in reaction to changes in liability and asset risks and variations in their long-term and short-term risk tolerance. This is highly unrealistic, as the behavioural finance literature documents extensively (see Blake 2006, for a review).

Instead, in a DC 2.0 framework, as discussed in previous Edhec-Risk Institute publications (see Sender 2012), DC funds can avoid the pitfalls of short-term retail funds. They can diversify using international markets, corporate bonds, listed real estate, commodities and unlisted assets. It is possible to offer some guarantees in DC funds, especially inflation guarantees. Today, the onus is on East Asia's regulators to implement the reforms to ensure that sufficient funds are channelled into retirement schemes and that these funds be exclusively managed to post-retirement consumption objectives, and on financial service providers to bring adapted but standardised and cost-effective lifecycle investment solutions to the market. ■

By Frederic Blanc-Brude, research director, Edhec Risk Institute Asia

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Pension asset management matters for long-term fiscal stability

Asset income must play a pivotal role in bridging the gap between lifecycle surplus and deficit. Asset management techniques that allow better targeting of liabilities at the relevant horizon will be instrumental in improving outcomes.

By Frederic Blanc-Brude

Recent efforts to develop macro measures of the evolution of lifecycle deficits in human societies highlight the role of micro-solutions (asset management) to manage the risks of individual and collective ruin.

In a recent paper on the state of pension systems in East Asia (Blanc-Brude, Cocquemas, and Georgieva 2013), supported by AXA Investment Managers within the Regulation and Institutional Investment research chair at Edhec-Risk Institute, we discuss how, as societies grow both wealthier and older, the change in the difference between total consumption and labour income creates a widening gap between the "lifecycle surplus" of the workforce (which earns more from its labour than it consumes) and the "lifecycle deficit" of the young and the elderly.

At the aggregate level, inter-generational transfers net off and this gap can only be financed by dis-saving, increasing debt or increasing "asset income" i.e. a combination of higher savings and higher returns on savings. Since dis-saving or higher indebtedness are necessarily bounded, asset income must play a pivotal role in the financial trajectory of nations.

The same problem arises at the individual level: inter-generational transfers can hide the size of the long-term liabilities created by increasing post-retirement consumption levels, but asset income must then play an even more urgent role so that the current workforce can finance in part the lifecycle deficits of dependents while saving for its own retirement.

Hence, asset management techniques that allow better targeting of liabilities at the relevant horizon, while relying on optimal diversification and implementing adequate risk control, will be instrumental in improving individual and collective outcomes.

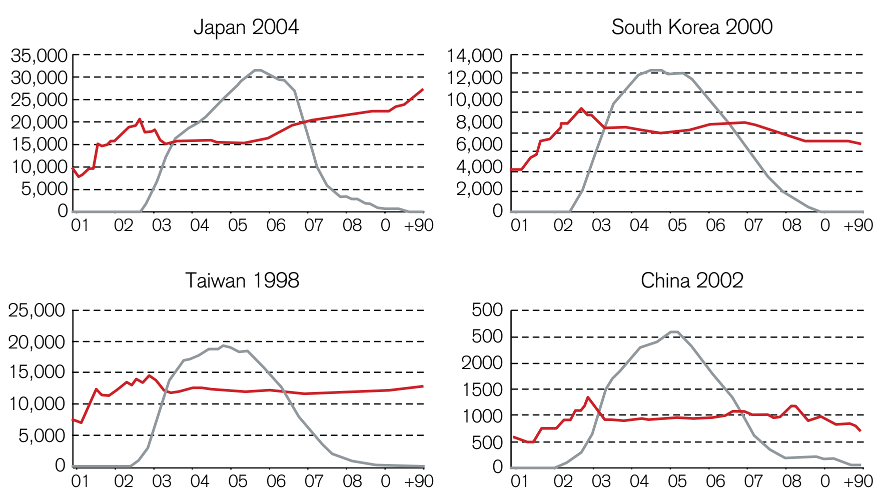
Measuring lifecycle liabilities

A better understanding of the dynamics of pension liabilities highlights the relevance of the liability-driven investment (LDI) and lifecycle investment (LCI) strategies discussed in previous Edhec-Risk Institute papers for the management of pension assets (see Martellini and Milhau 2010, for example).

The lifecycle hypothesis, according to which individuals alternate periods of borrowing, saving and dis-saving to smooth their lifetime consumption profile, underpins most pension thinking and modelling. However, the actual level and evolution of pre- and post-retirement consumption has not necessarily been well-documented until recently.

The approach developed by Lee and Mason (2011) in the context of the National Transfer Accounts (NTA) project, provides a good starting point to try and estimate the size of the individual and collective liabilities created by retirement in a given society. The authors develop a measure of the "lifecycle deficit" (LCD) of each age group as the difference between all private and public consumption (i.e. publicly provided goods and services) and all labour income from

Figure 1: Lifecycle surplus and deficit profiles in East Asia



Source: Lee and Mason (2011)

the formal sector including contributions made by employers as well as self-employment, before any taxes. The per capita labour income and consumption profiles by age of Japan, Korea, Taiwan and China are shown in figure 1.

The NTA flow identity states that lifecycle deficits or surpluses are equal to net transfers (public and private) plus the difference between asset income and savings received by each age group. For each year of age *t*, inflows (labour income, transfers and asset income) must be matched by outflows (consumption, transfers and savings) and by construction, LCDs are funded by net private and public transfers and by asset income or debt[1]. Hence,

Lifecycle deficit or surplus $_t$ = consumption $_t$ - labour income $_t$
= net transfers $_t$ + (asset income $_t$ – savings $_t$)

Since

Asset income $_t$
=private returns on financial and real assetst + returns on public assets $_t$ –debt service $_t$

and,

Savings $_t$=private savings $_t$–public debt $_t$

At the aggregate level, public and private transfers net off. Rearranging and simplifying:

Lifecycle deficit–Lifecycle surplus=asset income–savings
Lifecycle deficit=Lifecycle surplus+asset income–savings
Lifecycle deficit=Lifecycle surplus+asset income–private savings+public debt

Thus, at the aggregate level and in any given year, the lifecycle deficit of a population must, as a matter of accounting identity, equal its lifecycle surplus, plus any income from financial and real assets (public or private), minus any new savings, plus any new (public or private) debt.

The impact of wealth and population ageing on lifecycle deficits

To better understand the dynamics of lifecycle deficits, we use NTA data for 23 countries with a range of inter-generational transfer systems and per-capita wealth between 1984 and 2006 (Lee and Mason 2011).

We consider the aggregate lifecycle deficit (of the young and the elderly) and aggregate lifecycle surplus of the workforce in the sample countries i.e. the sum of the difference between labour income and total consumption for all age groups with a deficit as well as for all age groups with a surplus. This yields two aggregate values for each country in a given year. We also include GDP per capita and old age dependency ratios in relevant years. All values are expressed in US dollars at purchasing power parity (World Bank data).

Table 1 summarises the results of a linear regression of the cumulative deficits and surpluses of each age group against either GDP per capita or old age dependency. The level of it is very high, which should be expected since lifecycle surpluses are a residual measure of income and lifecycle deficits a partial measure of consumption, both of which are direct measures of GDP. Old-age dependency also tends to be highly related to wealth per capita because of the role of demographic transitions in economic development. Hence, it provides a good linear fit of the NTA data.

The non-trivial result is the size of the coefficient expressing the change in lifecycle deficits and surpluses as countries move up the GDP per capita scale or populations age.

Clearly, the combined deficits of the young and retirees tend to increase much faster than the surpluses of the workforce. Figures 2 and 3 illustrate this trend: as economies develop and wealth per capita increases, the cumulative deficit created by the consumption levels of the younger and older segments of society increases faster than the surplus labour income of the workforce and must therefore be financed by other means.

Table 1: Ordinary least square regression coefficients of per capita lifecycle deficits and surpluses in 23 countries, USD at purchasing power parity

Regressor	GDP per capita	Old-age dependency ratio
Lifecycyle deficit coefficient estimate(se)	-35.03 (1.748)	-39,754 (7,356)
Statistical significance	0.1%	0.1%
Adjusted R-Squared	95.55%	56.18%
Lifecycle surplus coefficient estimate (se)	12.964 (1.101)	17,437 (2,103)
Statistical significance	0.1%	0.1%
Adjusted R-Squared	86.21%	75.48%

The role of asset income

At the aggregate level, the NTA identity dictates that the difference between the deficits of dependents and the surplus of the workforce must be financed by either dis-saving (e.g. retirees could spend down savings accumulated in previous periods), incurring more debt (e.g. household or government debt) or earning higher income from financial and real assets, including pension and other savings.

In turn, higher asset income can either spring from higher savings or higher returns on assets.

