An EDHEC Risk & Asset Management Research Centre Publication

Assessing the Quality of Stock Market Indices: Requirements for Asset Allocation and Performance Measurement

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Foreword

Af2i and EDHEC are pleased to present the first study to have been carried out on the quality of market indices as a benchmark for institutional investors.

We feel that this study is particularly valuable given the changes that have taken place in recent years in asset management practices. For the vast majority of institutional investors, the construction of and adherence to a benchmark is central to their investment approach. And, very often, the choice of benchmark is a market index and/or a combination of market indices.

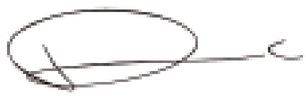
Since their design is not affected by the securities chosen by managers and since they benefit from the sound reputation of major financial institutions, credit rating agencies and major international stock exchanges, market indices appear to be the ultimate reference not only for strategic allocation but also as a measure of investment management performance.

Evaluating the quality of these indices as a benchmark is therefore a question that is essential to institutional investors.

It is the importance of this question that led Af2i and EDHEC to carry out research on the main market indices used by French and other European investors.

This work received the support of BNP Paribas Asset Management and UBS Global Asset Management, to whom we extend our warmest thanks.

We would also like to thank all of the authors who contributed to this study, in particular Felix Goltz, who coordinated the work.



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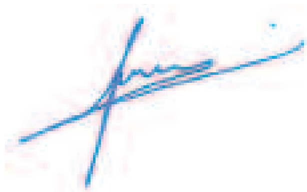

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Executive Summary

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The use of capitalisation-weighted indices is often justified by the central conclusion of modern portfolio theory – that the optimal investment strategy for any investor is to hold the market portfolio, the capitalisation-weighted portfolio of all assets. It should however be noted that empirical tests conclude that market indices are not efficient. This can be explained by the fact that these indices do not include all assets or by the fact that the theory does not hold. The practical conclusion is that using capitalisation-weighted portfolios is not necessarily the optimal method.

For purposes of asset allocation and performance measurement, the assumption of index efficiency is a central one. In addition, investors typically perceive the index to be a neutral choice of long-term risk factor exposure. These requirements mean that the existing indices may be of good or bad quality depending on the degree to which they fulfil the requirements. This survey addresses this issue using a number of well-known stock market indices.

Lack of Stable Risk Exposure

We conduct an empirical study assessing the stability of the allocations of existing indices. The goal is to identify the evolution of the weights in a range of broad market indices. We conduct this analysis since investors are typically interested in the allocation over the different subcategories of their equity portfolio. The most relevant subcategories for equity investors are investment styles such as growth and value and industry sectors. This stems from the fact that size (large cap, small cap, etc) and style (growth, value) have been shown to explain a significant portion of the cross-sectional difference in expected stock returns (see section one of this study). Likewise, sectors of the industry are useful building blocks for constructing equity portfolios, as different sectors of the economy have different exposure to the business cycle. As the portfolio composition by style and by sector directly impacts the risk and return properties of the portfolio, this decision requires major attention from investors.

Our analysis is motivated by the fact that the index is often viewed as a somewhat neutral investment decision. However, the choice of an index as an investment support involves an implicit rather than an explicit choice of allocation. Our focus is on qualifying the type of style-/sector- allocation choices made by investing in an index. We test the stability of existing indices in terms of exposure to both investment styles and industry sectors and we find that the relative weight of the different sub-indices varies drastically over time.

To summarise how the style weights of broad market indices vary over time, we calculate the style drift score. This score indicates the average variability of the style or sector weights for each index.

Style Drift Score based on style exposures

	Style Drift Score
Cac 40	4.2%
DAX 30	5.5%
FTSE 100	4.2%
DJ Euro Stoxx 50	4.9%
DJ Euro Stoxx 300	2.6%
DJ Stoxx 600	5.5%
Nikkei 225	17.6%
Topix 500	8.2%
S&P 500	2.3%
Russell 2000	11.0%
Dow Jones Industrials 30	26.0%

Results for the style weights are indicated in Illustrations 4 ,5, 6 and 7 of the full document. The figures show the variability of the weights given in the left hand side graphs of illustrations 4 ,5, 6 and 7 of the full study. The style drift indicator is calculated according to the method of Idzorek and Bertsch described in the complete text.

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The sector weights of the market indices that we analyse also show drastic variation over time. While this may be expected, given that our period covers the technology bubble and its burst, even when looking at relatively calm periods on the stock market, the variations in sector weights are considerable. The following table shows the sector drift scores, calculated in a manner analogous to the style drift scores.

Sector Drift Score based on sector capitalisations

Geographical Zone	Index	Sector Drift Score
Germany	Prime All Share Index 380	10.4%
United Kingdom	FTSE All Share Index 700	7.1%
Eurozone	DJ Euro Stoxx 300	7.2%
Europe	DJ Stoxx 600	6.6%
Japan	Topix 1666	7.0%
USA	S&P 500	7.3%

Based on the sector capitalisation weights shown in Illustrations 8, 9, 10, 11, 12 and 13 of the full document. These sector weights are based on the capitalisations for the period of October 1995 to September 2005. The style drift indicator is calculated according to the method of Idzorek and Bertsch described in the complete text.

The variation of the weights of the sectors in the global market index leads to a problem for the investor. The sector instability emphasises the fact that the sector allocation becomes an implicit decision induced by the choice of an index, as opposed to an explicit choice of the investor. We show that this implicit choice corresponds to a "view" on the returns of the different sectors, and we argue that holding the global market index is not optimal for an investor, unless he/she happens to share these views implied by the market capitalisation weights of different industry sectors.

If we consider each market index as a global portfolio, we can conclude on the implicit views of the representative investor. We use the Black-Litterman asset allocation model to extract these views from the index weights. We show that variations in the relative market capitalisation weights of the sectors correspond to a modification in the expected returns on the respective sector. In fact, the view of the market on the returns of the different sectors may show considerable variation. Thus, the burst of the technology bubble and the corresponding decrease of the weight of the information technology sector corresponds to a change in view of 17.40% return to 13.7% for the Euro Stoxx 300 index. Such variations may not be surprising, given that capitalisation weighting implies a trend following strategy. As a sector's relative price rises, so too does its weight in the portfolio. Implicitly, rising prices lead to an expectation of higher returns. Investing in the index means accepting these views, which may seem counterintuitive.

Lack of Efficiency

As stated above, we examine the efficiency of existing stock market indices since efficiency is the major claim made by index providers to establish that capitalisation weighted indices are a good investment choice.

We test the distance in terms of efficiency between a market index and its alternatives. These alternatives are based on portfolios of individual stocks rather than portfolios of style indices or sector indices in order to avoid a bias linked to a different universe of assets for the style/sector versus the market index. The question as to the efficiency of the index is whether an investor may obtain better results by using the same universe of stocks but a weighting scheme that is different from capitalisation weighting. We assess two weighting schemes – mean-variance optimisation and equal weighting.

Our conclusion is that the existing stock market indices are highly inefficient compared to the mean variance optimal portfolios. We show that

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the indices lie below the efficient frontier. Interestingly, even a simple weighting method such as equal weighting of the component stocks leads to more efficient portfolios than the capitalisation-weighted indices.

We can summarise the results obtained for existing stock market indices by showing their rank in terms of efficiency. This result is shown in the following table.

Efficiency Ranks of Indices

	Rank for Efficiency (from Mean Variance Analysis)
Dow Jones Industrials 30	1
DJ Euro Stoxx 50	2
Cac 40	3
DAX 30	3
FTSE 100	5
S&P 500	6
Nikkei 225	7
Topix 500	7
DJ Euro Stoxx 300	9
DJ Stoxx 600	9
Russell 2000	11

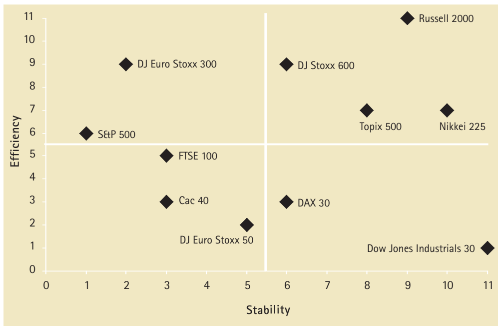
These rankings are taken directly from Table 15 B of the complete document.

The poor efficiency score of capitalisation-weighted indices may not be surprising, given that the weighting method automatically gives very high weights to some components and leads to concentrated portfolios. Usually, the 10-30 largest stocks make up the majority of the weighting in the index. Put differently, even if an index has more than 500 components, 90% of the components make up an almost negligible part of the index weights. Also, as shown by the dramatic changes of sector weights, at certain stages, some sectors have a dominant weight in the index.

It is interesting to note that the index that performs best is the only index that is not capitalisation-weighted. The Dow Jones Industrials Average actually uses a price-weighting methodology. While this methodology is subject to severe criticism, it seems that capitalisation-weighting is even less attractive in terms of efficiency.

The illustration below maps the indices according to their ranks for the style stability and the efficiency criterion. This illustration shows visually what the profile of each index is. The indices in the "south-westerly" quarter of the graph have high ranks in terms of both efficiency and stability. The indices in the "north-westerly" quarter have low ranks for efficiency, but are in the upper half of the indices studied in terms of the style stability criterion. Likewise, the indices in the "south-easterly" quarter are poor in terms of stability of style, but are among the most efficient. Finally, the "north-easterly" quarter contains indices that have low ranks according to both criteria.

Ranks of Indices



This illustration is based on Table 20 of the complete document. The rank obtained for the efficiency criterion is indicated on the vertical axis while the rank obtained for style stability is indicated on the horizontal axis. The lines at the centre indicate a rank of 5.5, which corresponds to the average rank among the 11 indices. The ranks are based on Table 7 (section two) and Table 15 B (section three of the complete document). The indices are ranked in ascending order for the style drift scores from Table 7. The ranks for efficiency are taken directly from Table 15 B of the complete document.

This illustration shows quite clearly that there is no index which unambiguously dominates the other indices. The S&P 500, for example, has the lowest style drift score from style weights that

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were obtained from a returns-based style analysis. On the other hand, when the location of the S&P 500 index in the mean variance plane is compared to portfolios on the mean variance frontier, it only obtains the sixth rank among all the indices studied. Likewise, the Dow Jones Industrial index obtains the leading rank in terms of efficiency, but shows pronounced variability of style weights leading to rank 11, the last rank among all the indices, with respect to this latter criterion.

It should be noted that indices for the same geographic regions obtain quite dissimilar profiles in this plot. For the US stock market, for example, the S&P 500 ranks well in terms of style stability and poorly in terms of efficiency, the Dow Jones Industrial ranks well in terms of efficiency but very poorly in terms of stable style exposure. The Russell 2000 index obtains low ranks with respect to both criteria. The picture for European and indices is equally disparate, while the Japanese indices map each other more closely.

Indices that rank well, both in terms of stability and efficiency, are the CAC 40, the FTSE 100 and the DJ Stoxx 50. These indices rank in the upper half of ranked indices according to both criteria. The most attractive one seems to be the CAC 40, which ranks third in terms of both criteria.

Implications and Remedies

In the last section of the study, we show some implications of the results from the empirical sections for different stages of the investment process, namely asset allocation and performance measurement. Should it be said that commercial indices are sub-optimal investment vehicles that should simply be avoided by investors? We actually believe not, as there is evidence that commercial indices can be used as building blocks to design efficient allocation strategies.

In order to deal with the problem of an exposure to risk factors that vary over time, we propose to build completeness portfolios that neutralise the sector biases of an index.

An obvious way to deal with the lack of stability is to construct portfolios that have constant weights over time. However, if investors choose to construct a portfolio themselves, they will forego some of the implementational advantages of investing into broad stock market indices (such as low management fees, low transaction costs, low information costs and simple implementation of orders dealing with intermediate cash flows). Therefore, we propose to construct completeness portfolios that allow for an investment in broad stock market indices while neutralising the sector shifts inherent in the indices. We concentrate on sector biases (rather than style biases) since sector weights are directly observable using the market capitalisation of sectors. The analysis is done for all portfolios where we did the sector stability analysis above, using the same dataset.

Adding the completeness portfolio resolves the problem of investors not being in control of the sector exposures of their equity portfolio. In addition, investors hold portfolios whose weights remain fixed, unlike with a buy-and-hold strategy.

These completeness portfolios not only have more stable sector exposure, but also achieve more favourable performance in terms of risk and return. Thus, investors seeking the most attractive risk return profile for their portfolio could benefit from implementing a simple neutralisation strategy by holding a global index and a completeness portfolio made up of

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sector indices. Similarly, for purposes of performance measurement, investors can construct benchmarks that are more sophisticated than a global index, by choosing a combination of indices. Such a benchmark is often called a "customised benchmark", to emphasise the fact that it is not simply a global index.

The fact that global indices show a pronounced lack of efficiency is probably the most interesting result of this study. The remedy we proposed for the asset allocation phases of the investment process is to construct efficient portfolios, for example from sector indices. These sector indices can be used as building blocks in an optimisation procedure that makes it possible to avoid the drawbacks of the global indices. The approach we proposed avoids estimation risk by focusing on the minimum risk portfolio and shows significant enhancement of efficiency in an out-of-sample exercise.

Our results show that the volatility of the minimum-variance portfolio is always significantly lower than that of the corresponding market index. It is important to note that this dominance is not achieved by construction and the portfolios can actually be obtained ex ante by an investor.

It is striking that the lower risk of the minimum-variance portfolio does not lead to a lower expected return for five out of six indices. This is only the case for the minimum-variance portfolio of sectors that make up the S&P 500 index. All other minimum-variance portfolios also have higher expected returns than the corresponding index. Consequently, the Sharpe ratios show strong improvements compared to the market index, except for the S&P 500.

On the Usefulness of Equity Indices

While our findings show that commercial indices pose serious challenges for an investor who wishes to use them in the investment process, these drawbacks do not necessarily mean that an investor should not use indices at all. Quite to the contrary, we have shown that there are straightforward remedies for the problems of commercial stock market indices. We have looked at such solutions for both asset allocation and performance measurement.

To conclude, it can be stated that this study identifies numerous problems with commercial stock market indices. At the same time, we propose a number of pragmatic solutions to these problems. All of these solutions are based on indices that reflect finer sub-segments of the equity market, such as investment styles or industry sectors. The main drawback of global stock market indices may actually be that they imply a somewhat confused allocation by sub-segments, rather than allowing a precise and explicit definition of the asset allocation. Sector indices and style indices seem to be appropriate tools that allow investors to gain control over the investment process, while focusing on its most rewarding phase – the asset allocation decision.

Résumé

On justifie souvent l'utilisation des indices pondérés par les capitaux par la conclusion qui est au coeur de la théorie moderne du portefeuille et qui stipule que la stratégie d'investissement optimale, pour tout investisseur, est celle qui consiste à détenir le portefeuille de marché. Ce portefeuille est par définition le portefeuille pondéré par les capitalisations boursières constitué de tous les actifs. Il convient cependant de remarquer que les tests empiriques sont arrivés à la conclusion que les indices de marché ne sont pas efficients. On peut expliquer ce résultat par le fait que ces indices ne contiennent pas tous les actifs ou alors en déduire que la théorie ne se vérifie pas. De façon pratique, on arrive à la conclusion que l'utilisation des indices pondérés par les capitaux n'est pas nécessairement la méthode optimale.

Pour les besoins de l'allocation d'actifs et de la mesure de performance, l'hypothèse d'efficience des indices est une hypothèse clef. De plus, les investisseurs perçoivent typiquement l'indice comme un choix neutre d'exposition aux facteurs de risque de long terme. Ces exigences signifient que les indices existants seront de bonne ou mauvaise qualité, suivant le degré avec lequel ils remplissent les conditions. La présente étude traite du problème de la qualité des indices en se basant sur un certain nombre d'indices de marché très usités.

Manque de stabilité dans l'exposition au risque

Nous avons mené une étude empirique pour juger de la stabilité de l'allocation des indices existants. Le but était d'identifier l'évolution des pondérations dans une gamme d'indices de marché couramment utilisés. Cette analyse a été menée car l'allocation de leur portefeuille d'actions entre les différentes sous-catégories d'actif est typiquement un sujet d'intérêt pour les investisseurs. Il est à noter que les sous-catégories les plus pertinentes pour les investisseurs actions sont les styles d'investissement, tels que growth et value, et les secteurs industriels. Ceci parce qu'il a été démontré que la taille (large cap, small cap, etc) et le style (growth, value) expliquaient une portion significative de la différence en coupe croisée des rentabilités espérées des actifs (voir la première section de cette étude). De même, les secteurs de l'industrie sont des blocs de construction utiles pour définir des portefeuilles d'actions, puisque les différents secteurs de l'industrie ont des expositions différentes au cycle économique. La composition du portefeuille par style et par secteur ayant une influence directe sur les propriétés de risque et de rentabilité du portefeuille, cette décision requiert une attention majeure de la part des investisseurs.

Notre analyse a été motivée par le fait que l'indice est souvent vu comme une décision d'investissement neutre. Cependant, le choix d'un indice comme support d'investissement sous-entend le choix implicite d'une allocation, au lieu que ce choix soit fait de façon explicite. Notre objectif central est de qualifier le type de choix d'allocation, aussi bien par style ou par secteur, qui est fait dans un indice. Nous avons testé la stabilité des indices existants, à la fois en terme d'exposition aux styles d'investissement et aux secteurs industriels, et nous avons trouvé que le poids relatif des différents sous-indices variait de manière radicale au cours du temps.

Afin de résumer la façon dont les pondérations de style des indices de marché courants variaient au cours du temps, nous avons calculé le score de déviation de style. Ce score donne la variabilité moyenne des pondérations de style de chaque indice. La même étude a été réalisée avec les pondérations sectorielles.

Résumé

Score de déviation de style basé sur les expositions au style

	Score de déviation de style
Cac 40	4.2%
DAX 30	5.5%
FTSE 100	4.2%
DJ Euro Stoxx 50	4.9%
DJ Euro Stoxx 300	2.6%
DJ Stoxx 600	5.5%
Nikkei 225	17.6%
Topix 500	8.2%
S&P 500	2.3%
Russell 2000	11.0%
Dow Jones Industrials 30	26.0%

Les résultats pour les pondérations de style figurent sur les illustrations 4, 5 et 6 du document complet. Les chiffres montrent la variabilité des pondérations des graphes de la partie gauche des illustrations 4, 5 et 6 de l'étude complète. L'indicateur de déviation de style a été calculé suivant la méthode de Idzorek et Bertsch décrite dans le texte complet de l'étude.

Les pondérations sectorielles des indices de marché que nous avons analysés présentent aussi des variations spectaculaires au cours du temps. Alors que l'on peut s'attendre à ce résultat sur la période de l'étude qui couvre la bulle technologique et son éclatement, on constate que les variations des pondérations sectorielles sont aussi considérables durant les périodes où le marché des actions était relativement calme.

Scores de déviation sectorielle basés sur les capitalisations sectorielles

Zone géographique	Indice	Score de déviation sectorielle
Germany	Prime All Share Index 380	10.4%
United Kingdom	FTSE All Share Index 700	7.1%
Eurozone	DJ Euro Stoxx 300	7.2%
Europe	DJ Stoxx 600	6.6%
Japan	Topix 1666	7.0%
USA	S&P 500	7.3%

Ce tableau est basé sur les poids des capitalisations sectorielles présentés sur les illustrations 8, 9, 10, 11, 12, et 13 du document complet, pour la période allant d'octobre 1995 à septembre 2005. L'indicateur de déviation sectorielle est calculé suivant la méthode de Idzorek et Bertsch décrite dans le texte complet.

La variation des pondérations des secteurs à l'intérieur de l'indice de marché global est un problème pour l'investisseur. Cette instabilité sectorielle renforce le fait que l'allocation sectorielle est une décision implicite induite par le choix de l'indice, par opposition à un choix explicite que ferait l'investisseur. Ce choix implicite correspond à une « vue » sur les rentabilités des différents secteurs et nous affirmons que détenir l'indice de marché global n'est pas optimal pour l'investisseur, à moins que celui-ci partage les vues induites par les poids des capitalisations boursières des différents secteurs industriels.

Si nous considérons chaque indice de marché comme un portefeuille global, nous pouvons en déduire les vues implicites d'un investisseur représentatif. Pour extraire ces vues des pondérations des indices, nous avons utilisé le modèle d'allocation d'actifs de Black-Litterman. Nous montrons que les variations des pondérations relatives des capitalisations de marché des secteurs correspondent à une modification des rentabilités attendues du secteur correspondant. La vue du marché sur les rentabilités des différents secteurs peut en fait présenter des variations considérables. Ainsi l'éclatement de la bulle technologique, et la baisse correspondante du poids du secteur des technologies de l'information, correspond pour l'indice Euro Stoxx 300 au passage d'une anticipation de rentabilité de 17,40% à 13,70%. De telles variations ne sont pas surprenantes, sachant que les pondérations par les capitalisations boursières impliquent une stratégie de « trend following ». Lorsque le prix relatif d'un secteur progresse, son poids dans le portefeuille progresse aussi. L'augmentation des prix conduit ainsi de façon implicite à des espérances de rentabilités plus élevées. Investir dans l'indice signifie que l'on accepte ces vues, ce qui peut sembler contraire à l'intuition.

Résumé

Manque d'efficience

Comme indiqué ci-dessus, nous avons examiné l'efficience des indices de marché existants puisque le critère d'efficience est une des principales affirmations des fournisseurs d'indices pour établir que les indices pondérés par les capitaux sont un bon choix d'investissement.

Nous avons mesuré la distance en terme d'efficience entre l'indice de marché et ses alternatives. Ces alternatives étaient basées sur des portefeuilles de titres individuels, plutôt que sur des portefeuilles d'indices de style ou d'indices sectoriels, de façon à éviter le biais lié à l'utilisation d'un univers de titres qui aurait été différent pour les indices de style ou les indices sectoriels, par rapport à celui de l'indice de marché. La question de l'efficience des marchés se réduit à savoir si un investisseur peut obtenir un meilleur résultat que l'indice, en utilisant le même univers de titres, mais en ayant recours à un système de pondération différent de la pondération par les capitalisations boursières. Nous avons évalué deux systèmes de pondération : l'optimisation moyenne-variance et l'équipondération.