In the case of East Asia, for example, if lifecycle deficits are set to increase three times as fast as lifecycle surpluses and domestic savings are already at historical highs (e.g. 50% of GDP in China), then for the NTA flow identity to hold, either the income from financial assets must play a significant role in meeting this collective liability, or (public) debt must increase significantly.

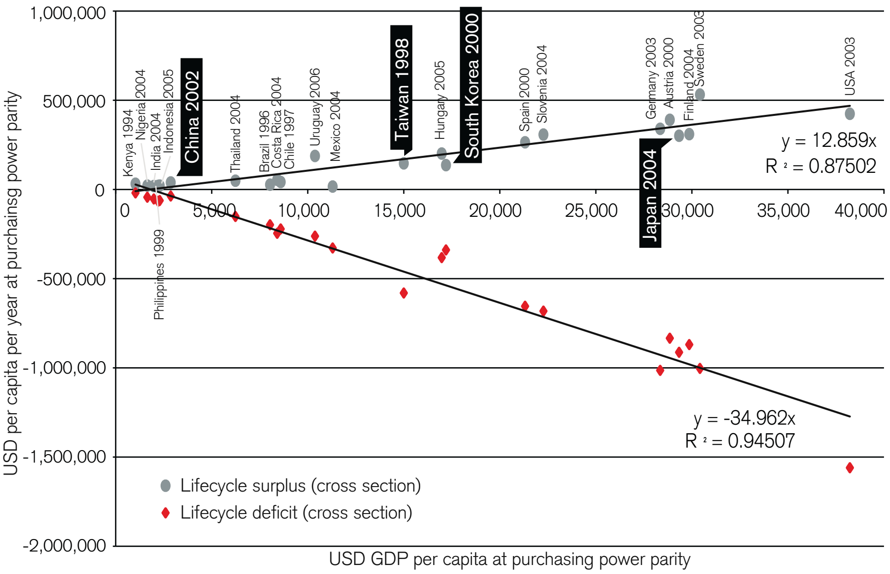
As we argue in our recent paper (Blanc-Brude, Cocquemas, and Georgieva 2013), this conclusion is evocative of the situation in Japan, where high savings, both by households and the public pension system, have long been invested in low-return vehicles without any explicit liability-targeting objective while the level of consumption, especially old-age-related health-care consumption, has increased considerably. Health care and pensions in Japan are for the most part a public sector liability, and public indebtedness has increased apace.

One may argue that the current state of public indebtedness of the Japanese economy is not solely the outcome of its demographic destiny, but also results from the failure to manage public and private savings to meet long-term liabilities.

At the individual level, asset income plays an equally central role but, as we argue in another article in this issue, current

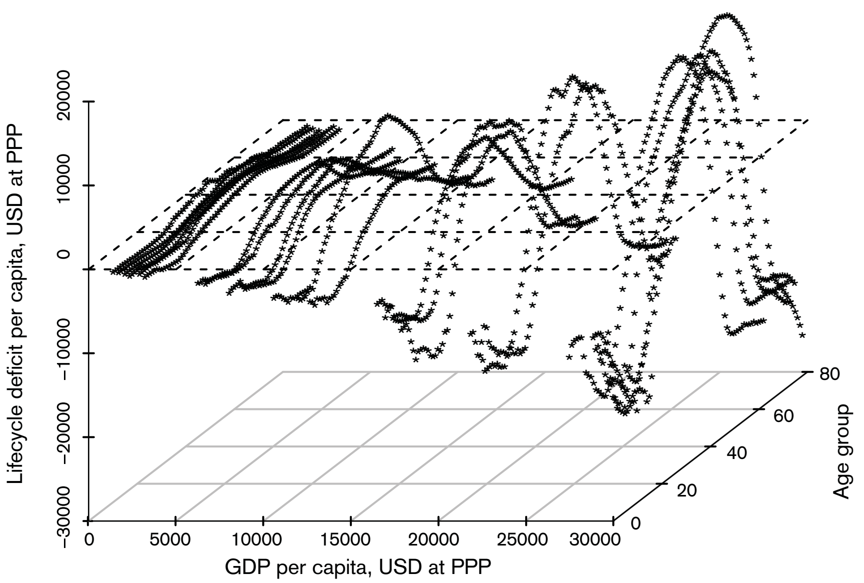
[1] Public transfers are divided between public inflows corresponding to publicly provided programs and public outflows to taxes. Negative net public transfers or public dis-saving corresponds to public debt. Private transfers can occur between or within households, including by firms or NGOs. Private asset income includes the return from financial and other assets as well as imputed rents. Public asset income includes the return on publicly owned assets and the service of public debt (negative). Asset income (inflow) is offset by any new savings (outflow); new debt is recorded as negative asset income (outflow) and dis-saving as an inflow. Per capita flows are estimated using age profiles derived from national surveys and made to add up to national aggregates. Survey data allows the allocation of public expenditure on health care and education public expenditures by age. Other public flows such as defence are considered constant for each age group. Private consumption is allocated by age in a similar way using household survey data. Aggregate flows at each age are calculated as the product of per capita flows and the population at each age. (See Lee and Mason 2011, for a detailed discussion.)

Figure 2: Aggregate lifecycle surpluses and deficits and GDP per capita, 23 countries



Source: Blanc-Brude, Cocquemas, and Georgieva (2013)

Figure 3: Lifecycle surpluses and deficits by age group and GDP per capita



Source: Lee and Mason (2011), author calculations

generations of retirees have not had to invest their savings to meet the growing long-term liabilities created by population ageing because growing inter-generational transfers have mostly removed the need to do so.

Younger generations find themselves having to finance the growing lifecycle deficits of retirees through public transfers (taxes) from their own lifecycle surplus and despite the growth differential between lifecycle surpluses and deficits documented above.

Because such transfers also limit the ability of the current workforce to accumulate for its own retirement, the role of asset income is all the more central for future generations of workers and retirees to address an increasingly significant long-term liability and inter-generational debt.

Why asset management matters

Understanding the role of asset income in preserving the financial and fiscal viability of nations is an important contribution of the NTA project. This result highlights the relevance of micro-approaches, which offer to design investment solutions maximising the likelihood of meeting a given objective function while respecting a set of constraints, for financial and fiscal stability at the macro-level.

The NTA data highlights the fact that funded pension systems provide a way to formalise an intergenerational debt which exists anyway and grows seemingly continuously as societies develop and undergo their demographic transition. Whether this debt is public or private and is met through funded pension schemes, other financial and real assets, public transfers financed by taxing the workforce, private (familial) transfers or new (public) debt issuance, does not fundamentally change the nature or dynamics of this liability.

But highlighting the role of asset income will not be sufficient to prevent the growth of unsustainable intergenerational debt. Asset income is the combined results of accumulation and asset allocation choices to meet long-term liabilities at the relevant horizon, while managing and controlling risk. Asset income thus requires asset management.

Using state-of-the-art techniques, public and private savings can be invested to maximise the likelihood of meeting long-term liabilities at the horizons of choice, while managing risks and respecting short-term constraints (with respect to risk aversion, for example). Pension funds and retirement products, when they are properly designed, essentially exist to play this role: investing savings towards meeting long-term consumption objectives.

The macro perspective on lifecycle deficits highlighted in this article shows that micro-solutions will be instrumental to preserve consumption levels and living standards in ageing societies only a few decades from now. In most of Asia in particular, fast accumulating surpluses, public and private, represent a unique opportunity to address the cost of population ageing today before it has morphed into a gigantic inter-generational debt overhang. ■

By Frederic Blanc-Brude, research director, Edhec Risk Institute Asia

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Corporate bond indices: considerable room for improvement

In light of the growth of passive investing, it will be increasingly important for index providers to construct indices using methods which account for the stability of identified risk factors.

By Felix Goltz

A recent "call for reaction" by Edhec-Risk Institute canvassed opinions from finance practitioners on previous research that had been critical of the quality of corporate bond indices.

That research – a 2011 paper from Edhec-Risk Institute, which is entitled *A Review of Corporate Bond Indices: Construction Principles, Return Heterogeneity, and Fluctuations in Risk Exposure* – concluded that corporate bond index construction methodologies tend to be sub-optimal.

Investors have always considered bonds a safe haven in which to park a share of their wealth. And in recent years passive investment has become increasingly popular with investors looking for easy, straightforward options.

But mixing bonds and passive investment turns out to be more complex than it first appears. Fixed-income indices are rather more difficult to pin down than their equity equivalents and although corporate bond indices have been around for some time, it is only recently that practitioners and academics have begun to discuss them.

In the last decade, debate has swirled around bond indices, and questions such as how a bond index should be built, what its objectives should be, for whom a particular bond index is suitable, and so on, have been examined in the literature.

Sangvinatsos (2010) discusses how corporate bond indices could be integrated with other asset classes such as stocks and treasuries in constructing optimal portfolios; Korn and Koziol (2006) and Meindl and Primbs (2006) discuss bond portfolio optimisation; Cai and Jiang (2008) study corporate bond returns and volatility, and Arnott et al. (2010) apply valuation-indifferent indexing to fixed income.

Market practitioners also seem to have been drawn to bond indices in recent years: when launched in the US in 2002, there were only a few fixed-income exchange-traded funds (ETFs), whereas now there are more than 70 based on corporate bonds, with inflows of $31.5 billion in 2009 alone.

These numbers convey the importance of passive investing in this asset class and are the reason for our interest in corporate bond indices. Moreover, we choose to work with investment-grade assets because information on such assets is more accessible than that on high-yield assets. But most of the conclusions we draw also apply to the junk universe (some will be even strengthened).

'Mixing bonds and passive investments turns out to be more complex than it first appears.'

We distinguish between an index (which attempts to represent the market activity of a segment of an asset class) and a benchmark (the best investment given the desired risk exposure). As indices, those available are not bad at all, in view of the challenges of representing a particular asset class such as corporate bonds. But we examine the optimality of considering them benchmarks, and to do so we must begin by defining risk.

Here, risk is best defined not as the variance of returns but as the likelihood of the investor meeting his objectives; in short, risk should be relative. What is risk-free to some investors can be risky to others: an investor seeking to hedge a fixed 10-year liability will find the short-term risk-free rate quite risky. So it is hard to believe that a single index will serve as an appropriate benchmark for all investors.

Despite the many papers on the corporate bond market, there are still questions to be answered. The goal of our research, in brief, was to spark debate on corporate bond indices, especially on the practice of using indices as benchmarks.

We not only review the theory, but also provide an empirical comparative analysis of indices. We review and analyse index-building schemes and the resulting risk and return properties. We also analyse interest-rate risk and credit risk, the two major risks (along with liquidity risk) in the bond market.

Results

The research assesses the performance of investment-grade corporate bond indices in both the US and eurozone markets (four indices in each market). For the US, the indices were as follows:

- Citigroup US Broad Investment Grade (USBIG) Corporate Bond Index
- Bank of America-Merrill Lynch US Corporate Bond Index (Master)
- Barclays US Corporate & Investment Grade Index (formerly called The Lehman Brothers US Corporate & Investment Grade Index)
- Dow Jones Corporate Bond Index

The eurozone indices were the following:

- iBoxx Euro Corporate Index (investment grade)
- iBoxx Liquid Euro Corporate Index (investment grade)
- Citigroup Euro Broad Investment Grade Corporate Bond Index
- Bank of America-Merrill Lynch EMU Corporate Bond Index (investment grade)

Index returns, as well as such exposures as duration and credit risk, are used to analyse the properties of these indices and compare them.

Apart perhaps from the singular case of the eurozone Citigroup index, the indices in each market have many similar characteristics, although there are also many differences.

Credit and interest-rate risk exposures for all eight indices turn out to be fairly unstable. This instability has major implications for investors: even if a particular index matches an investor's desired risk exposures today, there is no guarantee that it will do so tomorrow. The fluctuations in risk exposures are incompatible with investors' requirements that these exposures be relatively stable so that allocation decisions are not compromised by such fluctuations.

The investable indices based on a small number (less than 100) of liquid bonds (Dow Jones for the US and iBoxx Liquid for the eurozone) are in many ways different from the broader indices based on thousands of bonds. As a main result of the smaller number of bonds, instability is heightened.

In addition, the average index rating of the euro indices is slightly higher than that of the US indices – in other words, the euro indices are less exposed to credit risk. Likewise, the terms to maturity and the duration of euro-denominated bond indices are shorter. This result shows that switching from US bond indices to euro-denominated bond indices (or vice-versa) is a matter not only of currency risk but also of credit and interest-rate risks.

'Credit and interest-rate risk exposures for all eight indices turn out to be fairly unstable.'

Industry reactions

A recent "call for reaction" by Edhec-Risk Institute invited comment on this previous Edhec-Risk research which indicated that current corporate bond indices are inappropriate for many investors.

A questionnaire made up of 24 questions, covering the various issue points in detail, was sent out to investment professionals. In all, 68 responses were received, including respondents from North America (40%), the European Union (26%, ex-UK), the UK (17%), Switzerland (8%), and Australia and New Zealand (9%), thus constituting a diversified sample of investors. The population of respondents was made up mostly of asset/wealth managers (74%). The general conclusion was that the respondents were broadly in agreement with the criticism raised by Goltz and Campani (2011).

First, it appears that only 41% of the respondents to the "call for reaction" are satisfied or very satisfied with corporate bond indices, which confirms the inadequacy of corporate bond indices described by Goltz and Campani (2011).

The responses given by practitioners reveal that several issues are seen as paramount to investors in corporate bonds and corporate bond indices. Perhaps the most prominent conclusion to be drawn from the call for reaction is that credit ratings are seen as highly unreliable, as only 19% of respondents agree or strongly agree that credit ratings are an effective measurement of credit risk. In practice, many investors employ other methods or metrics to evaluate credit risk.

The finding of instability of risk factors with corporate bond indices was affirmed by the majority of respondents. For example, 64-80% of respondents agree or strongly agree that the instability of interest-rate-risk exposure is problematic. In addition, 45% of respondents agree or strongly agree that there is a conflict of interest in the duration of corporate bonds between bond issuers and investors. Derivative instruments may appear as a solution to interest-rate-risk instability.

However, only 57% of respondents can use them, leaving almost half with no tools to manage the instability problem. The instability of exposure to credit risk is also identified as problematic by about two-thirds of respondents. In that case, only one-third of respondents can use derivative products to manage instability.

Furthermore, nearly half of respondents recognise there is a direct trade-off between an index's risk-factor stability and its investability, which will probably present obstacles to index providers who wish to create indices to serve as the basis for an investment vehicle.

As corporate bond indices will be used by investors to achieve specified objectives, particularly the management of defined risk factors, it will be increasingly important – in light of the growing prevalence of passive investing – for index providers to construct indices using methods which account for the stability of these risk factors. ■

By Felix Goltz, head of applied research, Edhec-Risk Institute, research director, ERI Scientific Beta

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Smart-beta diversification indices: a focus on Japan

For investors agnostic about their capacity to identify the model with superior assumptions or to choose a particular model suited to expected market conditions, it may be reasonable to consider diversification across strategies.

By Saad Badaoui

Cap-weighted equity indices have long been perceived by practitioners as reasonable long-term proxies for the tangency (Maximum Sharpe Ratio) portfolio postulated by Modern Portfolio Theory (MPT).

However a consensus is emerging that while market-cap-weighted indices unquestionably remain a good representation of the market average, they tend to be poorly diversified portfolios and not good proxies for the tangency portfolio.

Implementing the objective of Sharpe ratio maximisation through an alternative weighting scheme, however, is a complex task because of the presence of strategy-specific risks and systematic risks.

Systematic risk is the risk from exposure to common equity-risk factors such as value or small cap. Strategy-specific risks are the risks related to (i) the use of a portfolio that is a priori sub-optimal, meaning it only coincides with the Maximum Sharpe Ratio portfolio under some restrictive assumptions (i.e. optimality risk); and (ii) making errors in estimating input parameters (i.e. parameter estimation risk).

In fact, the costs of parameter estimation errors may, in some cases, entirely offset the benefits of optimal portfolio diversification (see e.g. De Miguel et al., 2009b). Therefore some methodologies for constructing diversification strategy indices do not explicitly aim to obtain a portfolio with an optimal risk/reward ratio, but instead adopt heuristic approaches to diversification by trying to have fewer parameters to estimate or parameters whose estimation would be easier.

Heuristic or ad-hoc strategies, which have objectives different from Sharpe ratio maximisation, can be further categorised into deconcentration and decorrelation-based approaches. Deconcentration-based strategies simply focus on reducing the weight and risk concentration of portfolios by spreading out the constituents' weights or their risk contributions equally[1]. This can be seen as a response to concerns about weight or risk concentration which may arise in cap-weighted equity indices[2]. Decorrelation strategies focus on risk reduction that stems from the fact that assets are imperfectly correlated.

In contrast to these heuristic approaches, scientific or efficient diversification methodologies are based on the theoretical framework of Modern Portfolio Theory and aim to obtain efficient frontier portfolios, i.e. portfolios that obtain the lowest level of volatility for a given level of expected return (and thus the highest risk-adjusted return)[3]. We now will briefly describe three heuristic diversification weighting schemes (maximum deconcentration, diversified risk parity and maximum decorrelation) and then two efficient diversification strategies, namely efficient minimum volatility and efficient maximum Sharpe ratio. Additionally, it should be noted that ERI Scientific Beta applies turnover control and liquidity rules to all its indices to ensure they take into account practical investment constraints.