Notre conclusion indique que les indices de marché existants sont fortement inefficients comparés aux portefeuilles moyenne-variance optimaux. Nos résultats montrent que les indices se situent en dessous de la frontière efficiente. De façon intéressante, même une méthode de pondération simple, telle que l'équipondération des titres composant l'indice, conduit à des portefeuilles beaucoup plus efficients que les indices pondérés par les capitaux.

Les résultats obtenus pour les indices de marché commercialisés peuvent être résumés, en indiquant leur rang en terme d'efficience. Ce résultat figure dans la table suivante.

Classement d'efficience des indices

	Rang d'efficience (analyse moyenne variance)
Dow Jones Industrials 30	1
DJ Euro Stoxx 50	2
Cac 40	3
DAX 30	3
FTSE 100	5
S&P 500	6
Nikkei 225	7
Topix 500	7
DJ Euro Stoxx 300	9
DJ Stoxx 600	9
Russell 2000	11

Ces classements sont basés sur le rang d'efficience et sont directement issus de la table 15 du document complet.

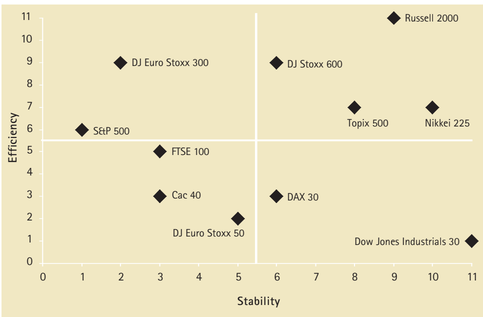
Le faible score d'efficience des indices pondérés par les capitaux n'est pas vraiment surprenant, étant donné que la méthode de pondération attribue de façon automatique des pondérations très élevées à seulement quelques composantes de l'indice, ce qui conduit à des portefeuilles concentrés sur un faible nombre de titres. En général, les dix à trente titres ayant la plus forte capitalisation boursière constituent la plus grosse part du poids de l'indice. Autrement dit, même si un indice a plus de 500 composantes, 90% de ses composantes constituent une part négligeable du poids de cet indice. De plus, comme le montre les changements spectaculaires des pondérations sectorielles, durant certaines phases, certains secteurs ont un poids dominant dans l'indice.

Il est intéressant de remarquer que le seul indice qui réussit une bonne performance est un indice qui n'est pas pondéré par les capitalisations boursières. Il s'agit de l'indice Dow Jones Industrials Average qui utilise la méthode de pondération par les prix. Bien que cette méthodologie fasse l'objet de sérieuses critiques, il semble que la pondération par les capitaux soit encore moins séduisante en terme d'efficience.

Résumé

Le graphique ci-dessous représente les indices suivant leur rang vis-à-vis des critères de stabilité du style et d'efficience. Ce graphique permet de visualiser le profil de chaque indice. Les indices situés dans le quart sud-ouest du graphe ont un bon classement, à la fois en terme d'efficience et de stabilité du style. Les indices situés dans le quart nord-ouest sont dans le bas du classement pour l'efficience, mais dans la moitié supérieure pour le critère de stabilité du style. De même, les indices dans le quart sud-est ne sont pas très performants en terme de stabilité du style, mais font partie des plus efficients. Enfin, les indices situés dans le quart nord-est ont de mauvais classements pour les deux critères.

Classement des indices



Ce graphique est basé sur le tableau 20 du document complet. Le classement obtenu pour le critère d'efficience apparaît sur l'axe vertical, tandis que le classement obtenu pour la stabilité du style apparaît sur l'axe horizontal. Les lignes de partage sont situées au rang de 5,5, qui correspond à la moyenne des rangs des 11 indices. Les classements sont basés sur la table 7 (section 2), pour le critère de déviation de style, et la table 15b (section 3), pour le critère d'efficience, du document complet. Les indices sont classés par ordre croissant vis-à-vis du score de déviation de style issu de la table 7.

Ce graphique montre bien qu'aucun indice ne domine vraiment les autres. L'indice S&P 500, par exemple, a le plus faible score de déviation de style, pour les pondérations de style obtenues à partir d'une analyse de style returns-based. Par ailleurs, lorsque la position de l'indice S&P 500 dans le plan moyenne-variance est comparée à celle des portefeuilles de la frontière efficiente, il n'obtient que le 6ème rang parmi tous les indices étudiés. De même, l'indice Dow Jones Industrial obtient le premier rang pour l'efficience, mais montre une variabilité prononcée des pondérations de style, conduisant à un rang de 11, le dernier rang parmi tous les indices, par rapport à ce dernier critère.

On constate également sur ce graphique, que les indices d'un même secteur géographique obtiennent des résultats très différents. Par exemple, pour le marché américain, le S&P 500 obtient un bon classement en terme d'efficience, mais se classe très mal en terme de stabilité d'exposition au style. L'indice Russell 2000 obtient un mauvais classement pour ces deux critères. Les indices européens ont également des profils assez différents, tandis que les indices japonais sont plus proches.

Les indices dont le classement est bon, à la fois en terme de stabilité et d'efficience, sont le CAC 40, le FTSE 100 et le DJ Stoxx 50. Ces indices se situent dans la moitié supérieure du classement des indices pour ces deux critères. Le plus séduisant semble être le CAC 40, qui se classe troisième pour les deux critères.

Conséquences et remèdes

Dans la dernière section de l'étude, nous présentons quelques conséquences sur les différentes étapes du processus de gestion, à savoir l'allocation d'actifs et la mesure de performance, des résultats obtenus aux sections empiriques de l'étude. Doit-on dire que les indices commerciaux sont des supports d'investissement qui doivent être purement et simplement évités par les investisseurs ? Nous pensons en fait que non, puisque nous avons des preuves que les indices commerciaux

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peuvent être utilisés comme des blocs de construction, permettant de définir des stratégies d'allocation efficientes.
Pour remédier tout d'abord au problème de l'exposition aux facteurs de risque qui varient au cours du temps, nous proposons de construire des portefeuilles de complétude qui neutralisent les déviations sectorielles de ces indices.
Une façon évidente de traiter le manque de stabilité est de construire des portefeuilles dont les pondérations sont constantes au cours du temps. Cependant, si l'investisseur choisit de construire un tel portefeuille lui-même, il va se priver des avantages que présentent l'investissement dans les grands indices de marché, à savoir les faibles frais de gestion, les faibles coûts de transaction, les faibles coûts de recherche d'information et une exécution simple des ordres. Pour cette raison, nous proposons de construire des portefeuilles de complétude qui permettent d'investir dans les grands indices de marché, tout en neutralisant les déviations sectorielles inhérentes aux indices. Nous nous sommes intéressés aux biais sectoriels plutôt qu'aux biais de style, car les poids des secteurs sont directement observables à partir de la capitalisation de marché des secteurs. L'analyse a été effectuée sur tous les indices pour lesquels nous avions auparavant fait l'analyse de stabilité sectorielle, en utilisant les mêmes données.
L'ajout du portefeuille de complétude permet de résoudre le problème de l'investisseur qui ne contrôle pas les expositions aux secteurs de son portefeuille. De plus, l'investisseur détient un portefeuille dont les pondérations restent fixes, à l'inverse de ce qui se produit dans une stratégie buy-and-hold.
Ces portefeuilles de complétude ont non seulement une exposition sectorielle plus stable, mais ils présentent aussi une performance plus favorable en terme de risque et de rentabilité. Ainsi, un investisseur qui recherche le meilleur profil risque-rentabilité pour son portefeuille peut tirer partie de la mise en œuvre d'une simple stratégie de neutralisation de son portefeuille, en détenant un indice global et un portefeuille de complétude composé d'indices sectoriels. Dans le même esprit, pour les besoins de la mesure de performance, un investisseur peut construire des benchmarks plus sophistiqués que l'indice général, en choisissant une combinaison d'indices. De tels benchmarks sont désignés sous le terme de « benchmarks sur mesure », pour souligner le fait qu'ils ne sont pas simplement constitués d'un indice général.

Le fait que les indices généraux présentent un manque d'efficience prononcé est peut-être le résultat le plus intéressant de cette étude. La solution que nous proposons pour les phases d'allocation d'actifs du processus d'investissement est de construire des portefeuilles efficients, en utilisant par exemple les indices sectoriels. Ces indices sectoriels peuvent servir de blocs de construction dans une procédure d'optimisation qui permet de s'affranchir des inconvénients des indices généraux. L'approche que nous proposons évite le risque d'estimation en s'intéressant au portefeuille de risque minimum et montre une amélioration significative de l'efficience dans un exercice out-of-sample.
Nos résultats montrent que la volatilité du portefeuille de variance minimum est toujours significativement plus basse que celle de l'indice de marché correspondant. Il est important de remarquer que cette dominance n'est pas obtenue par construction et ces portefeuilles peuvent être obtenus ex ante par un investisseur.
Il est frappant de remarquer que le risque plus faible du portefeuille de variance minimum ne

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conduit pas, pour cinq des six indices, à une espérance de rentabilité plus faible. Ceci se produit uniquement pour le portefeuille de variance minimum obtenu à partir des secteurs composant l'indice S&P 500. Tous les autres portefeuilles de variance minimum ont aussi des espérances de rentabilité plus élevées que celles de l'indice correspondant. Par conséquent, les ratios de Sharpe des portefeuilles de variance minimum montrent de fortes améliorations, comparés à ceux des indices de marché correspondant, à l'exception du S&P 500.

De l'utilité des indices actions

Alors que notre étude montre que les indices commerciaux posent de sérieux problèmes pour un investisseur qui désire les utiliser dans un processus d'investissement, ces inconvénients ne signifient pas nécessairement qu'un investisseur ne doit pas du tout utiliser d'indices. Bien au contraire, nous avons montré qu'il existe des remèdes simples aux problèmes des indices de marché commerciaux. Nous avons considéré ces solutions à la fois pour l'allocation d'actifs et la mesure de performance.

Pour conclure, nous pouvons dire que cette étude a identifié les nombreux problèmes des indices de marché commerciaux. En même temps, nous avons proposé un certain nombre de solutions pragmatiques à ces problèmes. Toutes ces solutions sont basées sur des indices qui représentent des sous-segments plus fins du marché d'actions, tels que les styles d'investissement ou les secteurs industriels. Le principal inconvénient des indices de marché généraux est peut être qu'ils impliquent une allocation confuse par sous-segments, plutôt que de permettre une définition précise et explicite de l'allocation d'actifs. Les indices de style et les indices sectoriels semblent des outils plus appropriés qui permettent aux investisseurs de gagner en contrôle sur le processus d'investissement, tout en se concentrant sur sa phase la plus rémunératrice qu'est la décision d'allocation d'actifs.

Zusammenfassung

Der Gebrauch von nach Marktkapital gewichteten Indizes wird häufig durch die zentrale Aussage der modernen Portfoliotheorie gerechtfertigt, dass die optimale Anlagestrategie für jeden Investor sei, ein Portfolio zu halten, welches nach dem Marktkapital ausgerichtet ist. Jedoch sollte dabei bemerkt werden, dass empirisch-statistische Tests zeigen, dass Marktindizes nicht effizient sind. Dies kann durch die Tatsache erklärt werden, dass diese Indizes eben nicht alle Werte einschließen, oder auch dadurch, dass die Theorie nicht ganz die Realität widerspiegelt. Man kann also daraus schließen, dass das nach Marktkapital gewichtete Portfolio nicht notwendigerweise die optimale Investitionsstrategie darstellt.

Zum Zwecke der Assetallokation und der Messung der Performance ist die Hypothese der Markteffizienz des Indexes von zentraler Bedeutung. Zudem nehmen Investoren typischerweise den Index als eine neutrale Wahl bezüglich des langfristigen Risikos war. Diese Bedingungen zeigen, dass die existierenden Indizes guter oder schlechter Qualität sein können, davon abhängig, inwieweit sie diese Kriterien erfüllen. Die vorliegende Studie beschäftigt sich mit dieser Qualitätsfrage und behandelt dabei eine Anzahl von bekannten Aktienmarktindizes.

Das Fehlen einer stabilen Abhängigkeit von Risikofaktoren

Wir führen eine empirische Studie durch um die Allokationsstabilität von existierenden Aktienmarktindizes zu untersuchen. Das Ziel ist es, die Entwickelung der Gewichtung in einer Reihe von breiten Marktindizes zu identifizieren. Wir führen diese Studie durch, da Investoren für den Teil ihres Portfolios, welches in Equity-Produkten investiert ist, typischerweise an Allokation in verschiedenen Subkategorien interessiert sind. Die relevantesten Unterkategorien für Equity-Investoren sind verschiedene Investmentstile, wie growth und value und Industriesektoren. Dies rührt daher, dass Marktkapitalisierung (large cap, small cap, usw.) und Investmentstil (growth und value) einen signifikant erklärenden Einfluss auf die Unterschiede der erwarteten Aktienrenditen haben (siehe Sektion eins der Studie). Desgleichen sind unterschiedliche Industriesektoren nützlich um Blöcke für das Equity-Portfolio zu konstruieren, da verschiedene Industriesektoren unterschiedlich auf die gesamtwirtschaftlichen Zyklen reagieren. Da die Zusammensetzung des Portfolios unter Bezugnahme des Investmentstils und der Industriesektoren einen direkten Einfluss auf das Risiko und den erwarteten Profit hat, erfordern Entscheidungen diesbezüglich größte Aufmerksamkeit des Investors.

Unsere Analyse wird durch die Tatsachte motiviert, dass ein Index oft als eine neutrale Investition gesehen wird. Jedoch impliziert die Wahl eines bestimmten Index als Investition eher eine Allokationsstrategie als diese explizit anzugeben. Unser Fokus liegt auf der Qualifizierung des Typus der Investmentstil- und Industriesektorallokationswahl, welche implizit durch die Investition in einen bestimmten Index vorgenommen wird. Wir testen die Stabilität von existierenden Indizes in Bezug auf die Aussetzung zu Investmentstil und den Industriesektoren und wir zeigen, dass das relative Gewicht von verschiedenen Subindizes drastisch über die Zeit variiert.

Um zusammenzufassen wie die Investment-stilgewichte von breiten Marktindizes mit der Zeit variieren, kalkulieren wir den Style Drift Score. Dieser ist ein Maß, der uns die Durchschnittsvariabilität der Gewichte der Industriesektoren beziehungsweise der Investmentstile für jeden Index angibt.

Zusammenfassung

Style Drift Score basierend auf dem Investmentstil

	Style Drift Score
Cac 40	4.2%
DAX 30	5.5%
FTSE 100	4.2%
DJ Euro Stoxx 50	4.9%
DJ Euro Stoxx 300	2.6%
DJ Stoxx 600	5.5%
Nikkei 225	17.6%
Topix 500	8.2%
S&P 500	2.3%
Russell 2000	11.0%
Dow Jones Industrials 30	26.0%

Ergebnisse fuer die Investmentstilgewichte, die in den Abbildungen 4, 5, 6 und 7 im vollstaendigen Dokument angegeben werden.

Die Gewichte der Sektoren in den Marktindizes, welche wir analysieren, zeigen ebenfall drastische Variabilität über die Zeit. Während dies erwartet werden kann (die von uns betrachtete Periode beinhaltet das Wachsen der Internetblase und ihr Platzen), überrascht, dass sogar in eher ruhigen Perioden der Märkte die Variationen in den Sektorgewichtungen bemerkenswert stark ausfallen. Die folgende Tabelle zeigt die Sector Drift Score, welche analog zu den Style Drift Scores berechnet werden.

Sector Drift Score basierend auf Markapitalisierung der Sektoren

Geographical Zone	Index	Sector Drift Score
Germany	Prime All Share Index 380	10.4%
United Kingdom	FTSE All Share Index 700	7.1%
Eurozone	DJ Euro Stoxx 300	7.2%
Europe	DJ Stoxx 600	6.6%
Japan	Topix 1666	7.0%
USA	S&P 500	7.3%

Basiert auf den Gewichten der Marktkapitalisierung der jeweiligen Sektoren in den Abbildungen 8, 9, 10, 11, 12, und 13 des kompletten Dokuments. Die Sektorengewichte basieren auf den Marktkapitalisierungen zwischen Oktober 1995 und September 2005. Der Style Drift Indicator wird berechnet nach der Methode von Idzorek und Bertsch, welche im vollstaendigen Text beschrieben wird.

Die Variationen der Gewichte der unterschiedlichen Sektoren im Gesamtmarktindex führen zu einem Problem für den Investor. Die Sektorinstabilität zeigt deutlich die Tatsache, dass die Sektorallokation eine implizite Entscheidung wird, vom Index gelenkt, und keine explizite Entscheidung des Investors mehr darstellt. Wir zeigen, dass diese implizite Entscheidung zu einer Ansicht der Gewinne der verschiedenen Sektoren korrespondiert, und wir argumentieren, dass das Investieren in einen Gesamtmarktindex nicht optimal für einen Investor ist, solange er nicht genau diese Ansichten, hinsichtlich der Marktkapitalgewichtung der verschiedenen Industriesektoren, welche durch den Markt implizit gegeben sind, teilt.

Wenn wir annehmen, dass jeder Marktindex ein Gesamtmarktportfolio darstellt, dann können wir dadurch auf die impliziten Ansichten des repräsentativen Investors schließen. Wir benutzen das Assetallokationsmodel von Black-Litterman um diese Ansichten aus den Indexgewichten abzuleiten. Wir zeigen, dass die Variationen der relativen Marktkapitalisationsgewichte der Sektoren zu einer Modifikation der erwarteten Gewinne korrespondieren. Wir sehen, dass die Ansicht des Marktes bezüglich der Gewinne der verschiedenen Sektoren beachtlich variieren kann. Demnach korrespondiert das Platzen der Technologieblase und der Verringerung der Gewichte der Informationstechnologie einem Wechsel der Ansichten von 17,40% bezüglich der Gewinne zu 13,7% des Euro Stoxx 300 Index. Solche Variationen mögen vielleicht nicht überraschend sein, gegeben dass das Gewichten nach Marktkapitalisierung bedeutet, einem Trend zu folgen. Wenn der relative Preis eines Sektors steigt, steigt das Gewicht dieses Sektors im Portfolio. Implizit führen steigende Preise zu höheren Gewinnerwartungen.

Zusammenfassung

Investieren in den Index heißt diese Ansicht zu akzeptieren, was eventuell nicht intuitiv erscheint.

Mangelnde Effizienz

Wie oben bemerkt untersuchen wir die Effizienz von existierenden Aktienmarktindizes, da laut den Indexanbietern gerade das Effizienzargument eine Investition in Indizes als eine gute rechtfertigt.

Wir untersuchen die Effizienzabstände zwischen Marktindizes und ihren Alternativen. Diese Alternativen basieren auf Portfolios, die einzelne Aktien enthalten, in Gegensatz zu Portfolios die Indizes verschiedener Investmentstile oder Industriesektoren enthalten. Der Grund hierfür ist, dass eine Verzerrung zwischen den Alternativen und den Markindizes vermieden werden soll, welche daraus resultieren könnte, das man aus unterschiedlichen Aktien auswählt. Die Frage nach der Effizienz gleicht letztendlich der Frage, ob ein Investor bessere Resultate erzielen kann, wenn er in die gleichen Aktien investiert, diese aber anders gewichtet, als es der marktkapitalgewichtete Index tut. Wir untersuchen im speziellen zwei Gewichtungsschema: die Mittelwert-Varianz Optimierung und die Gleichgewichtung.

Wir stellen fest, dass die von uns untersuchten existierenden Aktienindizes in hohem Maße ineffizient sind, verglichen mit dem Mittelwert-Varianz Portfolio, da wir zeigen, dass die Indizes unterhalb der efficient frontier liegen. Interessanterweise führt sogar ein simples Gewichtungsschema, wie das Gleichgewichtungsschema der vorhandenen Aktien, zu einem effizienteren Portfolio als das Marktkapitalgewichtungsschema.

Wir können die Resultate für die existierenden Aktienmarktindizes zusammenfassen, indem wir ihre Ränge im Hinblick auf ihre Effizienz darstellen. Diese Resultate sind in der folgenden Tabelle dargestellt.

Effizienzränge der Indizes

	Rang der Effizienz (aus der Mittelwert-Varianz-Analyse)
Dow Jones Industrials 30	1
DJ Euro Stoxx 50	2
Cac 40	3
DAX 30	3
FTSE 100	5
S&P 500	6
Nikkei 225	7
Topix 500	7
DJ Euro Stoxx 300	9
DJ Stoxx 600	9
Russell 2000	11

Diese Rangliste basiert auf den Rängen der Effizienz und ist direkt der Tabelle 15 b des kompletten Dokumentes entnommen.

Die niedrige Effizienzwertung der nach dem Marktkapital gewichteten Indizes ist vielleicht nicht überraschend, da diese Gewichtungsmethode mechanisch zu einer Konzentration auf einige wenige Aktien führt. Üblicherweise ist die Mehrheit des Indexes durch die zehn bis 30 größten Aktien abgebildet. Anders ausgedrückt: Selbst wenn ein Index aus mehr als 500 Komponenten besteht, so machen doch 90% dieser Komponenten einen fast zu vernachlässigenden Teil aus. Zudem wird durch die dramatischen Veränderungen der Industriesektorgewichte zu bestimmten Zeitpunkten gezeigt, dass bestimmte Sektoren ein dominierendes Gewicht im Index haben.

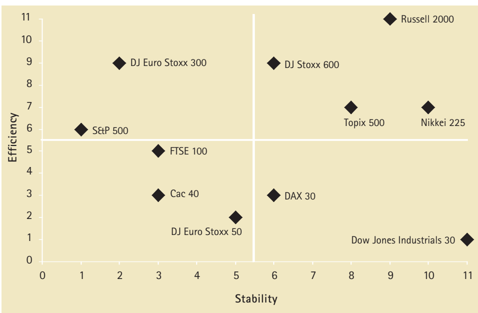
Interessant ist, dass der Index mit der besten Performance derjenige ist, der als einziger nicht nach dem Marktkapital gewichtet ist. Die Zusammenfassung des Dow Jones Industrials Average beruht auf einem Gewichtungsschema, welches auf Preisen basiert. Obwohl diese Methodologie harsche

Zusammenfassung

Kritik erregt, scheint eine Gewichtung, die auf das Marktkapital zurückgreift, zu noch weniger Effizienz zu führen.