Diversification strategies

Equal-weighting (also known as the "1/N" weighting scheme) is a simple way of "de-concentrating" a portfolio in terms of stock weights or maximising the effective number of stocks[4]. This strategy has been shown to deliver attractive performance even in comparison with sophisticated portfolio optimisation strategies (De Miguel et al., 2009b).

Depending on the size of the stock universe, equal-weighting can lead to relatively high turnover and liquidity problems[5]. Maximum Deconcentration is a form of equal-weighting that addresses this drawback by minimising

[1]The risk contribution of a constituent is defined as the product of the constituent's weight and the marginal contribution of this constituent to total portfolio volatility.
[2]Some of the known shortcomings of cap-weighted equity indices arise from the issue of (i) their high concentration in the larger capitalisation stocks – Malevergne, Santa-Clara and Sornette (2009) show that cap-weighted indices hold a very low effective number of stocks (as measured by the reciprocal of the Herfindahl index) relative to their nominal number of constituents – or (ii) their lack of risk/return efficiency (see for instance Ferson, Kandel and Stambaugh, 1987, as well as Goltz and Le Sourd, 2010, and the references therein).
[3]It should, though, be noted that the heuristic and scientific approaches to diversification are not mutually exclusive – for instance, the motivation for the addition of weight constraints to a scientific diversification methodology can be to bring it closer to a heuristic methodology in order to gain robustness.
[4]The effective number of stocks is defined as the reciprocal of the Herfindahl Index, which is a commonly used measure of portfolio concentration: where N is the number of constituent stocks in the index and is the weight of stock i in the index. In brief, the effective number of stocks in a portfolio indicates how many stocks would be needed in an equal-weighted portfolio to obtain the same level of concentration (as measured by the Herfindahl Index). Equal-weighting stocks in a portfolio will lead to the maximum effective number of stocks.

the distance of portfolio weights from the equal weights subject to constraints on turnover and liquidity.

Extending the notion of weight deconcentration to risk deconcentration, the general risk-parity approach aims to equalise the risk contributions of constituent stocks to the total portfolio risk:

$$w_i \frac{\partial \sigma_p}{\partial w_i} = w_j \frac{\partial \sigma_p}{\partial w_j}$$

where w_t is the (positive) portfolio weight of stock i and σ_p the portfolio volatility (see Maillard, Roncalli and Teïletche, 2010, for a detailed discussion).

Diversified risk parity, which is based on a specific case of the general risk-parity problem, is a weighting scheme that attempts to equalise the risk contributions of individual stocks to the total risk of the index, assuming uniform correlations across stocks. This assumption has the advantage that the optimal weights can be derived analytically, without relying on any numerical resolution.

Indeed, in the absence of any constraints, such as tracking error or sector neutrality constraints, diversified risk parity boils down to inverse volatility weighting. Furthermore, the use of identical pairwise correlations allows a high level of robustness to be achieved. Indeed, Elton and Gruber (1973) show that the assumption of identical correlations leads to surprisingly reliable estimates of realised correlations. In theory the constant correlation model may appear very unrealistic, but in practice setting all pairwise correlations between stocks to their overall average may be a reasonable approach. This is the case because estimates of the entire set of correlation coefficients tend to be very noisy when the number of constituents is large, and hence it may be better in some cases to use a simplifying assumption than to use potentially very noisy correlation estimates.

A large body of literature has assessed diversification benefits by focusing on a measure of how well the portfolio exploits correlation effects among its constituents (for example, Longin and Solnik (1995) and Goetzmann, Li and Rouwenhorst (2001)). The maximum decorrelation weighting scheme focuses explicitly on risk reduction by exploiting the correlation structure of stock returns. It aims to minimise portfolio volatility under the assumption of identical volatility across stocks. The approach has, in fact, been introduced to measure the diversification potential within a given investment universe (Christoffersen et al., 2010). Thus, just as the maximum deconcentration weighting scheme reduces concentration in a nominal sense, the maximum decorrelation weighting scheme reduces the correlation-adjusted concentration.

In contrast with the three ad-hoc diversification strategies discussed above, the true minimum volatility portfolio lies on the efficient frontier. Indeed, the minimum volatility portfolio corresponds to a particular spot on the efficient frontier representing the portfolio that has the lowest level of volatility among all feasible portfolios. The minimum volatility strategy can be seen as an attempt to exploit information on risk parameters, including stock volatility and correlations across stocks.

The fact that minimum-volatility portfolios do not rely on expected return estimates is an attractive feature as it is well documented that expected return estimates are unreliable (Merton, 1980) and from that viewpoint, the minimum-volatility portfolio is sometimes considered to be an efficient and robust proxy for the optimal portfolio.

Moreover, the negative performance of equity markets following the 2008 financial crisis has spurred the demand for defensive equity strategies. The minimum-volatility strategy is now a well-accepted solution among investors seeking low-risk equity investments.

Nevertheless, a common problem cited for the minimum volatility strategy is that of concentration in low-risk (low volatility or low beta) stocks, which in turn leads to pronounced sector biases towards defensive sectors such as utilities (see Chan et al., 1999). A possible remedy to this problem of concentration in low-volatility stocks is to introduce weight constraints.

Jagannathan and Ma (2003) show that weight constraints not only control the concentration, but also improve the performance of minimum-volatility portfolios. DeMiguel et al. (2009a) go beyond considering rigid constraints at the individual stock level and introduce flexible constraints on overall portfolio concentration ("norm constraints"). They show that using such flexible constraints leads to better out-of-sample risk and return properties of minimum-volatility portfolios.

'The minimum-volatility strategy is now a well-accepted solution among investors seeking low-risk equity investments.'

The efficient minimum volatility weighting scheme provides a proxy for the minimum volatility portfolio, and uses such flexible norm constraints within the optimisation procedure.[6]

In addition to norm constraints, one can use a sector neutrality constraint – which is a more direct tool to control the sector exposure of indices.

The efficient maximum Sharpe ratio strategy is an implementable proxy for the tangency portfolio in the MPT framework. In contrast to minimum volatility strategies, the maximum Sharpe ratio strategy relies on estimates of both risk parameters (volatilities and correlations) and expected returns.

As direct estimation of expected returns is known to lead to large estimation

[5]In particular, in very broad universes that contain stocks with little liquidity, the rebalancing back to equal weights may be difficult to implement (see Blitz, 2013). Plyakha, Uppal and Vilkov (2012), Demey, Maillard and Roncalli (2010) and Leote de Carvalho, Xu and Moulin (2012) show that equal-weighted strategies have moderately higher levels of turnover compared with market-capitalisation-weighted portfolios. Dash and Loggie (2008) point out that transaction costs can become important for equal-weighting when the universe includes less liquid stocks.

[6]DeMiguel et al. (2009a) show that using such flexible concentration constraints instead of rigid upper and lower bounds on individual stock weights allows for a better use of the correlation structure. For this study, we set the effective number to be at least one-third of the nominal number of stocks in the universe (N/3). So the quadratic norm constraints can be stated as:

errors (Merton, 1980), we estimate expected returns indirectly by assuming they are positively related to a stock's semi-deviation (see Amenc et al., 2011).[7] More specifically, an extra step is added to the estimation process to provide more robustness: stocks are sorted by their semi-deviation into deciles and all stocks in a decile are then assigned the median value of the decile.

The efficient maximum Sharpe ratio strategy can be an alternative to the minimum volatility approach, especially for investors who do not wish to hold, for long periods, a portfolio concentrated in low-volatility stocks.

Ultimately, it is clear that the fact efficient minimum volatility and efficient maximum Sharpe ratio are supported by a consistent academic research consensus for more than 50 years is a useful guarantee of robustness as long as their implementation is performed according to the established rules, whether involving the quality of parameter estimation or the implementation of the investment constraints (concentration, liquidity and turnover).

Table 1 show that the minimum Volatility strategy invests about 63% in the 40% least-volatile stocks and just about 20% in the 40% most-volatile stocks. The maximum Sharpe ratio strategy, on the other hand, features more homogeneous weight distribution across volatility quintiles.

These short descriptions put forward the idea that, although every strategy aims directly or indirectly to increase diversification, every weighting scheme has its own assumptions and set of parameters it draws on.