Die untere Abbildung verdeutlicht die Ausprägungen der Indizes bezüglich zwei ihrer Charakteristika: Der Stabilität des Investmentstils und die Effizienz des jeweiligen Indexes. Die Indizes im unteren linken Viertel der Graphik haben einen hohen Rang im Hinblick auf Stabilität und Effizienz, die Indizes im oberen linken Viertel haben einen niedrigen Rang in Bezug auf die Effizienz, aber sind in der oberen Hälfte bezüglich der Stabilität des Investitionsstil. Analog haben die Indizes im unteren rechten Viertel einen schlechten Rang im Hinblick auf die Effizienz, aber weisen eine hohe Stabilität ihres Investmentstils auf. Schließlich sehen wir die Indizes im oberen rechten Viertel, die weder gemäß ihre Effizienz noch in Hinblick auf das Stabilitätskriterium zu überzeugen vermögen.

Ränge der Indizes



Diese Abbildung basiert auf Tabelle 20 des kompletten Dokumentes. Auf der vertikalen Achse ist der Rang des Effizienzkriteriums eingetragen, auf der horizontalen Achse der des Investmentstilkriteriums. Die Linien im Zentrum korrespondieren zu dem Rang 5,5, welche den Mittelwertrang der 11 Indizes darstellt. Die Ränge basieren auf Tabelle 7 (zweite Sektion) und Tabelle 15 b (dritte Sektion des kompletten Dokuments). Die Indizes sind aufsteigend geordnet nach dem Style Drift Score der Tabelle 7. Die Ränge für die Effizienz sind direkt der Tabelle 15 b des kompletten Dokumentes entnommen.

Diese Abbildung zeigt recht augenfällig, dass es keinen Index gibt, der eindeutig die anderen dominiert. Wenn wir zum Beispiel den S&P 500 betrachten, so sehen wir, dass dieser den niedrigsten Style Drift Score aufweist, basierend auf einer Gewinnbasierenden Investmentstilanalyse. Jedoch, wenn wir uns den Rang des S&P 500 bezüglich seiner Effizienz anschauen, so bemerken wir, dass er nur den sechsten Rang zwischen all betrachteten Indizes erreicht. Gleichsam verhält es sich mit dem Dow Jones Industrial Index. Dieser erhält den ersten Platz gemäß seiner Effizienz, aber weist eine hohe Variabilität bezüglich der Investmentstilgewichte auf, so dass er für dieses Kriterium den elften und damit letzten Rang erreicht.

Ebenfalls bemerken wir, dass Indizes, die dieselbe Region abdecken, unterschiedliche Profile in dieser Grafik erhalten können. Wenn wir den amerikanischen Aktienmarkt betrachten so sehen wir, dass der S&P 500 gut in Bezug auf das Stabilitätskriterium abschneidet, jedoch schwach bezüglich der Effizienz. Mit dem Dow Jones Industrial verhält es sich genau umgekehrt, da dieser recht effizient erscheint, jedoch leidlich abschneidet in Hinblick auf die Stabilität. Der Russell 200 Index schneidet sogar in Hinblick auf beide Kriterien schlecht ab. Der Eindruck für die verschieden europäischen Indizes ist, dass diese ähnlich weit gestreut sind, wohingegen die betrachteten japanischen Indizes enger zusammen liegen.

Der CAC 40, der FTSE 100 und der DJ Stoxx 50 schneiden in Hinblick auf beide Kriterien recht gut ab, was dadurch deutlich wird, dass sie sich für beide Kriterien in der jeweiligen oberen Hälfte befinden. Der attraktivste Index scheint demnach der CAC 40 zu sein, der für beide Kriterien den dritten Platz erreicht.

Zusammenfassung

Implikationen und Lösungen

Im letzten Teil dieser Studie zeigen wir einige Implikationen für die verschiedenen Etappen des Investmentprozesses, insbesondere der Assetallokation und der Bewertung der Performance, welche aus den empirischen Resultaten folgen. Die Frage die sich uns stellt ist die folgende: Kann man aus dem bisher gezeigten schließen, dass kommerzielle Indizes suboptimale Investitionen darstellen, die vom Investor generell gemieden werden sollten? Wir glauben, dass dies nicht der Fall ist, da wir Anhaltspunkte dafür finden können, dass kommerzielle Indizes als Bausteine benutzt werden können, um effiziente Allokationsstrategien auszuführen.

Um dem Problem begegnen, dass wir zeitvariiernden Risikofaktoren ausgesetzt sind, schlagen wir vor completeness portfolios zu konstruieren, die die Sektorverzerrungen eines Indexes neutralisieren.

Eine offensichtliche Möglichkeit dem Problem der fehlenden Stabilität Herr zu werden ist das benutzen von Portfolios, welche konstante Gewichte im Verlauf der Zeit haben. Falls der Investor sich jedoch dazu entschließt ein solches Portfolio selbst zu gestalten, wird er einige Vorteile, die das Investieren in breite Aktienmarktindizes mit sich bringt, nicht nutzen können (wie zum Beispiel niedrige Gebühren, einfache Implementierung der Orders). Deshalb schlagen wir vor, completeness portfolios zu konstruieren, die es einerseits erlauben in einen breiten Aktienmarktindex zu investieren und gleichzeitig die inhärenten Sektorverschiebungen neutralisieren. Wir konzentrieren uns auf Industriesektorverzerrungen (mehr als auf Investmentstilverzerrungen), da Sektorverzerrungen direkt aus der Marktkapitalisierung heraus sichtbar sind. Wir führen diese Analyse für all die Portfolios aus, für die wir weiter oben bereits die Sektorstabilitätsanalyse ausgeführt haben, und benutzen dazu dieselben Daten.

Das Hinzufügen eines completeness portfolio löst das Problem des Investors, nicht die Kontrolle über die Aussetzung seines Equity-Portfolios zu bestimmten Sektoren zu haben. Zudem hält der Investor ein Portfolio, welches die Gewichte konstant hält, im Gegensatz zu einer Kaufen-und-Halten Strategie.

Diese completeness portfolios haben nicht nur eine stabilere Aussetzung zu den Sektoren, sie verfügen außerdem noch über eine bessere Performance in Bezug auf Risiko und Gewinn. Ein Investor, der das für sich interessanteste Risiko/Gewinn Profil für sein Portfolio sucht, könnte also von einer einfachen Neutralisationsstrategie für sein Portfolio profitieren, indem er einen Gesamtmarktindex hält und zusätzlich ein completeness portfolio, welches aus Sektorenindizes besteht. Für die Messung der Performance kann ein Investor im gleichen Sinne eine Benchmark konstruieren, die elaborierter als ein Gesamtmarktindex ist, indem er eine Kombination aus verschiedenen Indizes wählt. Solche Benchmarks werden im Sprachgebrauch als customised benchmark bezeichnet, um den Unterschied mit einem Gesamtmarktindex hervorzuheben.

Die Tatsache, dass es Gesamtmarktindizes bei weitem an Effizienz mangelt, ist vielleicht das interessanteste Resultat dieser Studie. Die von uns vorgeschlagene Lösung für die Assetallokationsphase im Investmentprozess besteht darin, effiziente Portfolios zu konstruieren, zum Beispiel unter Benutzung industriesektorieller Indizes. Diese sektoriellen Indizes können als Bausteine in der Optimisationsprozedur benutzt werden, die es uns erlaubt, die negativen Aspekte eines Gesamtmarktindexes zu umgehen. Die von uns

Zusammenfassung

vorgeschlagene Herangehensweise vermeidet das Schätzen von Risiken, indem wir uns auf das Portfolio mit dem minimalen Risiko konzentrieren. Zudem zeigen wir, dass unser Ansatz eine signifikante Effizienzsteigerung mit sich bringt, was wir aus dem Ergebnis eines out-of-sample Test entnehmen können.
Unsere Ergebnisse zeigen, dass die Volatilität des Minimum-Varianz-Portfolios immer signifikant niedriger ist als die des korrespondieren Marktindex. Diese Dominanz wird nicht alleine durch Konstruktion erreicht, was wichtig zu bemerken ist, da dies impliziert, dass es ex-ante für einen Investor möglich ist solch ein Portfolio zu konstruieren.
Für fünf von sechs Indizes führt das Minimum-Varianz-Portfolio nicht zu einem niedrigeren erwarteten Gewinn, was wir für bemerkenswert halten. Einzig für das Minimum-Varianz-Portfolio, welches aus den Sektoren des S&P 500 besteht, ist dies der Fall. Alle anderen Minimum-Varianz-Portfolios haben höhere erwartete Gewinne als der jeweils korrespondiere Index. Konsequenterweise sehen wir eine beachtliche Verbesserung der Sharp-Ratios bezüglich der Marktindizes, bis auf den Fall des S&P 500.

Über die Brauchbarkeit von Equity-Indizes

Während unsere Resultate zeigen, dass das Benutzen von kommerziellen Indizes den Investor vor ernsthafte Herausforderungen im Investmentprozess stellt, bedeutet dies nicht, dass der Investor diese Indizes komplett meiden sollte. Im Gegenteil haben wir gezeigt, dass es klare Lösungen gibt für das Verwenden von kommerziellen Aktienmarktindizes. Wir haben solche Lösungen sowohl für die Assetallokation als auch für die Messung der Performance betrachtet.
Zusammenfassend können wir sagen, dass die vorliegende Studie verschiedene Probleme von kommerziellen Aktienmarktindizes behandelt. Gleichzeitig schlagen wir verschiedene pragmatische Lösung dieser Probleme vor. All diese Lösungen basieren auf Indizes die feinere Untersegmente der Equity-Märkte repräsentieren, wie die der Investmentstile und der Industriesektoren. Das Hauptproblem mit einem Gesamtmarktindex mag darin liegen, dass die Allokation in die einzelnen Untersegmente verschwommen ist, eine präzise und klar definierte Allokation der Assets wird nicht vorgenommen. Sektorielle Indizes und Investmentstilindizes scheinen geeignete Werkzeuge für den Investor zu sein, die es ihm erlauben, seinen Investmentprozess zu kontrollieren, während er sich auf die am meisten lohnende Phase konzentrieren kann, nämlich die der Allokationsentscheidung.

Assessing the Quality of Stock Market Indices: Requirements for Asset Allocation and Performance Measurement

Introduction

There is an extremely large number of stock market indices. In recent years, the number of indices developed by various providers has increased significantly. Numerous investment products are based on such indices, as is the case for index funds (exchange-traded or not), options and futures. Indices are also used as benchmark portfolios by investment managers, both for asset allocation and performance measurement purposes.

The use of market indices as benchmarks is still widespread despite numerous initiatives related to the creation of customised benchmarks, or normal portfolios, more suited to reflect the allocation policy of the funds. In most cases, these broad stock market indices are not good benchmarks. This is because, on the one hand, they are not representative of all risks supported by the portfolio and, on the other hand, because they are not built to be efficient.

In addition to using an index in performance measurement, it is common for investors to use such constructs in their investment decision making. This either takes the form of finding an optimal allocation between different indices, or even of passively holding a single index, which is supposed to be well diversified. This latter strategy is often justified by a central conclusion of modern portfolio theory – that the optimal investment strategy for any investor is to hold the market portfolio.

It should however be noted that this conclusion is the result of investors using mean-variance portfolio analysis applied to the same universe of securities, for the same time horizon and with the same expectations from these securities. Under these assumptions, all investors hold the same portfolio of risky assets, leveraged up or down by holdings in a riskless asset. This portfolio is that of the efficient frontier located at the tangency point with the capital market line. The fact that all investors hold the same assets in the same proportions and that all the available assets must be held in equilibrium shows that investors hold a share of the market portfolio. The market portfolio is made up of the aggregation of all individual investors' risky portfolios, which represent the entire wealth of the economy. The proportion of each stock in the market portfolio is equal to the market value of the stock divided by the sum of the market value of all stocks.

While this strong theoretical conclusion is appealing, it should be noted that it relies on stringent assumptions, notably identical expectations of investors. In addition, the market portfolio cannot be equated with a commercial stock market index, since – by definition – it represents the entire wealth in the economy and includes all assets, including human capital for example. These remarks suggest that there is sufficient motivation to analyse the question of a good index in much more detail, rather than simply deferring to modern portfolio theory as a justification of the use of indices.

For both practical purposes of an index (its use in asset allocation and in performance measurement), certain qualities are required from the indices that are used. For example, a central assumption behind using an index as an investment choice is that the index is an efficient portfolio. In addition to its efficiency, the investor typically perceives the index to be a neutral choice of long-term risk factor exposure. Furthermore, in performance measurement, the index used is supposed to reflect fully and accurately the systematic risks to which the managed portfolio is exposed.

Introduction

These requirements mean that the existing indices may be of good or bad quality, depending on the degree to which they fulfil the requirements. Given the abundance of indices and index providers, a natural question for an investor to ask is which index to choose. This survey addresses the question of the quality of stock market indices.

First, in order to define what a good index is, we provide an overview containing a review of the existing literature (both academic and professional), as well as an analysis of the index industry. This allows us to situate the reasoning behind index construction and indexed investing within the context of financial theory. In addition, this section provides an overview of the current landscape within the index industry. In the following two sections, we complement this general overview by a detailed analysis of two questions relating to the quality of stock market indices. In section two, we conduct an empirical study assessing the stability of the allocations of existing indices. This section is motivated by the fact that the index is often viewed as a somewhat neutral investment decision. Section three continues the empirical study by examining the efficiency of existing stock market indices, since efficiency corresponds to the second major claim for indices to be a good investment choice. In the fourth and final section, we show some implications of the results from the empirical sections for different stages of the investment process, namely asset allocation and performance measurement. After having shown the implications of the limits of existing stock market indices, we propose some remedies to the problems identified.

1. Problem Outline

1.1 Indices in the Finance Literature

In this review of the existing literature, we will first look at the academic writings available on the topic of index construction. We start with the theoretical bases that led to the predominance of the market portfolio in both performance measurement and portfolio allocation. After this review of the basic concept, we will outline the criticism that the market portfolio has faced and the alternatives that have been proposed in the literature reviewed. In addition to the academic literature, we look at the market for indices and give an overview of different indices and their market share.

1.1.1 The market portfolio in financial theory

Importance of the market portfolio

According to classic portfolio theory, the optimal investment strategy for any investor is to hold the market portfolio. The theory's central conclusion is that this portfolio constitutes the best possible investment choice, and thus is efficient. From a theoretical point of view, the market portfolio is made up of the aggregation of all individual investors' risky portfolios, which represent the entire wealth of the economy. The proportion of each stock in the market portfolio is equal to the market value of the stock divided by the sum of the market values of all stocks. According to the CAPM (Capital Asset Pricing Model) derived by Sharpe (1964), investors all desire to hold the same optimal portfolio, and asset weights in this optimal portfolio are equal to those of the market portfolio.

It should be noted that this is the result of investors using identical Markowitz analysis applied to the same universe of securities, for the same time horizon and with the same expectations from these securities. This optimal portfolio is that of the efficient frontier located at the tangency point with the capital market line. The optimal risky portfolio of all investors is a share of the market portfolio. In order for the market to be in equilibrium, all the available assets must be held in portfolios. The price adjustment process therefore guarantees that all stocks will be included in the optimal portfolio.

As investors can obtain an efficient portfolio simply by holding the market portfolio, the passive strategy of investing in a market index portfolio is efficient. If everyone holds an identical risky portfolio, then everyone will agree on the appropriate risk premium for each asset. Market capitalisation portfolio weights are optimal for an investor using a mean-variance approach with equilibrium expected returns. These equilibrium expected returns are those drawn from the CAPM (or single index model), which establishes that the returns on assets, less the risk-free rate, are linearly related to the return on the market portfolio, in proportion to the asset risk.

Formally, if one assumes that the market is in equilibrium, all assets are held in investors' portfolios and the market portfolio is a convex combination of investors' individual portfolios. Assuming there are n assets on the market, the weight of the asset i in the market portfolio is:

$$w_i = \frac{N_i P_i}{\sum_{i=1}^{N} N_i P_i}$$

therefore

$$\sum_{i=1}^{N} w_i = 1$$

where P_i is the price of asset i and N_i is the quantity of asset i available on the market.

In equilibrium, the market portfolio will consist of all marketable assets held in proportion to

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their value weights: the proportion of each stock in the market portfolio equals the market value of the stock (price per share multiplied by the number of shares outstanding) divided by the total market value of all stocks. It is not theoretically clear which assets (for example, human capital) can legitimately be excluded from the market portfolio. Roll (1977) demonstrates that the market, as defined in the theoretical CAPM, is not a single equity market, but an index of all wealth. Indeed, the true market portfolio must be comprised of all risky assets, including those that are not traded. The market index must include bond, property, foreign assets, human capital and anything else, tangible or intangible, that adds to the wealth of mankind.

The true market portfolio is not observable

As it is not possible to measure returns on all these assets, the true market portfolio is not observable or measurable. It should therefore be approximated in practice (see Peirson et al., 1995). Data availability substantially limits the assets that are included in the approximation of the market portfolio. For simplicity, we generally refer to all risky assets as stocks, and broad-based market indices are used as proxy for the market portfolio. But these indices are not identical to the actual market portfolio and may sometimes constitute very imperfect proxies.

Concerning international investment, it has been stressed by Roll (1977) and many others that the world portfolio is untradable, and so the return on this portfolio is unobserved. Not only are there currently no markets to trade claims on human capital, but there are also no international liquid markets for claims on housing, social security wealth, and other assets that together account for a large part of individuals' wealth.

Since the market portfolio is not observable, a practical problem is how best to approximate this portfolio.

Academic literature provides us with examples of market portfolio proxies that have been used to test the CAPM. Shanken (1987) and Kandel and Stambaugh (1987) all argue that, even though the stock market is not the true market portfolio, it must nevertheless be highly correlated with the true market portfolio. Another response to the Roll critique is the use of proxies that include broader sets of assets such as bonds and property. However, Stambaugh (1982) finds that even when bonds and real estate are included in the market proxy, the CAPM is still rejected. Shanken (1987) uses a multivariate proxy for the true market portfolio, consisting of an equally weighted stock index and a long-term government bond index, to investigate the Sharpe-Lintner CAPM. The Fama and French market portfolio is a value-weighted average of all NYSE, AMEX and Nasdaq stocks.

Frankfurter (1976) deals with the problem of constructing a proxy for the market portfolio. Frankfurter argues that the proxy for the market portfolio has not yet been seriously studied from the point of view of its effect on the Sharpe model. In his paper, Frankfurter compares and contrasts the quality of three different stock market indices used in place of the market portfolio. He chooses the Dow Jones Industrial Averages (DJIA) to represent narrow base and (almost) equal weight indices, the Standard and Poor's 425 Industrial (S&P) to represent (relatively) large base, weighted, arithmetic mean indices and a Geometric Mean Index (GMI) that is market value-weighted and constructed specially for the universe of his population. It is believed that the DJIA would be the "poorest" proxy of the market factor.

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Frankfurter tests the hypothesis that dissimilar indices (with respect to their construction) will produce different portfolios when used as proxy for the "common factor" in the Sharpe portfolio selection model. He concludes that efforts should be made to create a "common factor" which is more "common" to the universe of interest than those which are readily available.

Ibbotson and Fall (1979) point out that an index made up of the main asset categories may not be considered an optimal market portfolio, as some assets, such as human capital and consumer durables, are left out while others might be overstated.

Kochman and Badarinathi (1981) found statistically significant differences among beta values for the same stock after regressing monthly stock returns on the seven most popular stock averages.

Kochman (1984) underlines that even if market indices that serve as a proxy for the market portfolio are highly positively correlated, this does not mean that they can be substituted for one another without consequences for portfolio management. According to him, the reliability of beta varies, depending on the indices used, and stock alpha may be in part a function of the market proxy. In particular, lower alphas seem connected to broader market indices. The three different market indices used in his study were the Standard & Poor's 500, the Dow Jones Industrial Average and the New York Stock Exchange Composite.

Following Mayer (1972), Elton and Gruber (1984) present non-standard CAPM forms for cases where there are missing and non-marketable assets. In the case of missing assets, the true market portfolio return is a weighted average of the return on the misestimated market portfolio and the missing assets.

$$r_M' = \frac{P_M}{P_H + P_M} r_M + \frac{P_H}{P_H + P_M} r_H$$

where r'_M is the true market return, i.e., the return on all assets;

r_M is the return on those assets which have been included in the incomplete definition of the market portfolio;

r_H is the return on those assets which have been inappropriately excluded from the definition of the market portfolio;

P_M is the market value, at the beginning of the period, of all assets included in the incomplete definition of the market portfolio;

and P_H is the market value, at the beginning of the period, of all assets inappropriately excluded from the market portfolio.

In the case of non marketable assets:

$$r_M' = \frac{\sum_i W_i r_{pi}}{\sum_i W_i}$$

where r'_M is the return on the aggregate of all risky assets including non-marketable assets;

r_{pi} is the return on investor i's optimum portfolio which includes marketable and non-marketable assets;

and W_j is the dollars of wealth which investor i will place in risky assets, including non-marketable risky assets.

Green (1986) evaluates the robustness of the Security Market Line relationship when the market proxy employed is not mean-variance efficient. He shows that, for any inefficient proxy portfolio, there are two other proxies arbitrarily close in mean-variance space, and two associated zero-beta rates arbitrarily close to each other, which exactly reverses the relative rankings of all returns.

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Lehman and Modest (1987) performed an empirical study to provide evidence of the sensitivity of commonly used mutual fund performance measures to the choice of benchmark. They employed the standard CAPM benchmarks, using the standard market proxies (the CRSP (Center for Research in Security Prices) equally weighted and value-weighted indices of NYSE stocks taken from the CRSP monthly index file) and a variety of APT (Arbitrage Pricing Theory) benchmarks. More specifically, Lehman and Modest examine whether different methods for constructing APT reference portfolios lead to different conclusions about the relative performance of mutual funds. They found that the Jensen measures and Treynor-Black appraisal ratios of individual mutual funds are quite sensitive to the method used to construct the APT benchmarks. There are considerable differences between the performance measures yielded by the standard CAPM benchmarks and those produced with the APT benchmarks. Moreover, the rankings are not insensitive to the method used to construct the APT benchmarks. They concluded by highlighting the importance of the choice of the benchmark for evaluating the performance of managed portfolios, as different benchmarks do not yield similar results.