Table 2 synthesises the description of the five diversification strategies. Interestingly, since the diversification strategies differ from each other in the assumptions they make and the objectives they aim to achieve, the combination of these different strategies allows the risks that are specific to each strategy to be diversified away by exploiting the imperfect correlation between the different strategies' parameter estimation errors and the differences in their underlying optimality assumptions. Moreover, as the single strategies' performance will show different profiles of dependence on market conditions, a multi-strategy approach can help investors smooth the overall performance across market conditions.[8] For instance, Amenc et al. (2012) form a combination of two diversification approaches[9] that leads to a smoother conditional performance and higher probability of outperforming the cap-weighted index.

In the same spirit, the ERI Scientific Beta diversified multi-strategy weighting scheme combines in equal proportions the efficient maximum Sharpe ratio, efficient minimum volatility, maximum decorrelation, diversified risk parity and maximum deconcentration weighting schemes.

Table 1

The table shows the weight distribution of the Scientific Beta Japan Efficient Minimum Volatility Index and Scientific Beta Japan Efficient Sharpe Ratio Index across volatility quintiles. The analysis is based on portfolio weights as of December 21, 2012. The stocks' volatility over the past 104 weeks has been used to form volatility quintiles. The total number of stocks in the Scientific Beta Japan universe is 500.

Scientific Beta Japan	Low volatility	2	3	4	High volatility
Efficient minimum volatility	40.6%	23.1%	16.5%	10.0%	9.9%
Efficient maximum Sharpe ratio	26.3%	17.3%	16.3%	18.6%	21.6%

Table 2

Overview of popular equity diversification strategies – The table indicates, for the diversification strategies, the optimisation objective (without taking into account any constraints, turnover control or liquidity rules), its unconstrained solution and the required parameters. The column "Optimality conditions" indicates under which conditions each diversification strategy would result in the maximum Sharpe ratio portfolio of modern portfolio theory. N is the number of stocks, μi is the expected return on stock i, σ_i is the volatility for stock i, ρ_{ij} is the correlation between stocks i and j, μ is the (Nx1) vector of expected return, ¶ is the (Nx1) vector of ones, σ is the (Nx1) vector of volatilities, Ω is the (NxN) correlation matrix and Σ is the (NxN) covariance matrix.

Strategy	Objective	Unconstrained closed-form solution	Required parameter(s)	Optimality conditions
Maximum deconcentration	Maximise effective number of stocks	$w^* = \frac{1}{N}\P$ ¤	None ¤	$\mu_{ii} = \mu\ \forall i$ ¶ $\sigma_i = \sigma_i \forall i$ ¶ $\rho_{ij} = \rho_{ij} \forall i$ ¤
Diversified risk parity	Equalise risk contributions under "constant correlation" assumption	$w^* = \frac{diag(\sigma^{-1})}{\P' diag(\sigma^{-1})}$ ¤	σ_i ¤	$\lambda_i = \lambda \forall i$ ¤ $\rho_{ij} = \rho\ \forall i$ ¤
Maximum decorrelation	Minimise the portfolio volatility under the assumption of identical volatility across all stocks	$w^* = \frac{\Omega\ ^{1}\P}{\P'\Omega^{-1}\P}$ ¤	ρ_{ij} ¤	$\mu_{ii} = \mu\ \forall i$ ¶ $\sigma_i = \sigma_i \forall i$ ¶
Efficient minimum volatility	Minimise portfolio volatility	$w^* = \frac{\Sigma\ ^{1}\mu}{\P'\Sigma^{-1}\mu}$ ¤	$\sigma_i, \rho_{ij}, \sigma_i, \rho_{ij}$ ¤	$\mu_{ii} = \mu\ \forall i$ ¤
Efficient maximum Sharpe ratio	Maximise portfolio Sharpe ratio	$w^* = \frac{\Sigma^{-1}\P}{\P'\Sigma^{-1}\P}$ ¤	$\mu_i, \sigma_i, \rho_{ij}$ $\mu_i, \sigma_i, \rho_{ij}$ ¤	Optimal by construction

[7]A number of studies show a positive relation between expected return and different measures of downside risk. Bali and Cakici (2004) and Huang et al. (2010) find that a stock's expected return has a strong positive relation with its VaR and its extreme downside risk, respectively. Chen et al. (2009) and Estrada (2007) show a positive relation between a stock's expected return and its semi-deviation. Ang et al (2006) document a positive relation between a stock's downside beta (stocks that are strongly correlated with the market when it goes down) and its expected return.

[8]This topic is discussed at greater length in Badaoui and Lodh (2013).

[9]Robust proxies for the minimum-volatility portfolio provide defensive exposure to equity markets that does well in adverse market conditions, while robust proxies for maximum Sharpe ratio portfolios provide greater access to the upside of equity markets. Tu and Zhou (2010), Kan and Zhou (2007) and Martellini, Milhau and Tarelli (2013) among others also study whether portfolio of strategies can improve the performance of individual strategies.

Performance analysis

Performance and systematic risks

'Achieving the objective set for this scheme will enable the risk-adjusted performance of the benchmark to be improved indirectly in comparison with cap-weighted indices.'

We present a comparative analysis of the performance and risks of the Scientific Beta flagship indices for the Japan universe. Flagship indices are based on the 50% most liquid stocks in the universe. This comparison is crucial not only to assess the benefits and the drawbacks that accompany each strategy, but also to give a clearer picture to investors as to why (and when) it may be important to choose a multi-strategy index instead of a single strategy. Table 3 shows absolute and relative performance summary statistics for the selected indices. All diversification strategies deliver higher returns than the cap-weighted reference index with annualised outperformance ranging from 1.27% to 2.26%.

Next we analyse the attainment of objective for each strategy in detail. The efficient minimum volatility index delivers the least volatility; it has a volatility of 18.69% compared with 22.25% for the reference cap-weighted (CW) index. Also, the efficient maximum Sharpe ratio index results in a Sharpe ratio of 0.10, which is well above that of the CW index (0.01).

However, the Efficient Minimum Volatility Index achieves an even higher Sharpe ratio of 0.13, resulting from both higher returns and lower volatility than the efficient maximum Sharpe ratio index over the analysis period, which tended to be favourable to defensive portfolios. The Efficient Minimum Volatility Index is more concentrated in low-volatility stocks and this defensive exposure is also confirmed by a low market beta of 0.84 as opposed to a market beta of 0.96 for the efficient maximum Sharpe ratio index. As a result, both these strategies are potential tangency portfolio proxies, and the choice between them depends on the degree of defensiveness desired by the investor.

For heuristic strategies, the explicit index construction objective is not to maximise its Sharpe ratio directly. The idea is that achieving the objective set for this diversification scheme will enable the risk-adjusted performance of the benchmark to be improved indirectly in comparison with cap-weighted indices.

Each of these schemes aims to correct a design flaw in cap-weighted indices which can often be summed up in terms of overconcentration. This

Table 3

Absolute and relative performance and risk characteristics – The table shows absolute and relative performance and risk characteristics for the Scientific Beta Japan High Liquidity indices. The statistics are based on daily total returns (with dividend reinvested) over the analysis period from inception date (21/06/2002) to 31/12/2012. The risk-free rate used is the "Japan Gensaki T-Bill (1M)" in Japanese Yen. All statistics are annualised and performance ratios that involve the average returns are based on the geometric average. Betas significant at the 95% confidence level are shown in bold. The total number of stocks in the Scientific Beta Japan universe is 500.

	Scientific Beta Japan High Liquidity indices						
	Maximum Deconcentration	Diversified Risk Parity	Maximum Decorrelation	Efficient Minimum Volatility	Efficient Maximum Sharpe Ratio	Diversified Multi-strategy	Cap-Weighted
Annual returns	1.61%	1.87%	2.28%	2.60%	2.22%	2.16%	0.34%
Annual volatility	23.99%	23.00%	21.47%	18.69%	21.07%	21.52%	22.25%
Sharpe ratio	0.0.6	0.07	0.10	0.13	0.10	0.09	0.01
Volatility concentration	0.46%	0.44%	0.78%	0.84%	0.71%	0.53%	0.84%
GLR measure	51.00%	50.70%	41.80%	40.70%	43.20%	44.80%	53.30%
Eff number of stocks	246	233	143	115	134	191	116
Excess returns	1.27%	1.53%	1.94%	2.26%	1.88%	1.82%	--
Tracking error	4.02%	3.40%	4.05%	6.05%	3.98%	3.38%	--
Information on ratio	0.32	0.45	0.48	0.37	0.47	0.54	--
Ann 1-way turnover	25.50%	26.00%	30.80%	31.90%	31.40%	23.80%	3.60%
Wgt avg market cap	8915	9342	8769	9783	8960	9154	22162
Alpha	0.55%	0.56%	2.05%	1.31%	1.72%	1.23%	0.00%
Market beta	1.09	1.05	0.98	0.84	0.96	0.98	1.00
Small-cap (SMB) beta	0.20	0.19	0.22	0.20	0.20	0.20	0.00
Value (HML) beta	0.02	0.03	-0.07	0.00	-0.05	-0.01	0.00

[10]Where is the weight of stock i in the index and is the volatility of stock i.

overconcentration can be understood in an initial analysis as an excessively low effective number of stocks (i.e. too much concentration of the value of the investment in a small number of stocks). In this case, the approaches that explicitly aim to maximise the effective number of stocks are the most effective. As such, the effective number of stocks (ENS) for the maximum deconcentration index is 246, which is significantly higher than 116 for the CW index.