Brown and Brown (1987) consider six different market proxies and use them to evaluate the performance of several portfolios. The market indices they constructed are based on the major classes of securities: common stocks, including NYSE, AMEX, and OTC equities; fixed-income corporate issues, including preferred stocks, intermediate and long-term bonds, and commercial paper; real estate, including the USDA aggregate market value of farm investments and residual housing aggregate values (excluding urban land values) assembled from estimates of net rental yields and an index of capital appreciation; United States government issues, including Treasury bills, notes, and bonds, as well as government agency securities; and municipal bonds, including both state and local, and short- and long-term bonds. Brown and Brown consider that these five categories of assets do measure the most identifiable and liquid of the capital market securities and that these assets correspond to the set of opportunities available to the vast majority of investors. Thus, they enable a reasonable representation to be made of the investment market. They construct the six indices in the following way: the first was made up of common stock; the second of index 1 plus fixed-income corporate issues; the third of index 2 plus real estate; the fourth of index 3 plus United States government issues; the fifth of index 4 plus municipal bonds; and the sixth of index 5 less common stocks.

Brown and Brown observed that only the five indices that contained common stocks provide any significant explanation for movements in the mutual fund yields. Thus, a market portfolio without stock is worthless for measuring the performance of funds investing primarily in corporate securities. Moreover, the indices including real estate produce different inferences from those without real estate. In particular, the average level of Jensen's alpha is not significant when real estate is left out, but the alpha is significantly negative otherwise. This is the consequence of the dramatic decrease in risk when real estate is added to the market portfolio. In addition, the average level of beta is far different for the two index groups. This demonstrates the importance of the choice of a suitable market portfolio proxies, in relation to the kind of assets evaluated. This conclusion is in accordance with that of Stambaugh (1982). Finally, using the six

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different indices, they found substantially similar rankings but different abnormal investment performance.

Empirical tests dealt with in the literature reviewed mostly adopted value-weighted proxies for the market portfolio. However, Haugen and Baker (1991) show that cap-weighted stock portfolios are inefficient investments. In order for them to be efficient, a certain number of assumptions must be true, including the following: all investors agree about the risk and expected return for all securities; all investors can short-sell all securities without restriction; no investor's return is exposed to federal or state income tax liability now in effect; and the investment opportunity set for all investors holding any security in the index is restricted to the securities in the cap-weighted index. According to Haugen and Baker, if these assumptions are not true, even the most comprehensive cap-weighted portfolios will occupy positions inside the efficient set.

The Wilshire 5000 is the most comprehensive cap-weighted index of the U.S. equity population. The existence of an income tax on investment returns further drives the cap-weighted index to a position of relative inefficiency. Investors differ in their exposure to federal taxes. A portfolio that is after-tax efficient for one investor will be inefficient for another, and the cap-weighted aggregate of these portfolios is unlikely to be efficient for a pension fund that pays no taxes. The existence of alternative investments that are not included in the market index also contributes to its inefficiency. One important factor for the vast majority of investors is their human capital (the present value of future earned income). Rational investors will take positions that are efficient with respect to their human capital. An equity portfolio that makes sense to one investor will appear inefficient to another when viewed out of context. Cap-weighted combinations of these financial investments are unlikely to be efficient investments. Foreign investors investing rationally do not build portfolios of U.S. securities that are efficient relative to the U.S. opportunity set. Rather, they will invest in securities that combine well with their domestic investments and their investments in other countries. Nevertheless their holdings of U.S. securities are a significant component of the Wilshire 5000 index, contributing to its inefficiency relative to the U.S. opportunity set.

Haugen and Baker perform an empirical test on the efficiency of the Wilshire 5000 index, which is the most comprehensive cap-weighted index. The evidence supports the hypothesis that investment opportunities existed from 1972 through to 1989 to build equity portfolios with equal or greater return but significantly lower volatility than cap-weighted portfolios in general and, in particular, than the most comprehensive capitalisation-weighted portfolio, a result that is fully consistent with established theoretical arguments. Market-matching to domestic cap-weighted stock indices is likely to be a sub-optimal investment strategy when investors disagree about risk and expected return, when short-selling is restricted, when investment income is taxed, when some investment alternatives are not included in the target index or when foreign investors are in the domestic capital market. In the presence of these factors, there will be alternatives to cap-weighted portfolios that have the same expected return but lower volatility. This will be true even in the context of an efficient market where all investors take

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efficient mean-variance positions within the context of their individual tax exposure and within the context of the constraints placed on their portfolio weights, including the required investment in their human capital.

Concerning international investment, one might think of the market portfolio as including all capital assets in the world, each in proportion to its market value. According to Ibbotson and Siegel (1983), the world market wealth portfolio is defined to include those "capital market securities that are most marketable and most readily identifiable […] the securities that make up the opportunity set faced by most investors". Many problems are associated with the construction of a portfolio designed to represent a single market. Ibbotson and Siegel indicated that it is almost impossible to represent all investment markets. They explain that they have left huge categories out of the portfolio, while at the same time they have included categories that are not wealth at all. The most important omission is human capital, which is probably the largest simple component of world wealth. They have also excluded foreign real estate, proprietorships and partnerships, many small corporations and personal holdings such as automobiles, cash balances and various consumer capital goods. They have not only omitted a large proportion of wealth, but they also have little idea as to how large the omitted proportion is.

Athanasoulis and Shiller (2000) drop the highly unrealistic assumptions of the CAPM that all risks are tradable and that all agents have some non-stochastic stock of wealth which they invest; they include in their model non-financial endowments such as labour income. They agree with Roll that the returns on the world portfolio are unobserved, but they assert that the dividends paid on the world portfolio are observed. Fama and French (2004) wonder if it is legitimate, when considering a narrow view of the CAPM with only traded financial assets, to further limit the market portfolio to U.S. common stocks, which is a typical choice, or if the market portfolio should be expanded to include bonds and other financial assets, perhaps around the world. Likewise, Dalang, Marty and Osinski (2001) note that in global markets, passive strategies exhibit underperformance because available indices do not replicate the global market portfolio in the sense of the CAPM.

Inefficiency of the market portfolio

The efficiency of the market portfolio at equilibrium is a consequence of the assumptions from which the CAPM is derived. According to these assumptions, investors have homogeneous expectations concerning the assets and they all construct the same efficient frontier of risky assets. This efficient frontier is made up of portfolios with the highest expected rate of return for a given variance, or equivalently, the lowest variance for a given expected return. Investors choose to invest only in efficient portfolios. Since the market is the aggregation of the individual investors' portfolios and since all individuals hold positive proportions of their wealth in efficient portfolios, the market portfolio is efficient when it is a combination of efficient portfolios. It lies on the upper half of the minimum-variance opportunity set. Furthermore, all unsystematic risk is diversified out in the market portfolio.

Thus, in theory, the market portfolio must be efficient. But this efficiency is based on many unrealistic assumptions, including homogeneous

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forecasts from the investors and either unrestricted risk-free borrowing and lending or unrestricted short selling of risky assets.

Without homogeneous expectations, we are no longer assured of the efficiency of the market portfolio. This was underlined by Roll (1977). Moreover, in order for the market portfolio to be mean-variance efficient, at least one of the two assumptions – the existence of risk-free assets or the possibility of unrestricted short sales of risky assets – must hold, as was demonstrated by Black (1972). If there is no risk-free asset and short sales of risky assets are not allowed, mean-variance investors still choose efficient portfolios. But in that case, we lose the convenient property that combinations of efficient portfolios are themselves efficient. This means that the market portfolio, which is a portfolio of the efficient portfolios chosen by investors, is no longer efficient.

The CAPM is obtained by proving that the market portfolio is mean-variance efficient in the interpretation of Markowitz (1959) when the market is in equilibrium. Therefore, according to Roll (1977), the only legitimate test to validate the CAPM consists in verifying that the market portfolio is mean-variance efficient. This can be truly done only if the exact composition of the market portfolio is known and used in the test. As the true market portfolio is not observable and market indices are used as proxy of the true market portfolio, the results of empirical tests are dependent on the index chosen as an approximation of the market portfolio. It is the efficiency of these indices that is tested, and not that of the market portfolio. If this portfolio is efficient, we conclude that the CAPM is valid. If not, we will conclude that the model is not valid. But these tests do not provide any information on the efficiency of the true market portfolio and do not allow us to assert whether the true market portfolio is really efficient; this is heightened by the fact that very poor proxies of the true market portfolio are used. Even if the proxy is highly correlated with the market portfolio, this does not mean that it exhibits the same level of efficiency as the market portfolio. The efficiency of the market portfolio and the capital asset pricing model are inseparable, joint hypotheses. It is not possible to test the validity of one without the other and, due to the difficulty of measuring the true market portfolio, these joint hypotheses are almost impossible to test. Roll (1977) indicates that no correct and unambiguous CAPM test has yet appeared and that there is practically no possibility that such a test will appear. CAPM tests are flawed in that the market portfolio has not been properly specified. He points out that the portfolio used by Black, Jensen and Scholes (1972) was certainly not the true market portfolio.

The efficiency of the market portfolio implies that expected returns on securities are a positive linear function of their market beta and that market betas suffice to describe the cross section of expected returns. All equity market portfolios are mean-variance inefficient. The main implication of using an inefficient market index for risk estimation is that the linearity of the security market line may not be evident. Empirical studies of individual stocks document a set of facts about the cross-section of returns that cannot be explained within the traditional CAPM. Specifically, stocks sorted by size, book-to-market ratio and momentum have returns that cannot be explained by their covariance with the market portfolio. Related to this, the market portfolio seems highly mean-variance inefficient. It is possible to achieve a significantly higher return and/or significantly

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lower variance by investing in portfolios with a higher weight of small caps, stocks with high book-to-market ratios and past winners. According to Lehman and Modest (1987), this leads one to question the use of the usual CAPM market proxies as performance benchmarks.

According to Sinclair (1998), clearly none of the market indices used in the anomaly studies as proxies for the market portfolio actually belongs to the ex post (actual) efficient set. Roll's demonstration shows that, if this were not the case, then there could not be any measurable anomalies, and differences in CAPM beta would explain all differences in realised returns. This implies that the "CAPM anomalies" may be predominantly due to benchmark misspecification and that any excess return from active management that comes from exploiting the CAPM anomalies simply reflects benchmark measurement error. Style indices typically correspond to such anomalies. Hence, the use of "style-based" performance benchmarks may partly correct the benchmark misspecification problem exploited by some "active" managers. The S&P 500 companies only account for approximately 70% of total market capitalisation and do not include other investment such as bonds or smaller companies. When large stocks outperform, index funds based on the S&P 500 do better than average. Sinclair explains that inconsistency in the CAPM has led index managers to seek more representative indices: the Russell 2000 Index for small companies; the Wilshire 5000 for extended market coverage; Style Index Funds for Value and Growth; International Index funds for Europe, Pacific and Emerging Markets; Fixed Interest Index Funds; and Property Index Funds.

The consequence of the Roll critique has been that subsequent tests of the CAPM are interpreted as tests of the mean-variance efficiency of the portfolio that is a proxy for the market. With an iid normality assumption on stock returns, Gibbons, Ross and Shanken (1989) provide an exact statistical test of a portfolio's efficiency, consisting in testing if it is possible to outperform the benchmark, while Shanken (1987), Harvey and Zhou (1990) and Kandel, McCulloch and Stambaugh (1995) examine the efficiency in a Bayesian framework.

Grinold (1992) applied the Gibbons, Ross and Shanken (GRS) test to benchmarks in five equity markets: the United States, the United Kingdom, Australia, Japan and Germany. The benchmarks are, respectively, the S&P 500, the FTA, the ALLORDS, the TOPIX and the DAX. The results indicate that the first four of these were not efficient over the period studied. However, Grinold underlined that the GRS test is based on assumptions that are not verified by the markets, i.e., the process that generates the returns does not change with time and the returns are normally distributed. Thus, results of the tests cannot be considered fully reliable. The GRS test uses Markowitz' mean-standard deviation notion of efficiency. The task is to see if the benchmark is efficient in terms of expectations. The difficulty is that the expected excess returns are not known and have to be deduced from observations. If the benchmark is inefficient, it is possible to beat the benchmark. Even if the benchmark portfolio is efficient in terms of expectations, it will not be efficient in terms of the realisations, i.e., the realised average returns will not equal the expected returns. There will be sample error.

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There is controversy between authors concerning the influence of market portfolio definition on the results of CAPM tests. Stambaugh (1982) has shown that tests of the Sharpe-Lintner-Black model are not sensitive to the proxy used for the market and have suggested that Roll's criticism is too strong. He has expanded the type of investments included in his proxy from stocks listed on the New York Stock Exchange to corporate and government bonds, real estate and durable goods such as house furnishings and automobiles. His results have indicated that the nature of the conclusion is not materially affected as one expands the composition of the proxy for the market portfolio.

In an effort to deal with the criticisms formulated by Roll, Shanken (1985) performs a multivariate test for the CAPM, jointly testing the efficiency of selected indices and correlations with unobservable market returns.

Roll points out that because the expected return on any asset can be written as a linear function of its beta, measured in relation to any efficient index, it is not necessary to know the market portfolio. One need only know the composition of an efficient index. The choice of the index used as a benchmark has consequences for performance measurement. If the index turns out to be ex post efficient, then every asset will fall exactly on the security market line. There will be no abnormal returns. If there are systematic abnormal returns, it simply means that the index that has been chosen is not ex post efficient. In that case, the portfolio performance result will depend on the index. Depending on the position of the reference portfolio relative to the sample efficient frontier, the average mutual fund "alpha" could easily be negative sometimes and positive other times. Roll (1978) showed that by changing the index the relative ranking of the portfolio is not necessarily maintained. According to Roll, for every asset, an index can be found to produce a beta of any desired magnitude, however large or small. Any index less efficient than the market portfolio will produce beta of uncertain reliability. An asset's beta will depend as much on the proxy selected to represent the universe of assets as on security-unique attributes. Thus, for every asset or portfolio, judicious choice of the index can produce any desired measured "performance", positive or negative, against the securities market line. Consequently, for every ranking of performance obtained with a mean/variance non-efficient index, there exists another non-efficient index which reverses the ranking. By using two different approximations of the market portfolio, Roll demonstrates that it is theoretically possible to generate exactly opposite rankings of "winners" and "losers".

1.1.2. Alternatives to Value-Weighted Indices

When constructing indices, the main two issues are the inclusion criteria for stocks and the weighting scheme. The choice of the index sample universe concerns the choice of the number and type of assets to put in the index. An example of a narrow-based market index is the Dow Jones Industrial Averages, which is made up of 30 stocks. On the other extreme, the New York Stock Exchange Index contains every share listed in the New York Stock Exchange. Index weighting is the second important factor in constructing indices. The choice of an appropriate weighting system makes it possible to produce acute and investable benchmarks in line with investing management. For several years, research has

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been conducted to propose alternative methodology to the traditional capital weighting.

Market-capitalisation weighting (or value weighting) is used by many index providers. Two major reasons can be offered for this. The capitalisation-weighted index is easier to implement as a tradable portfolio, because price changes do not necessitate portfolio rebalancing. Moreover, it corresponds to the way the theoretical market portfolio of Sharpe's CAPM is constructed. The Standard & Poor's and Russell indices use this methodology, as well as the CAC 40 in France and the FTSE 100 in the U.K. The market capitalisation characterises the size of the company.
These indices are calculated as follows:

$$I_t = I_0 \frac{\sum_{i=1}^{n} P_{it} N_{it}}{\sum_{i=1}^{n} P_{i0} N_{i0}}$$

where I_0 is the value chosen for the index at a reference date, for example, $I_0 = 100$. Over time, the assets that make up the index may change, as some of them are deleted from the index and replaced by others.

Value-weighted indices were originally created to measure markets' price movements. These indices may carry embedded risks that may not make them suitable for the evaluation of diversified investment. First, these indices lack diversification, whether they are market-cap or float-weighted. According to Bernstein (2003), the S&P 500 index cannot be considered a diversified portfolio because the ten largest companies in the index account for 25% of the market value, and the top 25 companies account for 40%. According to Strongin, Petsch and Sharenow (2000), because of the heavy weighting of the large capitalisation stocks, the S&P 500 index actually consists of 86 stocks and the Russell 1000 of 118. Consequently, index performance is often dictated by the few biggest companies of the index and these indices do not provide investors with the risk reduction through diversification they think they are achieving.

According to Schoenfeld (2002), market-capitalisation weighting is a prerequisite of a good index. He also defines seven key criteria that are useful in identifying a good broad-capitalisation equity benchmark. The first one is completeness, i.e., reflection of the overall investment opportunity set, both in terms of market cap-range/country coverage and company inclusion. The second is investability, i.e., the inclusion of only those securities that can be effectively purchased by investors. The third is transparency, i.e., clear publication of the rules that govern the benchmark, especially during index reconstitution periods and during major corporate actions. The fourth is accurate and complete data readily available to investors, including price/total/net dividend returns, consistent sub-indices, quality and timely release of data, transparent release of index changes and historical returns. The fifth criterion is acceptance by investors, i.e., an index that is well known and widely used. The sixth is availability of tradable products, as widely used indices offer potential cost savings. Finally, relatively low turnover and related transaction costs. It should be noted that an index with a pre-defined number of stocks (e.g. S&P 500, Russell 2000) will have some degree of additional turnover to maintain the fixed number of constituents.

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Here we review some of the papers that propose alternative construction methodologies. The main idea is that indices that are constructed differently may outperform capitalisation weighted market indices for a number of reasons. These include:

(i) Use of better allocation techniques;
(ii) Access to additional risk premia;
(iii) Exposure to undervalued securities and exploitation of market inefficiencies.

Differences to capitalisation weighting are twofold:

(i) The weighting criterion is different from the market capitalisation;
(ii) Strategies may not be buy-and-hold.

Price weighting

Price-weighted indices are computed by arithmetically averaging the prices of the assets that make up the indices. The drawback of this method is the fact that assets with low unitary value have less weight in the index than assets with high unitary value. Moreover, it does not take asset capitalisation and trade volume into account. The advantages are that computation and interpretation are simple.

This type of index is evaluated in the following way:

$$I_t = \frac{\frac{1}{n}\sum_{i=1}^{n} P_{it}}{divisor_t}$$

where n is the number of assets in the index and P_{it} is the price of asset i at the time the index is computed. The divisor is an adjustment term that makes it possible to express the index as a percentage with regard to a reference date. This formulation allows us to adjust the index by recalculating the divisor, in case of events occurring on firm capital.

The most well known price-weighted index, and the first one, is the Dow Jones Index Average. The Nikkei index in Japan is another example of this type of index. Because of the way they are calculated, these indices are not suited to an evaluation of the performance of a stock exchange. Indeed, these indices are more affected by price variation among assets with high unitary value than among assets with low unitary value. Moreover, as they are made up of a restricted number of assets, they are also unsuited to an evaluation of the performance of diversified portfolios.

Equal weighting

Equally weighted indices are computed as the average of the returns of their constituents. They give the same importance to the price movements of all the stocks they are made up of, so the price change of every company in the index has the same impact on the changing value of the index. Each stock has an equal influence on index performance, regardless of its market capitalisation or share price.

An index that has equal weights for each of the components may be associated with a contrarian strategy. This is because as the capitalisation of a company rises, the weight will not rise and, as the capitalisation falls, the weight will remain constant. Therefore, the weights of winners (losers) are lower (higher) than with capitalisation weighting. Aside from evolution over time, even at the starting dates equally weighted indices will have greater weights in small capitalisation stocks when compared to capitalisation weighted indices, which naturally underweight small stocks. In times when small cap stocks earn a premium, equally weighted indices will therefore earn higher returns.

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It has also been claimed that equally weighted indices will be less risky than capitalisation weighted counterparts, since the method of capitalisation weighting will lead to high concentration in a few stocks that have the highest market capitalisation. Wei and Zhang (2006) compare the volatility of capitalisation weighted and equally weighted indices using the CRSP data. They find that the volatility of the equally weighted index is higher than the volatility of the capitalisation weighted index, which they trace back to the overweighting in small cap stocks that are more volatile.

The major problem with equally weighted portfolios is that equal weighting only holds for an infinitely short period, since the weights will diverge from equal weighting if the components have returns that differ. The geometric mean index of stock prices has been shown to grow at the same rate as a portfolio that is equally weighted and rebalanced in continuous time (see e.g. Rothstein (1972, 1974) or Hodges and Schaefer (1974)). However, Brennan and Schwartz (1985) have shown that this is only true if the rate of return on individual stocks is stochastic. Even in this case however, the geometric mean index approximates the returns on the continuously rebalanced portfolio.

Southard and Bond (2003) note that the use of equal weighting instead of capital weighting is not an optimal solution as it does not result in a representative portfolio. The second limitation of conventional indices described by Southard and Bond is that the stocks selected to enter indices are not evaluated in terms of their performance. Stocks are placed in the index regardless of their investment value, creating embedded valuation risk when used as investable portfolios. According to these authors, when indices are used as investment support, it becomes necessary to evaluate their potential constituents before selecting them to enter the index. However, it should also be noted that this critique by Southard and Bond somewhat suggests advocating the selection of stocks from valuation principles rather than constructing representative indices, which does not seem to be convincing (see below for more comments on such weighting methods).

Free-float adjustment

According to Sauter (2002), an index must rely on objective, not subjective rules. It must adjust weighting for cross-holdings/float. In the mid-1980s, the Toronto Stock Exchange in Canada and Salomon Smith Barney (later Citigroup, then S&P) introduced the concept of free-float-adjusted weightings. Similar to market capitalisation weighting, free float is defined as the percentage of each company's shares that is freely available for trading on the market. It reflects the effective trading opportunities for investors more closely and thereby improves the investability and representation of the indices. The idea is to account for shares that are rarely available for trading, such as those controlled by the founding family of a company. The float-adjusted weighting methodology removes these strategically held shares from market capitalisation calculations; stocks are weighted based only on their "liquid" share counts.

The term "float adjustment" has become a popular catchphrase, as most major indices have been moving toward this concept in the last three years. An interesting observation is that while almost all global indices are float adjusted, there are a handful of U.S. indices (Standard and Poor's, Dow Jones Wilshire) that

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still use market capitalisation weighting to construct their indices. In spite of the benefits it offers, there may be cases where float adjustment is not entirely applicable.