'For investors agnostic about their capacity to identify the model with superior assumptions or suited to expected conditions, it serves to consider diversification across strategies.'

If the analysis of the flaw in the cap-weighted index relates more to concentration of the risks, defined as an excessive volatility concentration, rather than the stocks, we can define 'volatility concentration[10] (VC)' as the Herfindahl Index of the risk contribution of stocks where risk contribution is defined as the fractional volatility contribution of the stock to the total portfolio volatility.

A lower value for this statistic means more homogeneous stock contribution to portfolio risk. As expected, the Diversified Risk Parity Index shows a significantly low level of VC (0.44%) compared with the CW index (0.84%). The GLR measure[11] (Goetzmann et al. (2001)) is the ratio of the portfolio variance to the weighted variance of its constituents. The lower the GLR measure, the higher the diversification benefit of combining the set of stocks into a portfolio. The results show that the maximum decorrelation index fulfils its objective of reducing the GLR measure.

Ultimately, it should be observed that even though the Scientific Beta highly liquid indices are made up of half the stocks in the universe, all of these indices exhibit diversification and deconcentration indicators that are much better than the cap-weighted index containing twice as many stocks.

Table 3 shows the potential of the high liquidity diversified multi-strategy weighting scheme to diversify the risk by combining strategies. The excess return of the diversified multi-strategy weighting scheme, 1.82%, is higher than the mean excess return of the five constituent strategies (1.77%) while its tracking error (3.38%) is lower than the mean tracking (4.30%).[12] This leads to a high information ratio (of 0.54). The results also show that the indices are exposed differently to the systematic risk factors (i.e. market, SMB and HML factors). In general, all strategies have small-cap exposure brought about by deconcentration due to departure from cap weighting. Depending on the risk premium earned by these factors under particular economic conditions, the performance of the strategies can vary significantly. This idea is discussed in more detail in the next section.

Conditional performance

Amenc et al. (2012) show considerable variation in the performance of some popular smart-beta strategies in different sub-periods, revealing the pitfalls of aggregate performance analysis based on long periods. Table 4 shows that certain market conditions favour some smart-beta

Table 4

Conditional Performance – The table shows excess returns and tracking error of the Scientific Beta Japan High Liquidity indices in bull/bear and high/low volatility markets. The statistics are based on daily total returns (with dividend reinvested) over the analysis period from inception date (21/06/2002) to 31/12/2012. All statistics are on a quarterly basis and performance ratios that involve the average returns are based on the geometric average. The total number of stocks in the Scientific Beta Japan universe is 500. Calendar quarters with positive market index returns comprise bull markets and the rest constitute bear markets. The high-volatility market comprises the top 50% of quarters sorted on the quarterly cap-weighted benchmark's volatility and the low-volatility market comprises the rest.

Panel A: Excess returns over Scientific Beta Japan Cap-Weighted Index

	Maximum Deconcentration	Diversified Risk Parity	Maximum Decorrelation	Efficient Minimum Volatility	Efficient Maximum Sharpe Ratio	Diversified Multi-strategy
Bull market	1.24%	0.76%	0.31%	-1.35%	-0.10%	0.18%
Bear market	-0.45%	0.07%	0.64%	2.22%	0.97%	0.70%
High vol market	0.31%	0.63%	0.69%	1.84%	0.91%	0.89%
Low vol market	0.34	0.12%	0.27%	-0.81%	0.00%	-0.01%

Panel B: Tracking error with respect to Scientific Beta Japan Cap-Weighted Index

	Maximum Deconcentration	Diversified Risk Parity	Maximum Decorrelation	Efficient Minimum Volatility	Efficient Maximum Sharpe Ratio	Diversified Multi-strategy
Bull market	1.75%	1.54%	1.82%	2.64%	1.79%	1.55%
Bear market	2.23%	1.84%	2.21%	3.34%	2.16%	1.81%
High vol market	2.35%	2.01%	2.40%	3.60%	2.35%	1.98%
Low vol market	1.60%	1.32%	1.56%	2.29%	1.54%	1.33%

[11]Where is the number of stocks in the portfolio, is the return of portfolio, and is the return of stock.

[12]The indices presented here do not have any tracking error control mechanism. However, an explicit tracking error constraint can be applied to control the relative risk of the smart-beta indices while maintaining their outperformance (Goltz and Gonzalez (2013)).

strategies while proving detrimental to others. The reason for such behaviour is that each smart-beta strategy is exposed to a set of risk factors that have been shown to carry time-varying risk premia (Asness et al. (1992), Cohen, Polk, and Vuolteenaho (2003)).

Separating bull and bear market periods to evaluate performance has been proposed by various authors such as Levy (1974), Turner, Starz and Nelson (1989) and, more recently, Faber (2007). Unlike some of the diversification strategies, the diversified multi-strategy approach averages out the excess returns over different market regimes; its performance in bull/bear and high/low volatility markets is not extreme and its tracking error is quite low compared with its constituent strategies.

Conclusion

Our analysis shows that every smart-beta index displays performance and risk exposure values that are in line with its objective and construction methodology (e.g. the Efficient Minimum Volatility Index displays the lowest volatility among all strategies). However, there are certain limitations that stem from the specific risks of each strategy. The investor could address this issue and diversify the strategy-specific risk by allocating across strategies in a form similar to the Diversified Multi-strategy Index. Therefore, for investors who are agnostic about either their capacity to identify the model with superior assumptions or their capacity to choose a particular model that is suited to expected market conditions, it may be reasonable to consider diversification across strategies. ■

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Risk exposures of minimum-volatility index strategies

An illustration from Japan's equity market before, during and after the 2011 Fukushima nuclear crisis.

By Nicolas Gonzalez

The use of minimum-volatility alternative equity weighting has gained popularity ever since the 2008 financial crisis. Empirical evidence exists to show that a minimum-volatility strategy can deliver significantly lower volatility compared to its market-cap-weighted counterpart in global equity markets (Chan et al., 1999; Schwartz, 2000; Jagannathan and Ma, 2003; Clarke et al., 2006; DeMiguel et al., 2009a; Geiger and Plagge, 2007; Nielsen and Aylursubramanian, 2008; and Poullaouec, 2008).

In particular, minimum-volatility portfolios have been shown to provide market-like returns with less volatility, thus increasing their risk-adjusted performance (as measured by their Sharpe ratio) relative to the cap-weighted benchmark.

However, volatility only covers part of the story when it comes to assessing portfolio risk. A minimum-volatility strategy, like all other alternative beta strategies (also referred to as smart-beta strategies), admittedly bears risks that are significant, and significantly different than those of cap-weighted indices.

By construction, the methodological choices used in smart-beta strategies differ from those of the standard cap-weighted market index – this typically leads smart-beta strategies to be more or less exposed to systematic risk factors such as the market factor. With the aim of minimising the volatility of the strategy portfolio, the minimum-volatility strategy tends to tilt towards low-volatility stocks, exposing the investor not only to the volatility factor but also to pronounced sector biases towards defensive sectors.

The exposure of smart-beta strategies to systematic risk must be analysed by investors if they want to make an informed decision concerning the use of any smart-beta strategy. Being aware of all the factors to which the strategy is exposed can also help investors assess whether the strategy's performance is solely due to certain factor tilt(s).

More importantly, as the rewards for exposure to systematic risk factors have been shown to vary over time (see, for instance, Harvey, 1989; Asness, 1992; and Cohen, Polk and Vuolteenaho, 2003), a high exposure to those factors may lead the strategy to perform differently under different market conditions and potentially to severe underperformance with regard to the cap-weighted reference index in unfavourable market conditions.

To ensure the robustness of a strategy's performance as well as the reasonable levels of relative risk that investors may seek, understanding and, furthermore, controlling systematic risks is essential.

In this article, we will look at the systematic risk exposures of the minimum-volatility strategy in the Japanese equity market based on the Scientific Beta Japan Efficient Minimum Volatility Index[1].

We focus on Japan's equity market, as it represents a major part of Asian markets and one that investors are probably most familiar with. In addition, Japan recently experienced the 2011 Fukushima nuclear crisis that seriously affected the utilities sector, and therefore it can illustrate the effects of variation in sector exposure of the minimum-volatility strategy during this event.