Morgan Stanley Capital International (MSCI) first announced the move to the free float model for its global indices in the year 2000. Since then, almost all major index providers, including MSCI, FTSE, S&P, Russell and STOXX, have adopted the free-float methodology in constructing their indices. While free-float is probably the current *de facto* industry standard for index construction, some U.S. index providers still preserve the use of market capitalisation weighting in constructing their indices, such as S&P's multivariate indexing process (for the S&P family of U.S. indices), and Dow Jones Wilshire has kept a full market capitalisation version (in addition to the free-float version) of its Wilshire 5000 composite index.

Free-float weighting is, however, not the only way of addressing the liquidity issue. Shah and Thomas (1998) propose an approach to index construction which is aimed at creating a highly liquid index. High liquidity would result in reduced noise in the index time-series and help produce financial products based on the index. The approach described relies on measures of liquidity derived from "snapshots" of the limit order book. This approach was developed in the course of the creation of the NSE-50 index on India's National Stock Exchange (NSE), an open electronic limit order book market. The NSE-50 index has proved to be the most liquid of the indices which aim to represent the Indian equity market.

Likewise, according to Huang (2005) and Bagneris and Topscalian (1997), the most important point to focus on when building an index is liquidity. The introduction of free-float adjusted weighting in index computation has served to address part of this concern. However, Huang notes that a certain portion of the shares of many companies is often held by long-term and/or strategic investors. These shares, generally not available for trading, are difficult to account for and it appears difficult to float-adjust taking them into account. As an alternative, Huang proposes to deal with the liquidity problem using "trading value" to define index weightings. Trading value is defined as price multiplied by the number of shares traded:

$$TV = P_1S_1 + P_2S_2 + P_3S_3 + \ldots + P_nS_n = \sum_{i=1}^{n} P_iS_i$$

where TV is the trading value;

P is the share price;

S is the number of shares traded (volume);

and n is the number of trades in a day.

Trading value measures all of the actual transactions taking place on the market, giving the most accurate representation of the market and its liquidity. According to Huang, this weighting system offers the most accurate measure of liquidity for index constituents.

A study indicated that the market-cap weighting of the largest stock could be as much as 1,000 times that of the smallest stock in the S&P 500 index, which means that the smallest stocks have an insignificant impact on the index. By using trading value to weight components, the differences in weight between top and bottom stocks in an index could be reduced substantially, with some of the more liquid, actively-trading small-cap stocks gaining more representation in the index. Moreover, better performance can be expected for trading-value-weighted indices compared with traditional float-adjusted indices, as

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smaller companies generally outperform larger ones over time.

Geometric mean

The standard procedure for calculating an index is multiplication of prices by weights, summed over the stock population of the index and divided by the number of stocks included to produce an arithmetic mean.

An alternative exists with geometric mean indices. These indices are related to the group of equally weighted indices, as they do not take asset capitalisation into account. Price relatives of the stocks included are multiplied over all stocks and the n-th root is taken from the product thus obtained.

$$I_t = I_{t-1} \sqrt[n]{\prod_{i=1}^{n} \frac{P_{it}}{P_{it-1}}}$$

An example of a geometric mean index is the Value Line Index. It is in fact the only one.
The advantage of this index is that it does not depend on the asset prices, but on their relative variation.

According to Cootner (1966), a geometric mean index is a downward biased index of price changes compared to an arithmetic mean index. On the other hand, other authors underline that while arithmetic mean indices are sensitive to the selection of the time interval (monthly, quarterly, semi-annual, or annual) in the model, geometric indices will produce the same calculation of returns regardless of the time interval.

Stochastic Portfolio Theory

Fernholz and Shay (1982) introduce an equilibrium model that focuses on the long-term performance of portfolios in a continuous time setting. Rather than using the classic concepts of equilibrium as characterised by market clearing between supply and demand, their theory is similar to equilibrium in thermodynamics. They show that portfolios fulfilling the constraints that allow equilibrium to be attained are not necessarily limited to the market portfolio. In fact, while most portfolios obtained closely resemble the market portfolio, some portfolios are very different from the market portfolio.

Factor Analysis

Factor analysis techniques have been extensively used in finance, both in the context of term structure analysis (a classic reference is Litterman and Sheinkman (1991)) as well as in the time-series analysis of equity portfolios (e.g., Chan, Karceski and Lakonishok (1998)). In the context of empirical testing of the Arbitrage Pricing Theory (Ross (1976)), replicating portfolios are extracted in an attempt to track the performance of unobserved implicit factors that drive asset returns (see Huberman, Kandel and Stambaugh (1987)).

At the intuitive level, the aim of the methodology is to use a small sample of stocks to design a replicating portfolio for the return of the total stock market. To this end, the selection criterion is the loading of individual stocks on the first principal component. The higher the loading of a stock on the first principal component, the higher its contribution will be to the common trend in hedge stock returns following a given strategy. Given that the first eigenvector corresponding to the first principal component is determined so as to maximise the variance of the

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corresponding linear combination of stock returns, high factor loadings will be allocated to stocks which have been highly correlated with the total stock market over the calibration period. Such stocks should be the most representative. This allows a satisfactory level of representativity to be achieved, while respecting the constraint of investability based on a small number of stocks.

Alexander and Dimitriu (2004) propose to obtain portfolio weights from a principal component analysis of stock returns. Their model filters out the noise by focusing on replicating the common trend in stock returns, as described by the first principal component. This allows them to achieve significant outperformance of capitalisation weighted benchmarks while maintaining high correlation with the latter. They attribute this outperformance to exposure to the value and to the volatility premium. Affleck-Graves, Troskie and Money (2002) note that the trouble with the use of principal components in the construction of stock market indices is that it often results in the allocation of negative weights to some of the securities. The authors show that, by a simple restatement of the problem, this disadvantage can be easily overcome. In addition, extra constraints can be imposed on the weights assigned to the different securities if so desired.

The foundations of the construction of stock market indices based on a principal component analysis are to be found in Feeney and Hester (1964). The intuition is that if an index is designed to measure movement on the market, then it will be most sensitive (and hence most informative) if the weights are assigned in such a way that the index has a maximum variance over all linear combinations of the stocks to be included in the index. Such a combination is simply the largest principal component.

The problem of getting positive weightings can be solved using any of the methods for solving either general non-linear programming problems (e.g. the Flexible Tolerance method) or quadratic programming problems subject to quadratic constraints. One of the main advantages of the Flexible Tolerance method is that additional constraints can be easily included in the analysis. Since the Flexible Tolerance Method is an iterative search procedure, Himmelblau (1972) recommends that the analysis be repeated using several different starting solutions. As it results in somewhat more computation than the traditional principal component analysis, it is suggested that in practice the traditional first principal component be found. If it is non-negative and satisfies all of the additional restrictions imposed, then these weights should be used. However if the constraints are not satisfied, then the Flexible Tolerance Method should be used to find the index which is the most volatile, subject to the imposed constraints. In practice this will often be an iterative procedure.

Weighting by Fundamental Metrics

Arnott, Hsu and Moore (2004) create market indices where they change the weighting criterion from market capitalisation to other observable characteristics of the stocks. They use indices composed of 100 stocks that are weighted by variables such as firm size, book value, income, sales, gross dividend distributions, number of employees, etc. It should be noted that all of these variables proxy for firms, but by using a measure that is different from market capitalisation and thus more related to the

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physical size of the firm than to the value of shareholders' equity. Their portfolios generate outperformance relative to capitalisation weighted indices by as much as 165 basis points annually over the sample period used.

Southard and Bond (2003) define what they call intelligent indices, i.e., indices that select their securities for their capital appreciation potential rather than simply incorporating representative securities regardless of their investment merit. Risk management of intelligent indices is primarily controlled through a representative sampling portfolio optimisation process. A simpler way of optimising portfolio is to reduce risk by combining assets whose specific risks offset each other. The stratified sampling process divides the universe along the dimensions of sector and size and then forces the model to pick a proportionate amount of stocks from each of these groups. This optimisation process controls the exposure of intelligent indices to these segments of the market and ultimately manages the risk of the index as well as the tracking error to other widely used benchmarks. The important implication of this portfolio construction process is that it provides an accurate and representative portfolio while diversifying the stock-specific risk found in other conventional indices. Securities are selected using a multifactor approach, allowing the model to incorporate all relevant information factors. The methodology evaluates securities across a wide range of investment value factors which can be broken down into four perspectives: fundamental growth, stock valuation, timeliness and risk determinates. Each perspective is intended to bring an independent viewpoint to the stock valuation process. The methodology described by Southard and Bond actually consists more of active management, with a systematic stock selection strategy, than of passive index development. The aim of the process appears not to be to derive an index representing the market, but to generate alpha through security selection. Securities are selected for their capital appreciation potential, and not for their representativeness.

Diversity Weighting

Fernholz, Garvy and Hannon (1998) introduce diversity weighted indexing. They define a measure of stock market diversity which is provided by the distribution of capital in a given stock market. They show that the returns on the diversity weighted index are a function of the returns to a capitalisation weighted index with the same component stocks. Returns to the diversity weighted index will exceed those on the capitalisation weighted index unless diversity is continuously declining or dividends paid out by large companies significantly exceed those paid out by small company stocks.

Asset Allocation

It is possible to use the minimum-variance portfolio composed of individual stocks as a benchmark. Such a portfolio may be classified as an index since the derivation of the minimum-variance portfolio only includes a view on the variance-covariance of asset returns but not on the expected asset returns themselves. Kempf and Memel (2003) analyse the specific properties of the true global minimum-variance portfolio, which can be computed if the true return distribution parameters are known. They show the close link between the global minimum-variance portfolio and linear regression theory. This

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makes it possible to use the Ordinary Least Squares (OLS) method to estimate the weights of the global minimum-variance portfolio.
Traditionally, models suggest proceeding in two steps. First, the return distribution parameters are estimated, then the optimal portfolio weights are computed using these parameters. The specific interest of this article is the proposal of a new single-step approach for calculating optimal portfolio weights. Considering N assets, the weights of the global minimum-variance portfolio are estimated using a linear regression model where the return of stock N at time t is the dependent variable and the returns of the N-1 other stocks at time t are the independent variables. Relying on the well established properties of the OLS method, Kempf and Memmel conclude that the beta coefficients of the regression are the best unbiased weight estimators of the global minimum-variance portfolio; the alpha of the regression is the best unbiased estimate for the expected return of the global minimum-variance portfolio; and the variance of the residual terms of the regression is an unbiased estimator of the global minimum-variance portfolio. The authors demonstrate that their results are equivalent to those obtained with the traditional two-step approach and that both approaches lead to the same out-of-sample variance. A similar analysis is applied to portfolio construction for hedge fund portfolios by Amenc and Martellini (2002).

1.1.3. Other issues

Transparency

A major issue for practitioners is the rules for companies entering the index. The index providers use quantitative and/or qualitative criteria as a basis for governing the selection of companies in the equity index. Criteria include trading volume and market capitalisation. Sometimes, other more discretionary judgements exist. Sometimes, too, the industry composition of the index is taken into account when selecting only a few stocks that should nonetheless be representative of the larger universe, i.e., the whole stock market. The transparency of such index adjustments is the major concern for investors, especially since profits can be expected from trading on private information about components entering or leaving the index ("index effect").

In particular, the S&P 500 index is widely criticised for non-transparent and discretionary rebalancing (see e.g. Beneish and Whaley). Standard & Poor's is now seen to act in a rather active manner when replacing stocks that are understood not to be representative, a notion which is not clearly defined. While S&P deletes stocks due to declining market capitalisation, share price, or market share, it also deletes stock to make room for new entries to the index.

Rebalancing

The management of indices has consequences for market and index portfolios. According to Gastineau (2002), benchmark indices will never qualify as perfect fund indices because changes in the composition of the index are always public before the fund can act.

Jankovskis (2002) considers the impact of Russell 2000 rebalancing on small-cap performance. He notes that the fact that all rebalancing activity is concentrated on a single day creates substantial performance distortions around the June 30th rebalancing date each year. He shows that the speculative

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trading activity that surrounds rebalancing depresses the return of the Russell 2000 Index by an average of approximately 2% per year. Each May 31st, the Frank Russell Company ranks all U.S. domiciled companies by their market capitalisation, identifying those with rankings from 1,001 to 3,000 as small. These stocks become the constituents of the Russell 2000 Index one month later. This approach offers the opportunity of speculation on index changes months prior to the rebalancing date. Speculators sell the stocks that are likely to leave the index, thereby depressing their prices, and purchase shares from firms likely to be added to the index. As a result, stocks often join the index at artificially high prices, creating a drag on index performance as their prices return to more normal levels in the months following rebalancing.

The rebalancing procedure used for the S&P 600 is quite different. The stocks to be added to and deleted from the S&P 600 are determined by the Standard & Poor's Index Committee, using a combination of quantitative and qualitative criteria. Changes to the S&P 600 Index are normally implemented with five or fewer days' notice given to the financial community. Both the secretive nature of the selection process and the short notice given prior to any changes in the index limit the amount of speculative activity surrounding changes in the S&P 600 Index. This specific aspect gives an advantage to the S&P 600 and may explain why it is gaining in popularity in the area of small-cap benchmarks. A survey published in 2002 in *Pensions and Investments* indicated that 8% of all index and enhanced index managers responding to the survey offered products that were benchmarked to the S&P 600 while only 4% offered products benchmarked to the Russell 2000.

One of the main reasons why the Standard and Poor's Index Committee changed their policy concerning additions to and deletions from the S&P 500 in 1989 was the increase in abnormal returns of the stocks after those announcements. Under the new announcement policy, changes are pre-announced an average of five days before they become effective in order to alleviate price pressures during the event. Other indices that might appear to be equally important benchmarks in the U.S. market do not face such a problem, because there is less indexed money tracking them. For example, in the case of the Dow Jones Industrial Average (DJIA), the prices and trading volumes of added stocks are largely unaffected, consistent with the fact that index tracking is limited for that index.

The selection process for S&P 500 membership does not simply refer to a typical quantitative ranking system. Therefore, it is difficult for institutional investors and fund managers to anticipate the changes. This is in contrast with the procedures that operate for most other major indices. In the case of the FTSE 100 for example, where the main criterion is the company's capitalisation, the anticipation of the event is a simpler issue. In this case, by the time the capitalisation of a company falls below those of the largest excluded firms, the change takes place immediately on the next quarterly composition change date and the excluded stock with the highest capitalisation is added to the index. The "index effect" is not so intense in this case due to significant anticipation of the event.

1.1.4. Conclusion on Alternative Construction Methodologies

As indicated by Schoenfeld (2002), there are always tradeoffs in achieving goals by a given construction method. A great number of stocks

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enable the index to be exhaustive, but if an index is made up of too many stocks, some of them will be illiquid. A less broad index is therefore more investable. Another criterion – timely reconstitution and rebalancing – is what enables an index to accurately track the asset class it is designed to represent, but it is a source of turnover for investors which is costly.

The most serious drawbacks from the investor's standpoint seem to be that the predominant technique of index construction (market capitalisation weighting) neither ensures that the index has a stable or pure exposure to systematic risk factors nor constitutes an efficient portfolio. In other words, the investor who holds an index may be faced with:
(i) an allocation which is implicit in the index and which he does not control;
(ii) a risk return ratio which does not ensure the optimal trade-off between those two factors.

The different alternatives to constructing indices have to be seen in the light of the solution(s) they bring to these shortcomings. At the same time, one should be prudent when the label "index" is used. Some alternative construction methodologies actually more closely resemble active investment strategies, though these are implemented in a systematic manner. Indices that apply stock selection filters for high dividend yield or other characteristics may fall into this category. Above, we classified this as access to additional risk premia or exposure to undervalued securities and exploitation of market inefficiencies. In these cases, the index actually ceases to be representative of the whole market and becomes representative of some stock picking strategy. Therefore, it is more promising to focus on asset allocation or statistical techniques that achieve representativeness when considering index construction.

We will further analyse the topic of index construction in the following sections. Beforehand, however, we will offer a look at the current market for indices.

1.2. Indices in the Asset Management Industry

In this section, we will provide an overview of the current index market and index providers, as well as a brief introduction to the main characteristics of indices.

In view of the immense volumes in assets under management in passive indexing strategies, a great many index providers have emerged worldwide; not only the organisations specialising in the index service such as Standard&Poor's (S&P), Morgan Stanley Capital International Inc. (MSCI), FTSE Group (FTSE), Russell or Wilshire, but also stock exchanges, such as NYSE, Deutsche Boerse, Euronext and so forth. Each provider has created or is creating a host of indices representing a full complement of industries and sectors.

Generally, it can be observed that index family structures have become more and more diverse. Apart from the broad-based market index, some indices are specifically designed to have size or style characteristics, and others focus on sector orientation and geographic orientation and so on. If we take a close view of each index category from different providers, it is not hard to see that some common equity styles exist, though some providers may have particular classifications (see Table 1). The

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representation objectives of each index can be quite different. The selection universe can be a single stock exchange, the national or regional stock market or international coverage. Moreover, the number of stocks contained in an index may be fixed or variable over time, according to the changing conditions such as corporate issues (e.g., the company issuing the security is involved in a merger or an acquisition). In terms of sector classification, today nearly all the index providers have adopted common standards, which reduces differences among index providers. The same cannot be said of their equity style indices.

In this document, we only focus on "composite" or broad market indices. The first example of such an index is the Dow Jones Industrial Average, a price-weighted portfolio of very few stocks (30 in the version we know today). The creation of the market capitalisation weighting in 1932 by the Cowles Commission for Research in Economics (*The Yale Endowment*, 1996), which considered the stock price and the number of outstanding shares at the same time, greatly improved the quality of indices when compared with the price weighting method, which has no theoretical justification. Recently, some providers have opted for different weighting schemes, such as those outlined in the literature review. One example is FTSE, which will weight the seven FTSE indices using an indicator composed of net income, cash flow and book value. These indices effectively correspond to an active investment strategy in the index (*FTSE*, 2005).

If we take a view of various broad market indices currently available, we see that they largely follow capitalisation weighting, in the simplest or in adapted forms, but are guided by different construction details. These indices are a popular support for the creation of funds that directly replicate the indices. These index funds have become ever more popular, especially since they exist in the form of exchange-traded funds (ETFs), which trade like

Table 1: Brief review of main Index Providers and Equity Index Styles as of September 2005

Index Providers	Deutsche Boerse	Dow Jones & Company	Euronext	Frank Russell	FTSE	Morgan Stanley Capital International, Inc. (MSCI)	Morningstar Inc.	Nasdaq	New York Stock Exchange (NYSE)	Standard & Poor's (S&P)	Stockholm Stock Exchange (OMX)	Stoxx Limited	Swiss Exchange (SWX)	Wilshire Associates Incorporated
Equity Styles														
Composite√	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Large Cap √	•	•	•	•	•	•	•	•	•	•		•	•	•
Mid Cap√	•	•	•	•	•	•	•			•		•	•	•
Small Cap√	•	•	•	•	•	•	•			•		•	•	•
Micro Cap √		•		•		•								•
Growth√		•		•	•	•	•			•		•		•
Value√		•		•	•	•	•			•		•		•
Growth and Value mixture*		•					•							
Sector or Industry grouping√	•	•	•		•	•		•	•	•	•	•	•	•
Country or geographic area	•	•	•	•	•	•	•	•	•	•	•	•	•	•

* This category refers to the index in which the stocks have both value and growth characteristics.

This table shows an overview of the main index providers and the areas of the equity universe which they cover. The information was obtained from the web sites of the index providers during September 2005.

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a stock. In fact, the fund business is very prosperous in the U.S. and enjoying remarkable growth in Europe. Today, there is a large number of ETF issuers operating in the U.S., such as Barclays Global Investors (iShares), Vanguard, State Street Global Advisors and PDR Services LLC. In Europe, UBS ETF, Credit Suisse Fund Management, Indexchange, Unico Asset Management S.A. (iTracker), Lyxor Asset Management, AXA IM – BNP Paribas and Credit Agricole Asset Management are the major players. All of these companies commit to issuing funds by tracking not only the domestic index, but also foreign indices from various stock exchanges.

In this sub-section, we give an overview of the widely used broad-based market indices. We concentrate on indices for the U.S., for Europe as a region and on European country indices. We collected data on the traditional index funds and ETFs as well as index future trading, since these are the main instruments used to implement indexing strategies[1].

1.2.1. U.S. Equity Index Market

There are several broad market indices for the U.S. market, which follow different construction methodologies. The percentage of total market capitalisation represented by these indices ranges from 19% to 100% of the total market capitalisation (see Table 2).

We can see that the S&P 500 is the most popular index. It only includes the 500 leading companies in the major industry sectors of the U.S. economy. However, these 500 stocks make up a significant portion of the total market value. If we consider the total assets under management (AUM) in index funds, it can be seen that the S&P has a dominant market share with 70.41%. Even more dramatic is its market share of 90.43% in terms of total trade volume of ETFs. Likewise, the futures market reflects this dominance, with the S&P 500 index future making up 87% of open interest, though the number of futures contracts is the same as for the Dow Jones.

1 (1) In our research, traditional index funds managed by the Top 100 Asset Management Companies worldwide are used for the sample substantiating the popularity of the underlying indices. The fund can be defined as an index fund if:
• The fund's stated investment policy is to generate returns that replicate, match or correspond to or align with the target index performance;
• The fund invests all or at least a predefined percentage (normally 80%) of total assets in the target index by fully replicating or representatively sampling its constituents and weightings accordingly;
• The total expense ratio (TER) is around 1%. We find that most index funds have a TER below 1%, but as different share classes are provided for investors, the varying and "abnormal" expense ratio is possible. This can be used as the gauge for differentiating index funds. Generally, the index fund performance should be slightly lower than its target index.
Therefore, the funds we select may only deviate from "pure" index funds for reasons related to managing redemptions and subscriptions, which may lead to low proportions of cash and bonds, in addition to the equities. However, these funds may not deviate from indexing by using option strategies such as short option strategies added to the indexing strategy.

(2) To illustrate the availability of a given index future on the market, the open interest value is selected; this can also be considered as the indirect gauge of a portfolio manager's preference for an underlying index of that kind, for risk exposure hedging or portfolio leveraging needs. We calculate the open interest value for each index, and then the relative share of the index:

$$X = \sum_{i=1}^{N} OI_i$$

$$OI_i = P_i \times V_i \times N_i$$

where X is the open interest value for the target index;
N is the number of futures classes on the index;
P is the final settlement price;
N is the outstanding future contracts which have not expired at the end of the day;
and V is the contract value.

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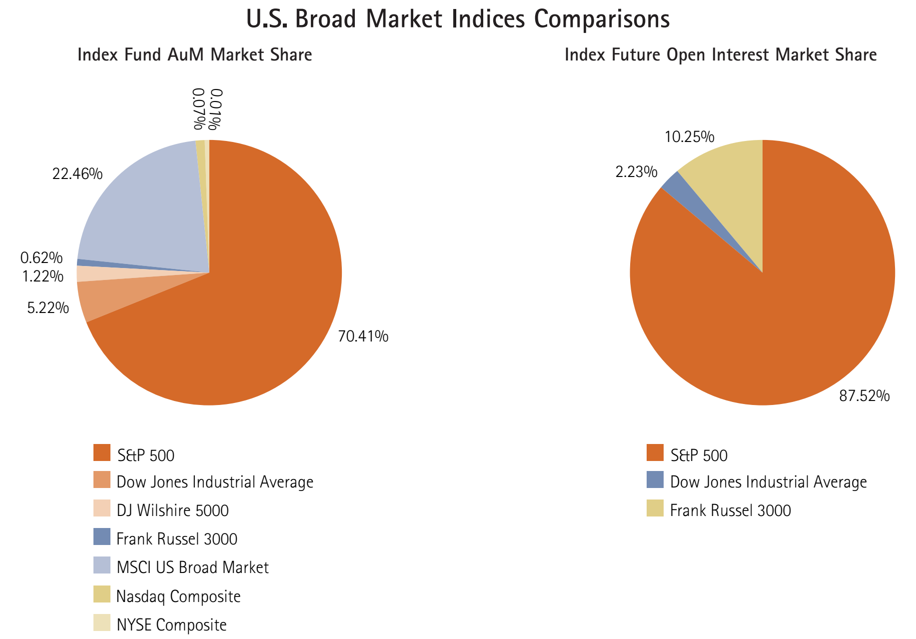
Table 2:
U.S. Broad Market Index Comparison as of September 2005

Index	Dow Jones Industrial Average	DJ Wilshire 5000	Frank Russell 3000	Morningstar U.S. Market	MSCI U.S. Broad Market	Nasdaq Composite	NYSE Composite	S&P 500
Measurement Objective	Broad Market	Broad Market	Broad Market	Broad Market	Broad Market	Nasdaq Exchange	NYSE Exchange	Broad Market
No of Components	30	4942	3000	1800	3857	3182	2066	500
Weighting	Price	Full Market & free-float	Free-float	Free-float	Free-float	Market Cap	Free-float	Free-float*1
Style Indices	No	Yes	Yes	Yes	Yes	No	No	Yes
Reconstitution	Replacements	Monthly	Annually	Semi-Annually	Semi-Annually	Daily	Quarterly	Replacements
Established	May-1896	Dec-1970	1984	Dec-1991	May-2003	Feb-1971	Jan-1939	Jan-1928
% of Total Market Cap	25%	100%	98%	97%	99.5%	19%	77%	80%+
Index fund number	5	3	1	NA	2	2	1	34
AuM market Share	5.22%	1.22%	0.62%	NA	22.46%	0.07%	0.01%	70.41%
ETF traded volume market share	9.22%	0.0043%	0.09%	NA	0.21%	0.05%	0.0017%	90.43%
Index future number	2	NA	2*2	NA	NA	1	NA	2
Open Interest market share	2.23%	NA	10.25%	NA	NA	NA	NA	87.52%

Notes: The index information is taken from the index providers' web sites.
The index number and AuM data is the sum of traditional index funds and ETFs.
The traditional index funds data is based on the information from the Top 100 AMCs ranked by the IPE (July/August 2005), as of 27/09/2005.
The ETF data used for calculation is mainly based on "Portfolio Trading & Index Strategy", Weekly Analysis, Deutsche Bank, 27/09/2005.
The index future data is calculated according to information from CBOT, CME and Eurex Web sites, as of 27/09/2005.
The exchange rate used for calculation is from 27/09/2005.
*1 The S&P implemented free-float adjustment following a transition schedule for shift of its U.S. index construction methodology.
*2 No index future based on Russell 3000. However, it consists entirely of Russell 1000 and Russell 2000. Thus, a combination of these sub- index futures can replace their parent index future.

This table shows a comparison of broad market indices for the U.S. The information was obtained from the web sites of the index providers, investment fund prospectuses and the exchanges that operate a segment for ETFs, as well as the futures markets.

Illustration 1:
Market Shares for U.S. Broad Market Indices



This illustration summarises the information in Table 2 with a focus on the market shares in terms of AuM and open interest.

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Although the Dow construction methodology is clearly obsolete, a large amount of investors still prefer to use it. As shown in Table 2, the percentage of total market capitalisation the Dow captures is only 25%; however, it owns more than a 5% market share in terms of AuM and over 9% in terms of daily ETF trading volume. In addition, there are two index futures contracts. Compared to the Wilshire 5000 and Russell 3000, which cover nearly the whole of the U.S. market with thousands of stocks involved, the Dow only covers 30 stocks, but appears to be more popular. This may be due to its brand name or to the fact that it is extremely easy to replicate.

In comparison with the competing total market indices, the MSCI U.S. Broad Market index seems to be more popular with investors. It should be noted that the index fund giant, Vanguard, regards MSCI indices as being well-constructed and is promoting these indices (*Morgan Stanley*, 2005). Vanguard has issued one traditional index fund and one ETF tracking the MSCI U.S. Broad Market index; both of them have quite large AuM amounts which shore up the MSCI index fund market share.

1.2.2. European Equity Index Market

The convergence of European Financial Markets led to the emergence of pan-European indices. Unlike the situation in the U.S., none of the existing providers to date has established itself as a clear leader and there is a multitude of indices that try to capture the same market segment. This has probably been helpful for the industry, since investors have started to ask how the different construction methodologies affect the quality of the index.

Different geographical groupings, such as Europe, the European Union or Eurozone, further increase the number of available indices. Table 3 gives an overview.

Dow Jones STOXX indices succeeded in quickly becoming one of Europe's leading regional equity indices. Launched in 1998, with the advent of the European Monetary Union, Stoxx Limited started development of its product line. Today, it has indices for many different sub-divisions of the European region (such as Eurozone, Europe ex U.K., Nordic Region, Europe ex Eurozone, etc). Their most prominent index, the Euro Stoxx 50, consisting of 50 blue-chip indices in 17 Eurozone countries, is the favourite of the index fund providers, as shown by Table 3. The dominance of the Dow Jones Euro Stoxx can be clearly seen from the market shares for funds and futures, though for the investment funds, the MSCI Europe also has an important share of the market.

Illustration 2 gives a graphical representation of part of the information in Table 3. The graphs underline the strong position of the Euro Stoxx 50 and the MSCI Europe.

FTSE, as another index provider, had European indices for a long time but recently started cooperation with Euronext to issue a new European index series called FTSEurofirst, which is made up mainly of the FTSEurofirst 80, FTSEurofirst 100, FTSEurofirst 300 and Supersector indices.

MSCI first developed the MSCI Europe in 1969 and MSCI EMU in 1987 to represent equity market performance within Europe and the EMU respectively. Later, in 1996, the narrow

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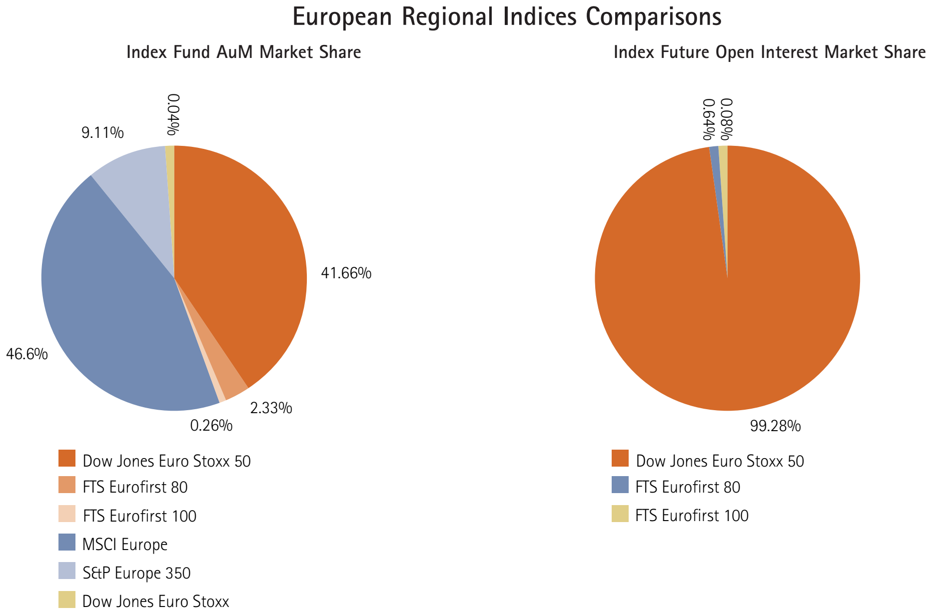
Table 3:
European Regional Broad Market Index Comparison as of September 2005

Index	Dow Jones Euro Stoxx	Dow Jones Euro Stoxx 50	Euronext 100	FTSEurofirst 80	FTSEurofirst 100	FTSEurofirst 300	MSCI EUROPE	S&P Europe 350
Measurement Objective	Broad Eurozone	Blue-chip	Euronext exchange	Broad market	Broad market	Broad market	Developed market	Broad Regional
Country coverage	17	12	NA	8	9	17	16	17
No of Components	200	50	100	81	101	311	550+	350
Weighting	Free-float	Free-float	Market Cap	Free-float	Free-float	Free-float	Free-float	Free-float
Style Indices	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Reconstitution	Quarterly	Annually	Quarterly	Annually	Annually	Quarterly	Quarterly	Annually
Established	Dec-1991	Dec-1986	Dec-1999	Dec-1993	Dec-1993	Sep-04	Dec-1969	1998
% of Total Market Cap	NA	60%	80%	NA	NA	91.4%	85%	70%
Index fund numbers	1	14	NA	2	1	NA	4	2
AuM market Share	0.04%	41.66%	NA	2.33%	0.26%	NA	46.60%	9.11%
ETF Traded volume market share	0.0094%	87.30%	NA	1.5%	1.21%	NA	4.06%	5.93%
Index future numbers	NA	1	NA	1	1	1	NA	NA
Open Interest market share	NA	99.28%	NA	0.64%	0.08%	0	NA	NA

Notes: The index information is taken from the index providers' web sites.
The index number and AuM data is the sum of traditional index funds and ETFs.
The traditional index funds data is based on the information from the Top 100 AMCs ranked by the IPE (July/August 2005), as of 27/09/2005.
The ETF data used for calculation is mainly based on "Portfolio Trading & Index Strategy", Weekly Analysis, Deutsche Bank, 27/09/2005.
The index future data is calculated according to information from Eurex and Euronext Liffe, as of 27/09/2005.
The exchange rate used for calculation is from 27/09/2005.

This table shows a comparison of broad market indices for the European region. The information was obtained from the web sites of the index providers, investment fund prospectuses and the exchanges that operate a segment for ETFs, as well as the futures markets.

Illustration 2:
Market Shares for European Broad Market Indices



This illustration summarises the information in Table 3 with a focus on the market shares in terms of AuM and open interest.

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MSCI Euro and Pan-Euro indices were launched to include only the largest and most liquid securities. In terms of market share, the MSCI Europe index is the market leader, although the number of issuers is less than that of the DJ Euro Stoxx 50.

Standard&Poor's also introduced its own product in 1998 – the S&P Europe 350 Index series –, which consists of S&P Europe 350, S&P Euro, S&P Euro Plus and S&P United Kingdom. Each category provides an exposure to either a region or a country (e.g. the S&P Europe 350 includes stocks in 17 countries in Europe and the S&P Euro concentrates on stocks for the Euro zone).

It is interesting to note that, just as in the case of the U.S., the less broad indices seem to capture a higher market share. For example, the DJ Euro Stoxx 50 just represents the 50 largest stocks in 12 European countries but dominates the European ETF and index future trading. On the other hand, the DJ Euro Stoxx contains 600 companies in Large, Mid and Small segments with a coverage of 17 European countries but only has a very small market share. It can also be noted that the FTSEurofirst Series seems to fall far behind the Stoxx indices in terms of AuM and trading volume, though funds and futures for these indices have been launched.

1.2.3. European Country Equity Index Market

Along with further integration of European stock markets, it may be expected that country indices will lose ground to the European regional indices. If we compare the importance of country indices and regional indices for Europe, we find that AuMs of index funds give a figure of €27,010.56 million for the regional indices and €16,946.36 million for the national indices. This shows that the regional indices have outgrown national indices in importance. However, the ETFs based on the country indices are traded more actively than their pan-European counterpart (€181.57 million compared with €106.16 million).

When comparing the AuM and trading volume for index products based on national indices, it should be noted that the higher market share may just come from the fact that investors' asset allocation decisions favour a certain country, which is not at all linked to the quality of the index. This is probably the reason why the market shares are so disparate for the different national indices. Therefore, the interpretation is different from the preceding two tables, where we may assume that a higher market share stems from investors' perception of the quality of the index.

The construction methodologies of these national indices appear to be quite similar, as shown in Table 4. The indices usually contain a very small number of stocks (The FTSE 100 with just 100 stocks is already the index with the largest number of components). The CAC 40 and DAX 30 are the dominant indices in terms of AuM of index funds, with 28.33% and 24.82% respectively. On the other hand, the OMXS 30 and BEL 20 represent only 1.54% and 0.21% of the market. In terms of turnover of ETF shares, the DAX 30-based ETFs have the highest volume, followed by the ETFs based on the MSCI country indices and the FTSE 100. The FTSE 100 is also the most active index in futures trading.

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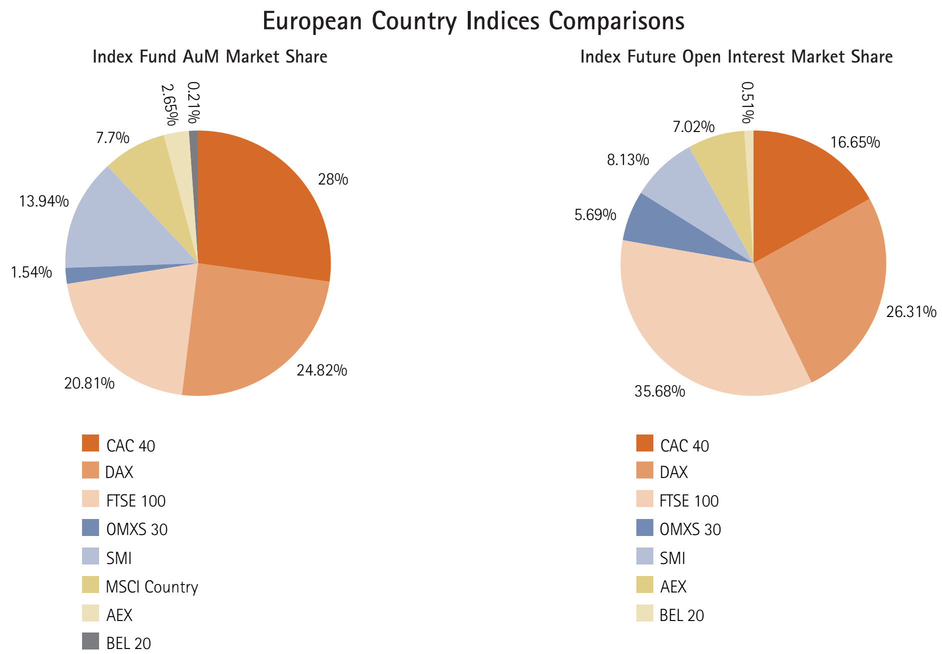
Table 4:
European National Broad Market Index Comparison as of September 2005

Index	MSCI Country	FTSE 100	AEX	BEL 20	CAC 40	DAX	OMXS 30	SMI
Measurement Objective	Broad Market	London Stock Exchange	Euronext Amsterdam	Euronext Brussels	Euronext Paris	Frankfurt Exchange	Stockholm Exchange	SWX Swiss Exchange
Country coverage	16 countries	U.K.	Netherlands	Belgium	France	Germany	Sweden	Switzerland
No of Components	16	100	24	19	40	30	30	27
Weighting	Free-float	Free-float	Full Mar. Cap	Full Mar. Cap	Free-float	Free-float	Market Cap	Free-float
Style Indices	No	Yes	Yes	No	Yes	Yes	No	Yes
Reconstitution	Annually	Quarterly	Annually	Annually	Quarterly	Annually	Semi-annually	Annually
Established	NA*1	Jan-1984	1983	Dec-1990	June-1988	Dec-1987	Sept-1986	June-1988
% of Total Market Cap	85%	80%	84%	77%	60%	54%	71%	90%+
Index fund numbers	10	10	2	1	7	6	1	4
AuM market Share	7.7%	20.81%	2.65%	0.21%	28.33%	24.82%	1.54%	13.94%
ETF Traded volume market share	12.15%	10.64%	0.66%	0.06%	9.9%	58.49%	1.8%	6.31%
Index future numbers	NA	1	2	1	1	1	1	1
Open Interest market share	NA	35.68%	7.02%	0.51%	16.65%	26.31%	5.69%	8.13%

Notes: The index information is taken from the index providers' web sites.
The index number and AuM data is the sum of traditional index funds and ETFs.
The traditional index funds data is based on the information from the Top 100 AMCs ranked by the IPE (July/August 2005), as of 27/09/2005.
The ETF data used for calculation is mainly based on "Portfolio Trading & Index Strategy", Weekly Analysis, Deutsche Bank, 27/09/2005.
The index future data is calculated according to information from Eurex and Euronext Liffe, as of 27/09/2005.
*1 The inception dates are different. The Finland index was established in Dec. 1981, indices for Ireland, Greece and Portgual were set up in Dec. 1987 and the rest in Dec. 1969.

This table shows a comparison of broad market indices for European Countries. The information was obtained from the web sites of the index providers, investment fund prospectuses and the exchanges that operate a segment for ETFs ,as well as the futures markets.

Illustration 3:
Market Shares for European National Broad Market Indices



This illustration summarises the information in Table 4 with a focus on the market shares in terms of AuM and open interest.

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Industry Developments: What Index Providers Think About Alternative Construction Methodologies

Closely related to the technological limitations of the time, index construction methodology started with the relatively straightforward geometric and arithmetic mean price-weighted system and progressed to the more sophisticated but relevant market capitalisation-weighted methodology. By accounting only for the number of shares issued, market capitalisation-weighted indices should better reflect market movements.

As mentioned in the earlier section, one criterion for a good index from practitioners' point of view is the possibility that their portfolios can realistically be selected from the benchmark. It is therefore essential that the stocks in the index are actually tradable. In recent years, as the amount of domestic and cross-border equity investments has risen, limited issuance in public shares and/or shares with foreign ownership restrictions has increased concerns for investors. It is not uncommon for large companies to make initial public offerings and partial privatisations with a low percentage of shares made available to the public. Hence, the free float weighting, which only accounts for the freely available shares for trading on the market, was developed to address the need to reflect the effective trading opportunities for investors more closely and thereby improve the investability of the indices.

Although the free float construction methodology has made a slight change to the measurement of component weights, the methodology is still essentially based on capitalisation weighting. Recently, some index providers have started to deviate more significantly from the concept of capitalisation weighting, proposing to actually weigh stocks using fundamental metrics. Here, we give an overview of industry initiatives to make changes in construction methodology towards both free float adjusted and fundamentally weighted indices.

Adoption of free float market capitalisation weighting

Back in 1989, Salomon Smith Barney introduced the Salomon Smith Barney Global Equity Indices (SSBGEI), the first fully float-weighted global equity index. To date, almost all the index providers have adopted free float weighting in the field of domestic indices or global indices following a big bang or phased-in changes.

Stoxx Limited undertook the adjusted moves with all its equity indices for free float in September 2000. Since June 15th, 2001 all FTSE equity indices have been fully free float weighted, but all its new constituents had been adjusted for free float restrictions since December 31st, 1999. Except for the average series still using the price-weighted method, Dow Jones has implemented free float for other indices. Other index providers like SWX and Deutsche Boerse announced the construction of their indices by free float in October 2002 and June 2002 respectively.

S&P only adopted full free float in its newly created global indices in 1997, as the market paid little attention to this matter. Along with further concerns caused by liquidity problems, S&P adjusted its U.S. section to fully free float in September 2005. Another example of the phased-in approach is MSCI, with the first adjustment in November 2001, followed by the second stage in June 2002 to increase target market representation at the same time. Moreover, free float weighting is also currently employed on some indices provided by Euronext, such as CAC 40.

Unlike other providers, Wilshire Associates keeps a full market capitalisation version, in addition to the free float version, for their Wilshire 5000 composite index.

Initiatives on fundamental metrics weighting

Compared with market capitalisation weighted indices, fundamental metrics weighted indices

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are based on the rationale that the company's share price must follow the company's underlying wealth. Providers of such indices claim that the construction method leads to lower volatility in the long run.

Following their announcement made on November 28th, 2005, FTSE and Research Affiliates LLC were the first to apply the fundamental metrics weighting method. The new series consists of the FTSE EAFI 1000, FTSE RAFI ex-U.S. and an additional 22 separate country indices; the universe of eligible constituents is the FTSE Global Equity Index Series (GEIS).

In addition, another initiative towards this weighting method taken by FTSE is conveyed by the announcement made on July 4th, 2005. Jointly working with Global Wealth Allocation Limited (GWA), FTSE has created nine new "non-price" strategy indices for the global equity market — constituents selected from the FTSE All-Share Index and FTSE Developed Index — by an indicator composed of net income, cash flow and book value. These indices effectively correspond to an active investment strategy in the index.

Dow Jones has created so-called "Select Dividend" indices, where the weighting of each company is determined by the annual net dividend yield, i.e., the annual dividend of that company divided by the total annual dividend of all index components. To avoid the index being influenced heavily by one company, the maximum weighting of one company is 15%. These select dividend indices are available at country level.