We further introduce the sector-neutral version of the Scientific Beta Japan Minimum Volatility Index, whereby we control the sector risks of the minimum-volatility strategy by imposing constraints so as to match the sector weights of the strategy index to the cap-weighted index, to assess the role that controlling sector risk would have had on the Scientific Beta Japan Minimum Volatility Index.

Factor exposures of the Scientific Beta Japan Efficient Minimum Volatility Index

Factor analysis is a common way of measuring the exposure of a strategy portfolio to a set of well-known systematic factors. We employ the Fama-French three-factor model to assess the strategy's risk exposures to three systematic factors: the market factor, as represented by the market-cap-weighted reference index; the small-cap factor (small-minus-big or SMB); and the value factor (high-minus-low or HML) (see Fama and French, 1992).

Exhibit 1 below shows the coefficient estimates and R-squared of the regression of the index's excess

[1]The Scientific Beta Efficient Minimum Volatility weighting scheme aims to provide an implementable proxy for the Minimum Volatility portfolio envisaged by Modern Portfolio Theory (MPT). It uses state-of-the-art risk parameter estimates and provides an improvement upon standard Minimum Volatility portfolios by enforcing constraints on portfolio concentration.

returns (over the risk-free rate) on the three Fama-French factors from index inception (21/06/2002) to 30/06/2013.

Exhibit 1 Risk factor exposure of the Scientific Beta Japan Efficient Minimum Volatility Index – This table shows the coefficient estimates and R-squared of the regression of the index's excess returns over the risk-free rate using the Fama-French three-factor model over the analysis period from June 21, 2002, to June 30, 2013. The regression coefficients (betas) significant at the 95% confidence level are highlighted in bold. Reported alphas are geometrically averaged and are annualised.

SciBeta Japan Minimum Volatility

Index	Coefficient
Alpha	1.84%
Market factor	0.79
Size (SMB) factor	0.44
Value (HML) factor	-0.04
R squared	0.94

The statistics are based on daily total returns (with dividend reinvested). The market factor is the daily return of the cap-weighted index of all stocks that constitute the index portfolio.

The SMB factor is the daily return series of a cap-weighted portfolio that is long the top 30% of stocks (small market-cap stocks) and short the bottom 30% of stocks (large market-cap stocks) sorted by market capitalisation in ascending order.

The HML factor is the daily return series of a cap-weighted portfolio that is long the top 30% of stocks (value stocks) and short the bottom 30% of stocks (growth stocks) sorted by book-to-market value in descending order. The cap-weighted reference index used is the Scientific Beta Japan Cap-weighted Index. We use the returns on the 'Japan Gensaki T-Bill (1M)' as the risk-free rate in yen.

The above results show that the exposure of the Efficient Minimum Volatility Index to the market factor is quite low (market beta of 0.79). This is explained by the fact that minimum volatility overweights low-volatility stocks, which are usually low-market-beta stocks.

We also observe a significantly high exposure to the size factor. Given that a cap-weighted index is typically concentrated in the largest capitalisation stocks, a minimum-volatility strategy will deviate weights away from the large stocks and naturally introduce a size tilt toward smaller-cap stocks.

Sector exposures of the Scientific Beta Japan Efficient Minimum Volatility Index

An understanding of the sector allocation of a strategy can also provide insights into its systematic risk exposures, as sectors are considered to be sources of common factor risk and the sector biases of smart-beta strategies have been well documented (see, for example, Amenc, Goltz and Le Sourd, 2009).

Exhibit 2 shows the deviations of sector weights relative to the cap-weighted reference index for the Scientific Beta Japan Efficient Minimum Volatility Index based on the portfolio's stock weight profile as of the last index rebalancing date in 2013 (June 21, 2013).

The cap-weighted reference index is the Scientific Beta Japan Cap-weighted Index. The sector classification used is the Thomson Reuters Business Classification.

As mentioned in the introduction, the minimum-volatility strategy is known to overweight stocks from defensive or low-beta sectors. This property of minimum-volatility strategies has been documented empirically by, for example, Chan, Karceski and Lakonishok (1999) and Clarke, De Silva and Thorley (2011).

It can be seen that the Scientific Beta Efficient Minimum Volatility index indeed shows a significant tilt towards low-volatility sectors such as non-cyclical consumer, health care and utilities[2] (with overweights of 9.2%, 4% and 1.5% respectively with respect to the cap-weighted index) and significantly underweights volatile sectors such as financials (with an underweight of about 10% with respect to the cap-weighted index).

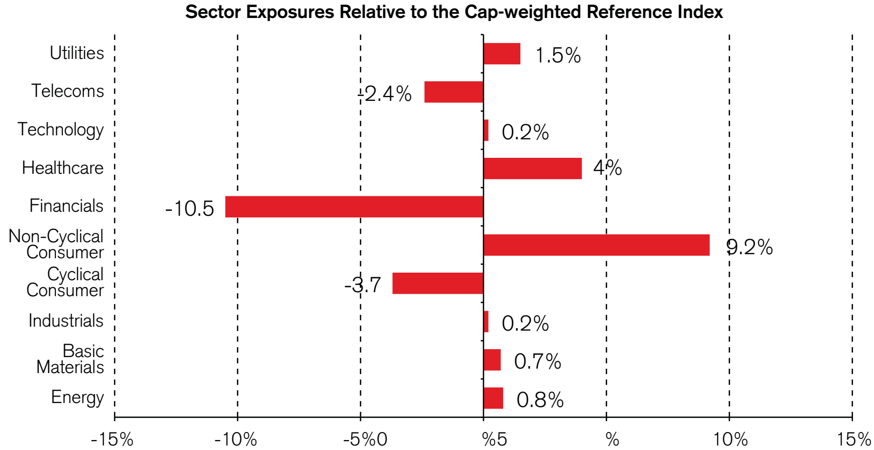
Controlling sector exposures: a focus on the Fukushima crisis

On March 11, 2011, the Fukushima Daiichi nuclear plants on the coast of northeast Japan experienced serious structural damage that had a direct impact on power supplies and radioactivity, following the Tohoku earthquake and tsunami that struck that day. Due to expectations of the consequences of this disaster, the Japanese equity market was quickly and significantly affected. The S&P Japan 500 index dropped by as much as 10% and the S&P Japan 500 Utilities index declined by 20% in the following week.

Exhibit 3 reports the sector weights of the Scientific Beta Japan Minimum Volatility Index over three time periods: the three-month period immediately before the Fukushima event, the period from the event day to five days later, and the three-month period immediately following the Fukushima event period. Within each time period, we also attribute the relative performance of the strategy with regard to cap-weighted reference index to sectors. The relative performance is broken down into two factors:

Exhibit 2: Relative sector exposures of the Scientific Beta Japan Efficient Minimum Volatility Index with respect to the reference cap-weighted index

This figure shows relative sector exposures (in weight %) of the index with respect to the reference cap-weighted index, based on its stock weight profile at the last rebalancing date (June 21, 2013).



[2]In order to avoid the problem of concentration in low-volatility stocks in the resulting portfolio, Scientific Beta follows DeMiguel et al.'s (2009a) approach of adding a constraint on overall portfolio concentration (a method referred to as "norm constraints") during optimisation. The norm constraints apply in the Scientific Beta Japan Efficient Minimum Volatility framework, which prevents large positions in individual stocks.

Exhibit 3: Sector attribution of Scientific Beta Japan Efficient Minimum Volatility Index

This figure shows sector attribution of the index's relative performance with respect to the reference cap-weighted index over three time periods: the three-month period immediately before the Fukushima event, the event period from event day to five days later, and the three-month period immediately following the Fukushima event period. The sector weights are also reported.