At present, other index providers such as MSCI and S&P currently have a reserved attitude towards the application of such weighting methodologies for the construction of indices. For example, MSCI points out that fundamental weighting methods are thought to be biased by the overweighting of the value companies, and S&P adheres to the free float adjusted market capitalisation weighting.

1.3. Conclusion

To conclude our review of the literature available on stock market indices, we would like to assert that despite their popularity, broad market indices have serious shortcomings, both in the context of asset allocation and performance measurement. When used in performance measurement, it should be kept in mind that broad market indices do not reflect the characteristics of managed portfolios and are not suitable for evaluating their performance, because they contain securities not included in the manager's portfolio. In addition, the proportions of each security in the indices are generally different from those chosen by the manager. Moreover, index style composition is not stable over time. A manager who selects a market index as a benchmark can see his risk exposure being modified over time. As a result, it may happen that his risk exposure no longer corresponds to his initial choices. The construction of customised benchmarks, therefore, appears to be the best way of providing managers with a benchmark suited to the style of their portfolio.

When used to support an investment, the shortcomings of broad market indices are equally apparent. In fact, if the market portfolio is not observable, one can be sure that the observed index does not constitute the optimal portfolio, which seriously questions the decision to hold this portfolio in the first place. The same is true if the broad index does not represent all of the systematic risk factors available on stock markets, or does not have a controllable exposure to these factors.

Consequently, a great many alternatives to capitalisation weighted market indices have been proposed. In the following sections, we

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will run some tests in order to come up with a statement on the quality of a few common market indices. We are also going to look at some of the alternatives and compare them against those indices. In section two, we test the purity of existing indices in terms of exposure to investment styles and industry sectors. In section three, we test the efficiency of global stock market indices and compare it against benchmarks that use asset allocations other than those implied in those market indices. These alternatives are based on portfolios of individual stocks rather than portfolios of style indices or sector indices in order to avoid a bias linked to a different universe of assets for the style/sector index, as against the market index.

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2. Lack of Stability

The goal of this section is to identify the evolution of the weights in a range of broad market indices. We conduct this analysis because investors are typically interested in the allocation between the different sub-categories of their equity portfolio. The most relevant sub-categories for equity investors are investment styles such as growth and value and industry sectors. This stems from the fact that size (large cap, small cap, etc) and style (growth, value) have been shown to explain a significant portion of the cross-sectional difference in expected stock returns (see section one of this study). Likewise, sectors of the industry are useful building blocks in the construction of equity portfolios, as different sectors of the economy have different exposure to the business cycle. As the portfolio composition by style and by sector directly impacts the risk and return properties of the portfolio, this decision requires considerable attention from investors. The choice of an index to support an investment implies the choice of an allocation, without making it explicit. Qualifying the type of style-/sector-allocation choices made when investing in an index is the main focus of this section. We test the stability of existing indices in terms of exposure to both investment styles and industry sectors.

Table 5: Overview of selected indices

European Country	Europe	Japan	United States
FTSE 100	Euro Stoxx 50 (Eurozone)	Nikkei 225	S&P 500
DAX 30	Euro Stoxx 300 (Eurozone)	Topix 500	Russell 2000
CAC 40	Stoxx 600 (Eurozone plus other European countries)		Dow Jones Industrials

2.1. The Data

2.1.1. Selection of Indices

The indices used in these studies are indices that reflect the broad market rather than some sub-segment of the equity market. We consider a host of indices for different regional zones. Our choice is driven by a concern over relevance in terms of choosing the indices that are the most widely used. Therefore, we concentrate on the household names, which coincide with the indices that have the highest AuM according to our market analysis provided in section one. In particular, we choose the indices indicated in Table 5.

This choice allows us to cover a wide set of indices for different categories, such as country indices for Europe, the U.S., and Japan, as well as regional indices for the Eurozone. On the other hand, taking groups of indices that are supposed to represent the same asset universe, such as competing U.S., Japanese and European indices, allows us to assess the difference in quality between competing indices. The following remark is necessary with regard to the Russell 2000 index. This index is actually constructed from the 2,000 stocks that follow the largest 1,000 stocks traded on U.S. markets. Therefore, the 1,000 largest capitalisation stocks are excluded from the composition of the Russell 2000, which means that this index deviates from the others in the sense that it is more a small cap segment index than a broad market index (the broad market equivalent would be the Russell 1000, which includes the 1,000 largest capitalisation stocks or the Russell 3000, which combines the constituents of the Russell 1000 and Russell 2000). Since the

2. Lack of Stability

Russell 2000 is widely used by institutional investors as a complement to a U.S. large cap index, the criterion of relevance still holds and we include the index in our analysis.

2.1.2. Period and Returns Data

We choose a ten-year period for our empirical tests. The period runs from October 1995 to September 2005. We choose this period in an attempt to cover the most recent data. The data used were the returns data for the broad market indices. We obtain price indices at monthly frequency from Datastream. In addition, we use the returns data for MSCI style indices that correspond to the regional coverage of the chosen index. We also use the set of corresponding sector indices, whenever they exist, in order to perform a sector analysis of these indices. In the following section, we describe our results.

2.2. Style Composition

2.2.1. Returns-based style analysis: Methodological remarks

In order to analyse style exposure of broad market indices, we choose to use returns-based style analysis. This method goes back to William Sharpe (1992). It is widely used to identify the holdings of mutual fund managers when the investor has information on the past returns of the fund but does not have full information on the fund holdings. Since the investor is particularly concerned about the possibility that the fund manager may deviate from his declared investment style, returns-based style analysis (RBSA) proves a useful tool for monitoring the manager. Our objective is somewhat different. We observe index returns and are interested in the question of the stability of the exposures that are implicit in the broad market index. As outlined in the literature review, the investor's concern here is that passively holding an index may lead to implicit bets on the performance of different investment styles that may not correspond to the decision the investor would state explicitly. In particular, holding a broad market index is typically understood to amount to holding a neutral exposure to different investment styles. Our concern is to check whether the exposure implicit in the indices is stable over time and balanced at any given point in time.

In order to conduct RBSA , we need to specify the factors we use in order to represent different investment styles. However, the problem of selecting the securities that are included in the style index composition is well known. While any classification is arbitrary, a major issue when classifying stock into the growth and value categories is that the attributes that characterise the style of the stocks contained in an index are not necessarily stable over time. In addition, it is difficult to integrate all information into a classification scheme (for example, a stock with a low P/E ratio could be an undervalued growth stock or a value stock). In this context, it currently seems that there is no index that dominates the market. In addition, the implementation of style indices is subject to intense competition, whether in the American market (notably Frank Russell, Wilshire Associates, Barra-S&P and Prudential Securities) or the international market (Boston International Advisors (BIA) have created style indices for 21 different countries and 7 regional zones; Parametric Portfolio Associates, their competitor, offer the

2. Lack of Stability

same set of indices). The result of the competition is that the references that make up the indices are very different from one another, both in terms of composition and return. This diversity therefore poses the problem of the representativeness of style indices.

We choose to use the MSCI Growth, Value and Small Cap indices for the following analysis. This provides the advantage that we have a geographically exhaustive range of style indices that can be used for all the indices we study. In addition, since May 30th, 2003, MSCI is using a style classification which relies on the use of multiple attributes. In particular MSCI uses three variables for the value classification and five for the growth classification. MSCI states the explicit goal of having an equal weighting between value and growth indices in terms of free float adjusted market capitalisation at country index level. Prior to May 30th, 2003, the MSCI indices used the Book-to-Market ratio as the sole factor for dividing the MSCI country indices into value and growth categories. Another advantage is that the three style indices for a given geographic region (growth, value and small cap) are mutually exclusive, which is a prerequisite for style factors in an RBSA.

We use the growth, Value and Small Cap counterparts for the corresponding country/regional indices, as indicated in Table 6.

Table 6:
Overview of selected style indices

European Country	Europe	Japan	United States
MSCI U.K.	MSCI EMU (Eurozone)	MSCI Japan	MSCI USA
MSCI Germany	MSCI Europe (Eurozone plus other European countries)		
MSCI France			

We estimate the vector of style exposures $\varpi = (\varpi_1, \varpi_2, \varpi_3)'$ where ϖ_1 is the exposure to growth, ϖ_2 the exposure to value and ϖ_3 the exposure to small cap in the linear model

$$r = \lambda\varpi + \epsilon$$

where r denotes the T x 1 vector of return observations for the broad market index, λ denotes the T x 3 matrix of return observations for the style indices, and ϵ denotes the vector of errors (return differential between the style benchmark and the broad market index). We denote the demeaned errors $\epsilon - E(\epsilon)$ by e. The estimate of style exposures ϖ is obtained by minimising the sum of squared errors e'e.

The RBSA method is problematic, because we use some overlapping data in each style analysis. This has a tendency to underestimate the style shifts in the index that actually occur. In order to analyse the style analysis with a more reactive tool, we use the method introduced by Vaissié and Ziemann (2005). They introduce a tool for conditional analysis called the Switching Kalman Smoother (SKS). The Vaissié-Ziemann SKS takes the form of a two-step procedure that combines Switching Regime Models with the Kalman Smoother. This new method accounts for both abrupt structural changes in the style composition of an index and smooth temporary evolution of the style exposures. We prefer the simple Kalman filter combined with a Kalman Smoother over the SKS method advocated by Vaissié and Ziemann for the following reasons. First, their method requires too many computational resources in the context of our data set. Second, the SKS was created for mutual fund holdings, where the logic of structural breaks in the allocation is more

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convincing than in the case of stock market indices, where — by construction — no abrupt allocation shifts occur. By applying the Kalman filter combined with a Kalman Smoother, we can obtain the style exposure over the entire period, as opposed to the classic RBSA, where we cannot show any results for the initial calibration period of 36 months. In addition, the use of the Kalman Smoother enables us to filter out the noise in the changes of style exposure and show only the smooth evolution of style weights. Details on all of these statistical tools can be found in the original paper by Vaissié and Ziemann (2005).

The following remark should be made concerning the frequency of the returns data. The returns data used is with monthly frequency since the MSCI style indices are available with monthly frequency. We are limited to the ten-year period for reasons of availability of the EMU and Europe indices. It is not possible to use daily data since the MSCI style indices are not available with daily frequency over the whole period. It should be noted that the use of monthly frequency limits our analysis, as we run our tests with a low number of observations. This forces us to use a long time span in order to estimate the exposures. Using daily or weekly data would allow us to observe possible style shifts over short periods. Therefore, we can state that our analysis will underestimate the variability of the style exposure by only reflecting the long-term changes. However, these are also the types of changes that are most relevant to the investor. We will now turn to the results obtained for each set of indices with both methods of returns-based style analysis.

2.2.2. The results for broad market indices

The results below indicate the style exposure obtained from classic returns-based style analysis of stock market indices. The data used is for the ten-year period mentioned above. In order to estimate the style weights, we use a calibration period of 36 months. Then we repeat the style analysis every month, rolling forward the data used for calibration. As a result, we obtain style exposures for the seven-year period following the initial calibration period (October 1998 to September 2005). In addition, we include the results obtained when applying a Kalman filter and a Kalman Smoother to the regression. The exposures obtained with the Kalman methodology are shown for the entire period (October 1995 to September 2005).

It should be noted that our analysis is primarily concerned with providing evidence of the variability of shifts in style exposure rather than assessing the level of the exposures. It can be seen that the levels of exposure show pronounced differences on certain dates for certain indices. Looking at the overall variation, however, we see that the weights obtained with the Kalman methodology confirm the results from the classic RBSA. The weights obtained with the Kalman Smoother methodology also show an evolution of the weights that is less erratic when compared to the classic RBSA method. However, the Kalman Smoother analysis still shows some pronounced variations of style exposures for the majority of the indices.

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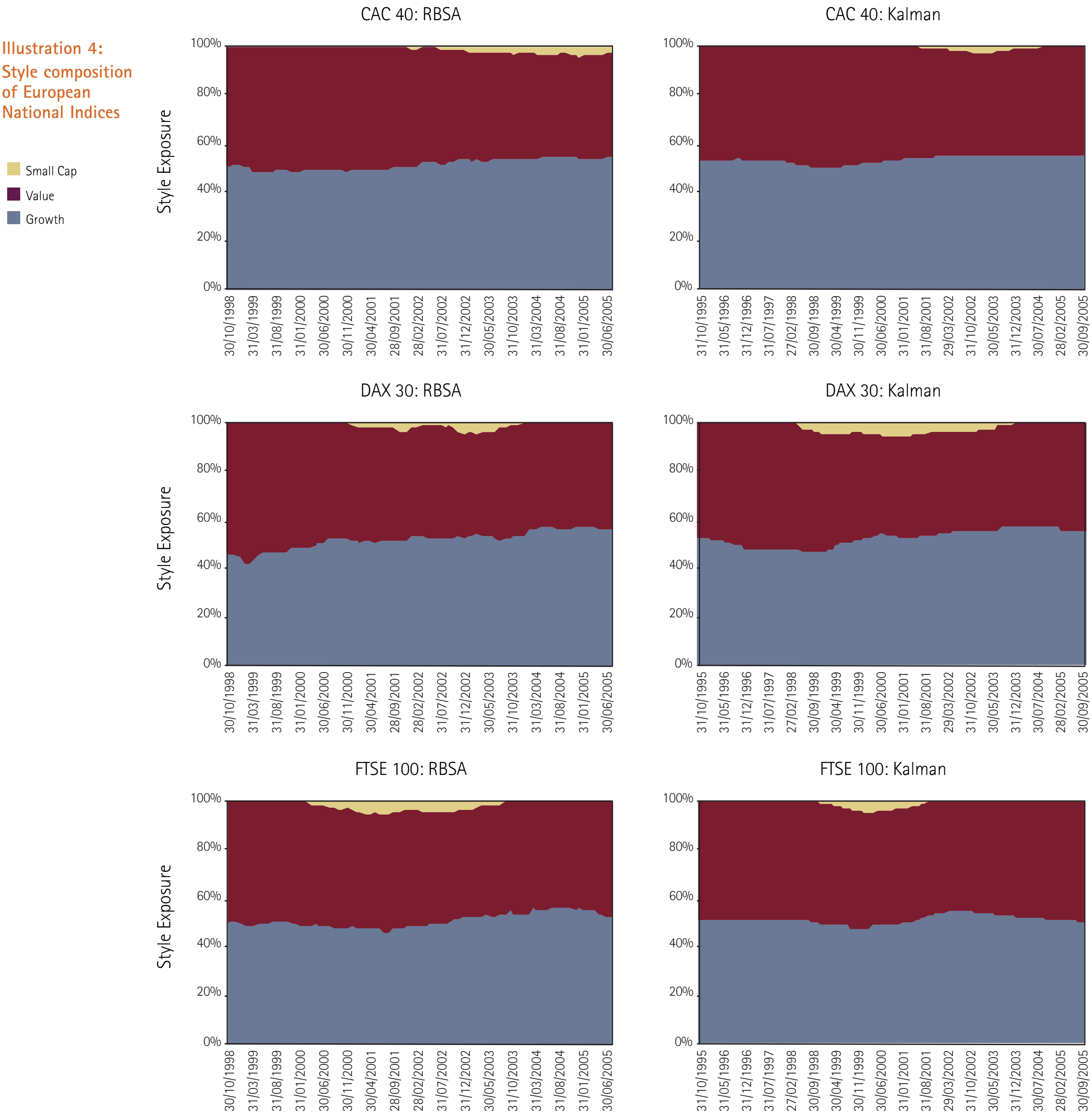
The results obtained for each index are indicated below, with a sub-section dedicated to the description of the results obtained for the indices of each geographical zone.

European Country Indices

The graphs below indicate the evolution of style weights for the three European country indices: the CAC 40 for France, the Dax 30 for Germany and the FTSE 100 for the U.K.

Illustration 4: Style composition of European National Indices



This illustration shows the style composition of the CAC 40, the Dax 30 and the FTSE 100. The left-hand side shows the style weights obtained by a classic RBSA over the period of 10/1998 to 09/2005. The style weights are based on a calibration period of 36 months for the RBSA model. The right-hand side graphs show the style weights obtained from an RBSA using the Kalman Smoother, which enables the weights over the entire period of 10/1995 to 09/2005 to be displayed.

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When looking at the results for the classic RBSA, it can be seen that the style exposures of these three indices evolve in a rather parallel manner over the period studied. The weights of the growth and value styles show some variation over time. While the graphs may look rather smooth, it should be highlighted that the exposures to styles can be completely different from one point in time to the other. For example, the maximum exposure to growth is 55% for the CAC 40 whereas the minimum is 48%. For the Dax, the difference in exposure is even more significant, with a maximum of 52% and a minimum of 41%. For the FTSE 100, these figures are 56% and 47%. The exposure to value also shows considerable variation across all indices. Again, the Dax shows the most variation, with a maximum exposure of 58%, and a minimum exposure of 42%. Another interesting point is the exposure to small cap. A significant exposure to the risk of small capitalisation stocks is not expected for any of these indices, as they concentrate on a rather restrained blue chip segment of the stock market. However, all of these indices post a positive exposure in the order of three to six percent. Furthermore, this exposure occurs at different points in time. For example, the CAC 40 begins to show exposure to small cap at the end of 2002, while the FTSE 100 has a positive weight for small caps from the beginning of 2000. The exposures from the Kalman method confirm these results.

European Regional Indices

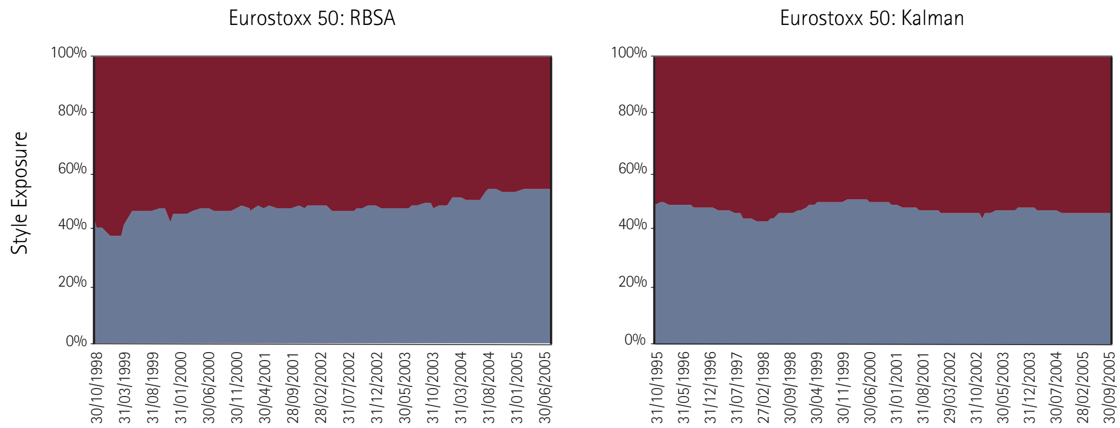
Below we reveal the variation of style weights for three European regional indices, two indices for the Euro zone and one which also includes non-Euro countries. These three indices have considerable differences in terms of their constituents. The Euro Stoxx 50 only covers the 50 largest capitalisation stocks of the Euro zone, while its broader counterpart, the Euro Stoxx 300, includes an additional 250 stocks. Finally, the Stoxx index covers additional components from non-Euro countries, with a constituent list of 600 stocks.

It should be noted that we were unable to include the small cap indices for this particular group of indices, since the Eurozone/Europe small cap indices from MSCI are not available over the whole period analysed.

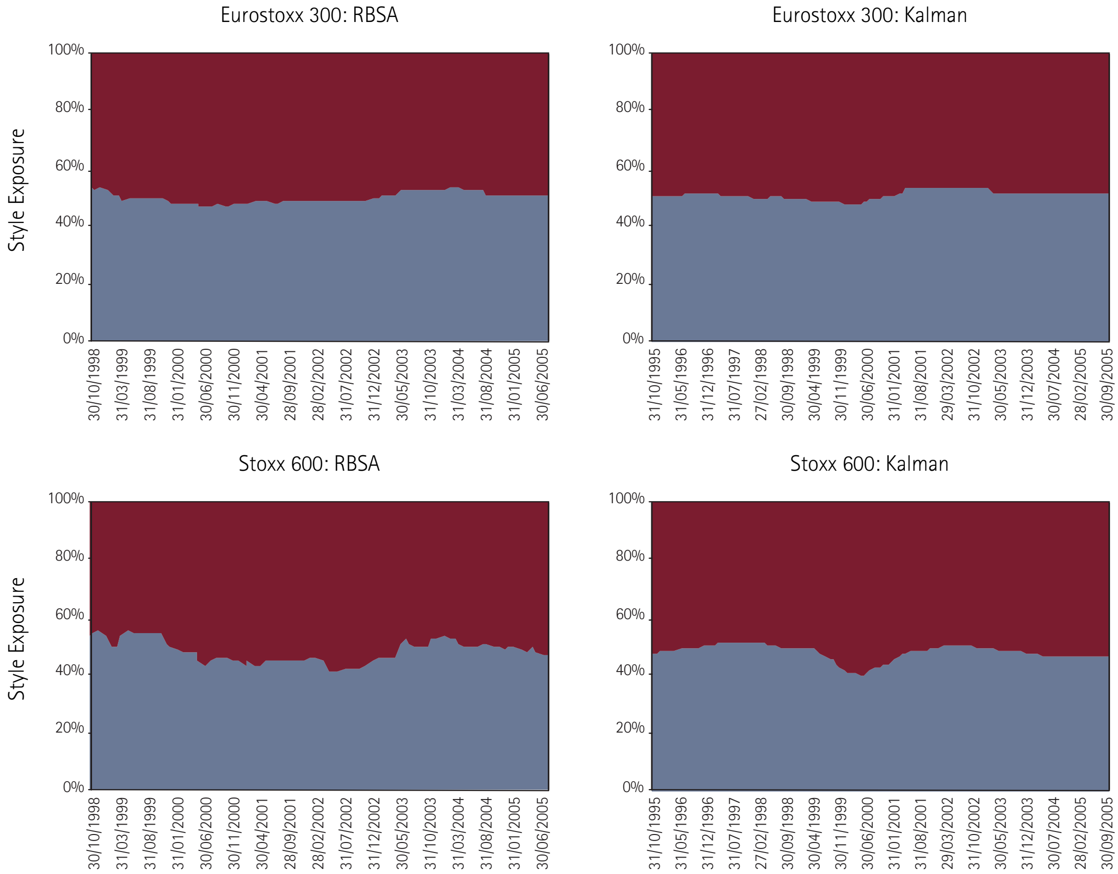
When it comes to the estimated style exposure, the indices can be seen to behave quite differently from one another. The Euro Stoxx 50 shows style variations that are comparable in

Illustration 5: Style Composition of the European Regional Indices

Small Cap
Value
Growth



2. Lack of Stability



This illustration shows the style composition of the Euro Stoxx 50, the Euro Stoxx and the Stoxx 600 indices. The left-hand side shows the style weights obtained by a classic RBSA over the period of 10/1998 to 09/2005. The style weights are based on a calibration period of 36 months for the RBSA model. The right-hand side graphs show the style weights obtained from an RBSA using the Kalman Smoother, which enables the weights over the entire period of 10/1995 to 09/2005 to be displayed.

magnitude to the country indices discussed above. The exposure to growth (value) varies from 51% to 43% (57% to 49%). The variations for the larger Euro Stoxx 300 index are less significant with the growth (value) exposure ranging from 53% to 48% (52% to 47%). The larger Stoxx 600 index, on the other hand, poses serious problems for investors seeking a stable style allocation, as its growth/value composition evolves from 52/48 to 40/60, i.e., from a small growth bias to a sharp value bias.