Sector attribution of Scientific Beta Japan Efficient Minimum Volatility Index

	Before the crisis 17/12/2010-11/03/2011					Ongoing crisis 14/03/2011-18/03/2011					After the crisis 19/03/2011-17/06/2011				
	Strategy weights	Cap Weight Ref. Index weights	Sector-weighting	Stock-weighting	Total Rel. Perf.	Strategy weights	Cap Weight Ref. Index weights	Sector-weighting	Stock-weighting	Total Rel. Perf.	Strategy weights	Cap Weight Ref. Index weights	Sector-weighting	Stock-weighting	Total Rel. Perf.
Energy	2.6%	0.9%	0.2%	0.0%	0.2%	2.6%	0.9%	0.2%	-0.1%	0.1%	2.8%	1.7%	0.0%	0.0%	0.0%
Basic materials	8.0%	7.5%	0.0%	0.1%	0.1%	8.0%	7.6%	0.0%	0.0%	0.0%	7.7%	7.7%	0.0%	0.2%	0.2%
Industrials	21.2%	24.9%	0.0%	-0.5%	-0.5%	21.1%	25.0%	-0.1%	0.3%	0.2%	20.3%	24.6%	-0.1%	-0.4%	-0.4%
Consumer cyclicals	22.3%	23.4%	0.0%	-0.2%	-0.2%	22.3%	23.1%	0.0%	0.1%	0.1%	22.5%	22.5%	0.0%	0.9%	0.9%
Consumer non-cyclicals	14.1%	5.5%	0.1%	-0.2%	-0.1%	14.2%	5.6%	0.0%	0.2%	0.2%	12.8%	5.2%	0.6%	0.0%	0.6%
Financials	7.3%	16.3%	0.0%	0.0%	0.0%	7.3%	16.3%	0.2%	0.2%	0.3%	9.1%	17.4%	0.3%	0.2%	0.5%
Health care	9.5%	5.5%	-0.1%	0.0%	-0.1%	9.5%	5.6%	0.1%	0.0%	0.1%	9.7%	5.2%	0.2%	0.1%	0.3%
Technology	6.4%	7.0%	0.0%	0.3%	0.3%	6.3%	7.0%	0.0%	0.0%	0.1%	6.1%	6.7%	0.0%	0.0%	0.0%
Telecom. services	1.5%	3.9%	-0.2%	0.0%	-0.2%	1.5%	3.9%	0.0%	0.0%	0.0%	1.6%	4.0%	-0.1%	0.0%	-0.1%
Utilities	7.2%	5.1%	0.0%	-0.1%	-0.1%	7.2%	5.1%	-0.2%	0.7%	0.5%	7.2%	5.0%	-0.7%	0.8%	0.1%
Total	100.0%	100.0%	0.0%	-0.7%	-0.7%	100.0%	100.0%	0.2%	1.6%	1.7%	100.0%	100.0%	0.1%	1.9%	2.0%

the stock-weighting factor and the sector-weighting factor.

Consistent with the previous section, the results in exhibit 3 show that the weights of the minimum-volatility strategy in stable sectors such as health care, consumer non-cyclicals and utilities were, on aggregate, about 30% higher relative to the cap-weighted reference index during the Fukushima crisis.

On the one hand, the bias towards defensive sectors leads to the minimum-volatility strategy's outperformance over the cap-weighted reference index during the crisis period. The total relative performance was 1.6% in the event period and 2.0% in the post-crisis period, while the total relative performance was -0.7% before the crisis.

On the other hand, the minimum volatility strategy's sector bias towards the utilities sector inevitably exposed it heavily to the Fukushima crisis, and as a result its performance suffered severely. The sector-level attribution reveals that the overweight on the utilities sector detracted from the performance of the minimum-volatility strategy as measured by the sector-weighting factor, with a relative return of -0.2% during the crisis period and -0.7% in the post-crisis period.

We use a holding-based method of performance attribution (Brinson, Hood, and Beebower (1986)) to analyse the sources of the relative performance of the Scientific Beta Japan Efficient Minimum Volatility Index with respect to the reference cap-weighted index.

Relative performance is broken down into two factors: the stock-weighting factor, which accounts for the share of relative performance attributable to the ability of the strategy to select stocks; and the sector-weighting factor, which accounts for the share attributable to the ability of the strategy to overweight sectors that outperform the reference index.

The total contribution is the sum of the contribution from these two factors. The contribution is the overall excess return over the reference index during the period without annualisation.

The cap-weighted reference index is the Scientific Beta Japan Cap-weighted Index. The sector classification used is the Thomson Reuters Business Classification.

However, it should be noted that investors can choose to control the systematic risks of the minimum-volatility strategy. One way of controlling the systematic risks proposed by Edhec Risk Institute (ERI) Scientific Beta is by imposing constraints on risk-factor exposures within the weighting scheme. Such constraints allow, in particular, for problems such as sector biases to be solved.

To achieve this objective, ERI Scientific Beta enables investors to construct a sector-neutral version of the Scientific Beta Japan Efficient Minimum Volatility Index. As the name suggests, it is a risk-control scheme that attempts to maintain sector neutrality with regard to the market-cap-weighted reference index.

'Investors can choose to control the systematic risks of the minimum-volatility strategy.'

Exhibit 4 reports sector attribution results similar to those in exhibit 3 for the sector-neutral version of the Scientific Beta Japan Efficient Minimum Volatility Index.

We use a holding-based method of performance attribution ((Brinson, Hood, and Beebower (1986)) to analyse the sources of the

Exhibit 4: Sector attribution of Scientific Beta Japan Efficient Minimum Volatility Index (sector-neutral)

This figure shows sector attribution of the index's relative performance with respect to the reference cap-weighted index over three time periods: the three months immediately before the Fukushima event; the five days from the event day (including that day); and the three months immediately after the event. The sector weights are also reported.

Sector attribution of Scientific Beta Japan Minimum Volatility Index (sector-neutral)

	Before the crisis 17/12/2010-11/03/2011					Ongoing crisis 14/03/2011-18/03/2011					After the crisis 19/03/2011-17/06/2011				
	Strategy weights	Cap Weight Ref. Index weights	Sector-weighting	Stock-weighting	Total Rel. Perf.	Strategy weights	Cap Weight Ref. Index weights	Sector-weighting	Stock-weighting	Total Rel. Perf.	Strategy weights	Cap Weight Ref. Index weights	Sector-weighting	Stock-weighting	Total Rel. Perf.
Energy	1.7%	0.9%	0.1%	0.0%	0.1%	1.7%	0.9%	0.1%	0.0%	0.1%	1.9%	1.7%	0.0%	0.0%	0.0%
Basic materials	9.9%	7.5%	-0.1%	0.1%	0.0%	9.9%	7.6%	0.0%	0.0%	0.0%	9.4%	7.7%	0.1%	0.3%	0.4%
Industrials	24.9%	24.9%	0.0%	-0.6%	-0.6%	24.9%	25.0%	0.0%	0.2%	0.2%	24.0%	24.6%	0.0%	-0.4%	-0.4%
Consumer cyclicals	22.6%	23.4%	0.0%	-0.2%	-0.2%	22.6%	23.1%	0.0%	0.1%	0.1%	22.9%	22.5%	0.0%	1.0%	1.0%
Consumer non-cyclicals	8.0%	5.5%	0.0%	-0.1%	0.0%	8.1%	5.6%	0.0%	0.2%	0.2%	7.1%	5.2%	0.1%	0.0%	0.1%
Financials	11.9%	16.3%	0.0%	0.0%	0.0%	11.9%	16.3%	0.1%	0.2%	0.3%	13.5%	17.4%	0.1%	0.3%	0.4%
Health care	5.2%	5.5%	0.0%	0.0%	0.0%	5.2%	5.6%	0.0%	0.1%	0.1%	5.3%	5.2%	0.0%	0.1%	0.1%
Technology	7.0%	7.0%	0.0%	0.3%	0.2%	7.0%	7.0%	0.0%	0.0%	0.0%	7.3%	6.7%	0.0%	0.0%	0.0%
Telecom. services	3.5%	3.9%	0.0%	0.0%	-0.1%	3.5%	3.9%	0.0%	0.0%	0.0%	3.7%	4.0%	0.0%	0.0%	0.0%
Utilities	5.3%	5.1%	0.0%	-0.1%	-0.1%	5.3%	5.1%	0.0%	0.6%	0.6%	4.9%	5.0%	0.1%	0.6%	0.6%
Total	100.0%	100.0%	0.0%	-0.7%	-0.7%	100.0%	100.0%	0.1%	1.5%	1.6%	100.0%	100.0%	0.4%	1.9%	2.3%

relative performance of the Scientific Beta Japan Efficient Minimum Volatility Index (sector-neutral) with respect to the reference cap-weighted index.

Relative performance is broken down into two factors: the stock-weighting factor, which accounts for the share of relative performance attributable to the ability of the strategy to select stocks; and the sector-weighting factor, which accounts for the share attributable to the ability of the strategy to overweight sectors that outperform the reference index. The total contribution is the sum of the contribution from these two factors.

The contribution is the overall excess return over the reference index during the period without annualisation. The cap-weighted reference index is the Scientific Beta Japan Cap-weighted Index. The sector classification used is the Thomson Reuters Business Classification.

As shown in the results, the sector-neutral version effectively brings down the difference in sector weighting between the minimum-volatility strategy and the reference cap-weighted index. This adjustment in sector weighting reduced the sector weights in utilities from 5.3% before the crisis to 4.9% after the crisis. As a result, the sector-neutral version improved the relative performance of the utilities sector from -0.2% to 0.0% in the five-day crisis period and from -0.7% to 0.1% in the three-month post-crisis period, while preserving about the same level of relative performance within the utilities sector. ■

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