Japanese Indices

In our choice of indices, we include two indices for the Japanese stock market: the Nikkei 225 and the broader Topix 500.

An initial observation is that the value exposure of both indices is very pronounced. In fact, for both indices, the weight for value attains levels above 60% and never drops significantly below 50%. This may not be surprising given the stale performance of the Japanese stock market over the last decade. More importantly, compared to the indices previously analysed, both indices show dramatic variations in style exposure over time. For example, the exposure to growth varies from 33% to 4% for the Nikkei, and from 46% to 43% for the Topix for the classic RBSA. A surprising finding is that the small cap exposure for the narrower Nikkei is actually higher than that of the larger Topix. In summary, it can be said that a controlled

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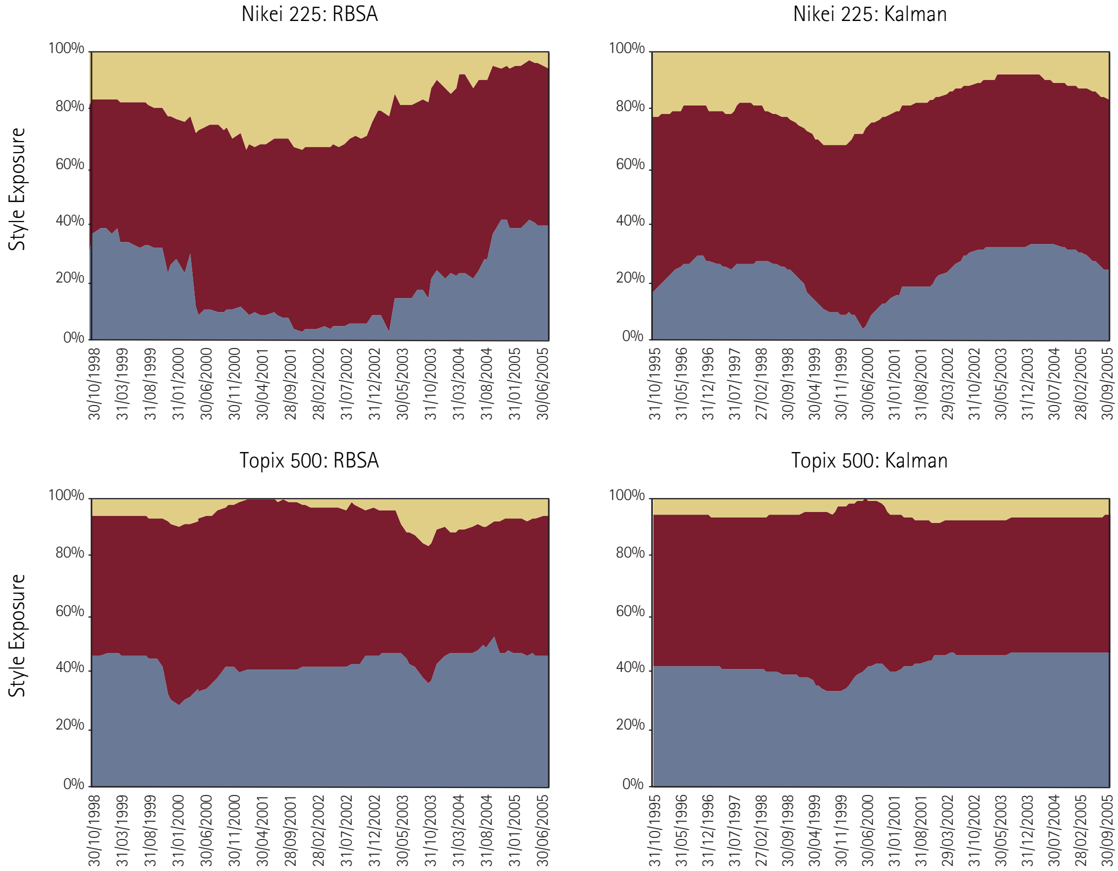
Illustration 6: Style Composition of Japanese Indices

Small Cap
Value
Growth



This illustration shows the style composition of the Nikkei 225 and the Topix 500 indices. The left-hand side shows the style weights obtained by a classic RBSA over the period of 10/1998 to 09/2005. The style weights are based on a calibration period of 36 months for the RBSA model. The right-hand side graphs show the style weights obtained from an RBSA using the Kalman smoother, which enables the weights over the entire period of 10/1995 to 09/2005 to be displayed.

exposure to different styles could not have been achieved by investing in these indices.

U.S. indices

For the U.S., we analyse three popular indices. By far the most relevant index for investors is of course the S&P 500. In addition, we look at the style composition of the Russell 2000 index, which includes the 2000 stocks following the 1000 largest capitalisation stocks. We also include the Dow Jones Industrials, which is constructed as a price-weighted average of 30 stocks.

The S&P 500 appears to be rather stable in its style composition. This justifies its use as the predominant underlying instrument for index funds and index futures. However, slight variations in style exposure do occur. The growth and value exposures vary over a range of 3%. Likewise, the small cap exposure takes on values between 1.7% and 3.8% approximately. In addition, it should be noted that the S&P has constantly been tilted towards the growth style, which takes on values between 50% and 53%. The benefits of the construction methods of the S&P 500 can be seen immediately when this index is compared to the Dow Jones Industrials. The price weighting of only 30 stocks in the Dow Jones Industrials leads to a very unstable and unbalanced exposure to styles. While the

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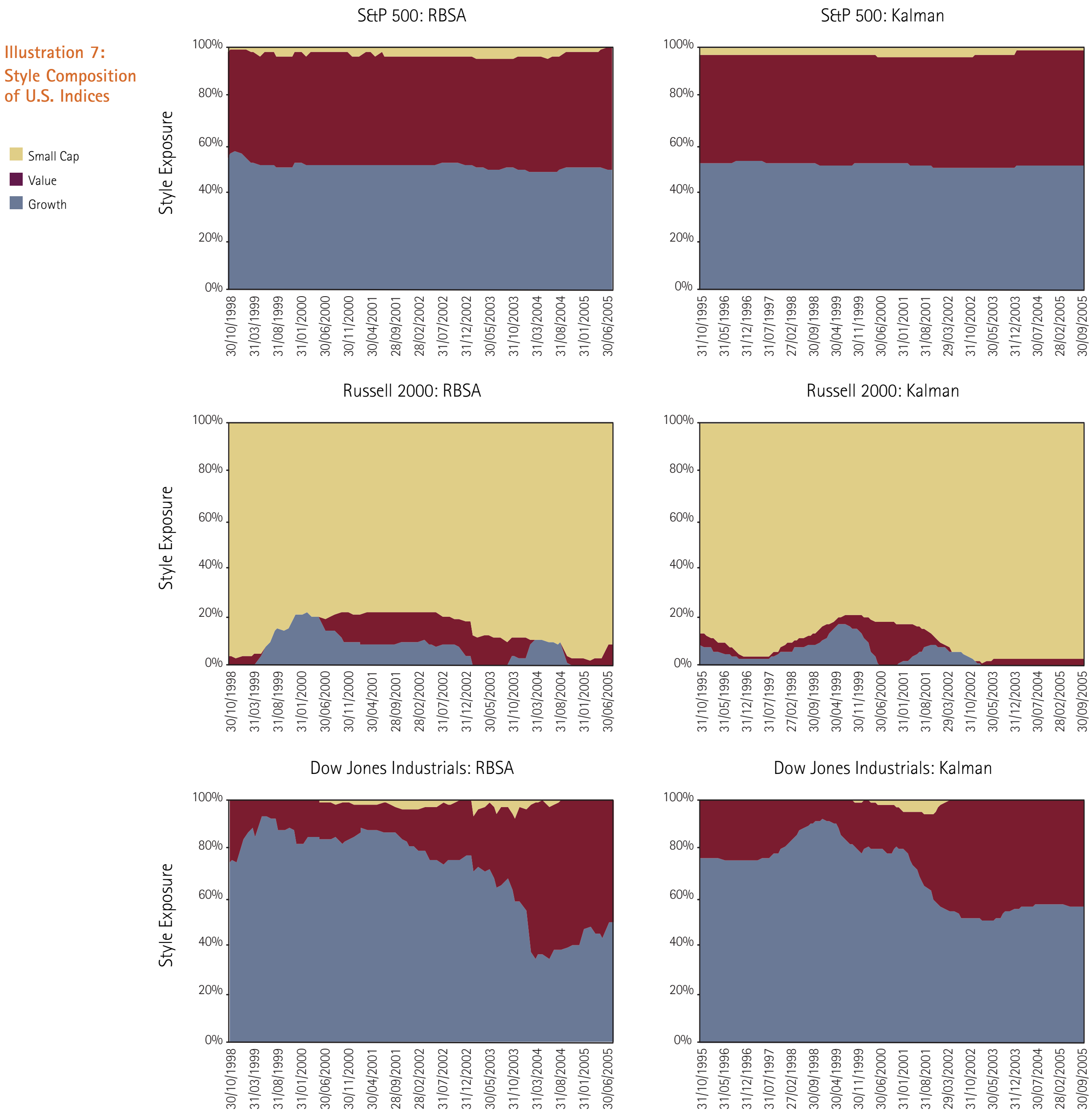
Illustration 7: Style Composition of U.S. Indices



This illustration shows the style composition of the S&P 500, the Russell 2000, and the Dow Jones Industrial Average indices. The left-hand side shows the style weights obtained by a classic RBSA over the period of 10/1998 to 09/2005. The style weights are based on a calibration period of 36 months for the RBSA model. The right-hand side graphs show the style weights obtained from an RBSA using the Kalman smoother, which enables the weights over the entire period of 10/1995 to 09/2005 to be displayed.

appearance of small cap exposure for this index does not seem to be very consistent with its market coverage, the variations between growth and value exposure are a point of major concern. The weights for growth and value fluctuate by amounts of 40%. Thus, the index switches from a 90% exposure to growth to an equally weighted composition between growth and value.

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The style analysis of returns on the Russell 2000 index confirms the small cap orientation that can be expected from this index. However, two sources of style variation are a concern to investors, who want to maintain a stable allocation over time. First, the exposure to small cap varies over time and takes on values ranging from almost 100% to approximately just 75%. This means that the Russell is a pure small cap index in some periods, but takes on large cap risks in other periods, as represented by the exposure to value and growth indices. Second, the composition of the residual exposure to large cap risk varies between value and growth, ranging from being composed entirely of growth exposure to being composed entirely of value exposure.

Conclusion on style stability

From our analysis, it can be seen that exposures to style factors show considerable variations over time. In addition to comparing the intensity of the style drifts (the style instability) of the different indices, we calculate the style drift score proposed by Idzorek and Bertsch (2004)[2], defined as

$$D = \sum_{k=1}^{3} \sigma_k^2$$

where σ_k^2 denotes the variance of the style exposure ϖ_k over time. This approach allows us to rank the different indices by the variability of the style weights over time. From the following table, it can be seen that the Dow Jones Industrials index and the Nikkei 225 are the least stable indices. The S&P 500, on the other hand, is the most stable. Broadly speaking, the results in the following table confirm the result from inspection of the graphs above.

The style drifts of the indices are of concern to investors since we can conclude that broad market indices constitute specific choices of risk factors rather than a "neutral" risk exposure. This means that investors who passively hold an index or managers who select a market index as a benchmark can see their risk exposure being modified through time. As a result, it may happen that their risk exposure no longer corresponds to the initial asset allocation and thus no longer corresponds to their initial choice of risks.

Table 7:
Style Drift Score based on style exposures

	Sharpe RBSA	Kalman RBSA
Cac 40	4.2%	3.3%
DAX 30	5.5%	5.6%
FTSE 100	4.2%	3%
DJ EuroStoxx 50	4.9%	2.7%
DJ EuroStoxx 300	2.6%	2.1%
DJ Stoxx 600	5.5%	4%
Nikkei 225	17.6%	11.1%
Topix 500	8.2%	6.2%
S&P 500	2.3%	1.5%
Russell 2000	11%	9.3%
Dow Jones Industrials 30	26%	19%

Results for the style weights indicated in Illustrations 4, 5, 6 and 7. The column "Sharpe RBSA" shows the variability of the weights given in the left-hand side graphs of Illustrations 4, 5, 6 and 7. The column "Kalman RBSA" indicates the variability of the weights shown in the right-hand side graphs of Illustrations 4, 5, 6 and 7. The style drift indicator is calculated according to the method of Idzorek and Bertsch described in the text.

2.3. Sector Stability

In addition to style weights, we identify the evolution of sector weights in an index. As outlined above, the sector composition of a portfolio is a factor that investors typically would like to control in a similar manner to the style exposure.

2.3.1. Methodological comments

The evolution of sector weights is obtained from the market capitalisation of each sector and its evolution, rather than the returns-

[2] Idzorek, T. and F. Bertsch, "The Style Drift Score", *Journal of Portfolio Management*, 2004.

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based methodology above. This holdings-based analysis has the advantage that we can actually observe – rather than estimate – the exposures of the indices. Rather than looking at the composition of the index by individual component securities, we find sector indices that correspond to the broad market index and assess the market value of these indices. We obtain the market value of sector indices from Datastream and calculate the sector weight as:

"market value of sector i" / "market value of all sectors".

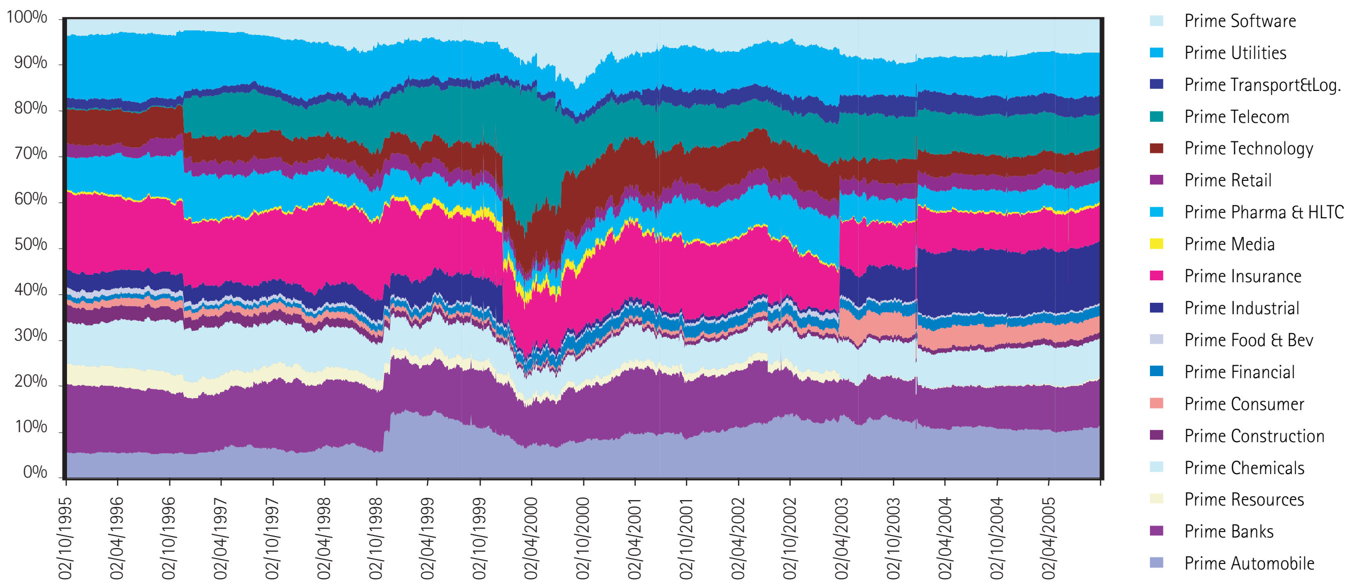
As we were unable to find the sector indices for all indices, we present a limited number of indices. Where the precise sector indices are available, our analysis is actually equivalent to an analysis of the individual component securities, since the sector indices are mutually exclusive, and combining the sector indices into one portfolio where each sector index is weighted with its market value yields the broad index composition. In some cases, sector indices were not available for the index considered in this study, but for a broader one including this index. In this case, we still assess the sector composition of this broader index. The following list indicates which indices were used:

Table 8:
Data on Sector Indices

Geographical Zone	Index
Germany	Prime All Share Index 380
U.K.	FTSE All Share Index 700
Eurozone	DJ Euro Stoxx 300
Europe	DJ Stoxx 600
Japan	Topix 1666
USA	S&P 500

The period considered is the full ten-year period from 10/1995 to 09/2005. The sectors covered for each index are indicated in the graph for the respective sector composition.

Illustration 8:
Sector composition of the German index



The graph indicates the sector composition calculated as the relative market capitalisation weight over the entire sample period of 10/1995 to 09/2005. It is based on the daily observations for the market value of sector indices obtained from Datastream Thomson Financial. The industry sectors used are displayed in the legend on the right-hand side of the graph.

2. Lack of Stability

2.3.2. European countries

Germany

The index for which sub-sector indices are available is the Prime All Share Index. This index is made up of 380 shares listed on Prime Standard, including the 30 shares of the DAX 30. This index is subdivided into 18 sector indices.

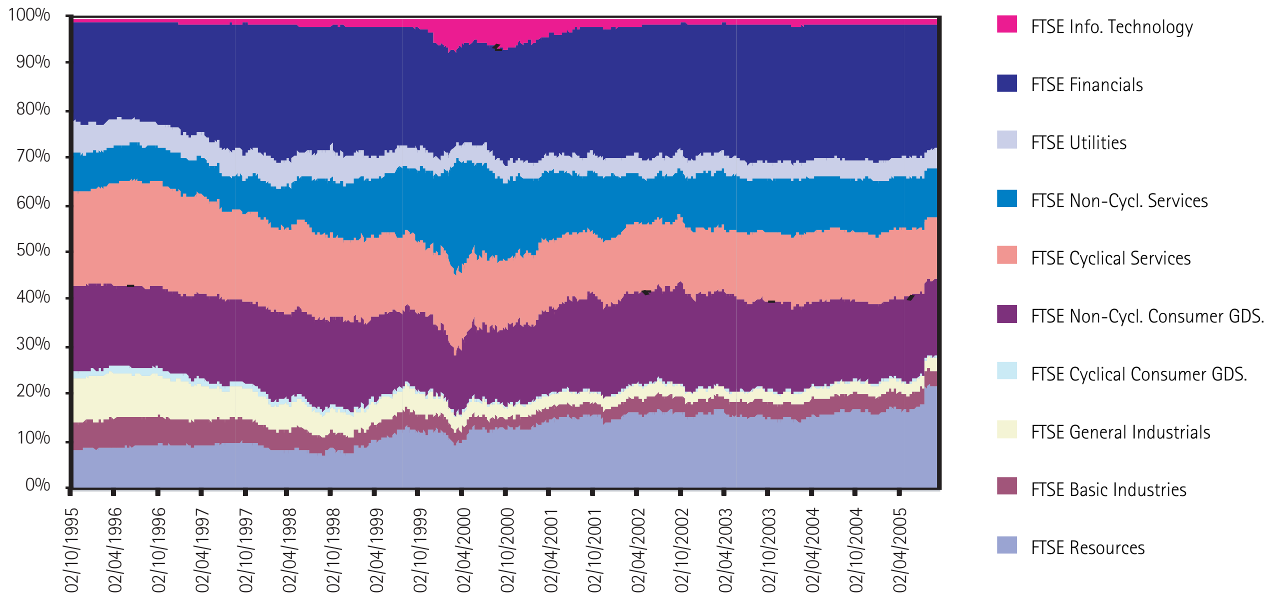
The chart shows that the German index undergoes significant changes in style, notably for the telecom sector, which has a weight of approximately 25% in 2000 and then falls to less than 10%. Other sectors also show significant variations, such as the automobile sector, which constitutes 5% of the index during the first three years, and, following the restructuring of the German automobile industry and the improved results of the sector's corporations, takes on a share of approximately 15% in the index. The software sector parallels the trend observed in the telecom sector but actually still increases over the ten-year period from 2.5% to more than 5%.

United Kingdom

The index for which sub-sector indices are available is the FTSE All Share Index. This index is made up of the 700 largest companies on the London Stock Exchange, including the shares of the FTSE 100. It is subdivided into 10 sector indices.

The variability of sector exposures is more directly apparent than in the German case, as the index is subdivided into fewer categories. The most variable sector exposures are for the information technology and resources sectors, but all other sectors show considerable variation.

Illustration 9:
Sector composition of the U.K. index



The graph indicates the sector composition calculated as the relative market capitalisation weight over the entire sample period of 10/1995 to 09/2005. It is based on the daily observations for the market value of sector indices obtained from Datastream Thomson Financial. The industry sectors used are displayed in the legend on the right-hand side of the graph.

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2.3.3. Eurozone and Europe Indices

DJ Euro Stoxx 300

The DJ Euro Stoxx 300 index is subdivided into 18 sector indices. As the data were not available for the whole period for three of them, we restricted our study to the relative variation of the 15 other indices. The three sectors excluded were: Personal & Household Goods, Retail and Travel & Leisure.

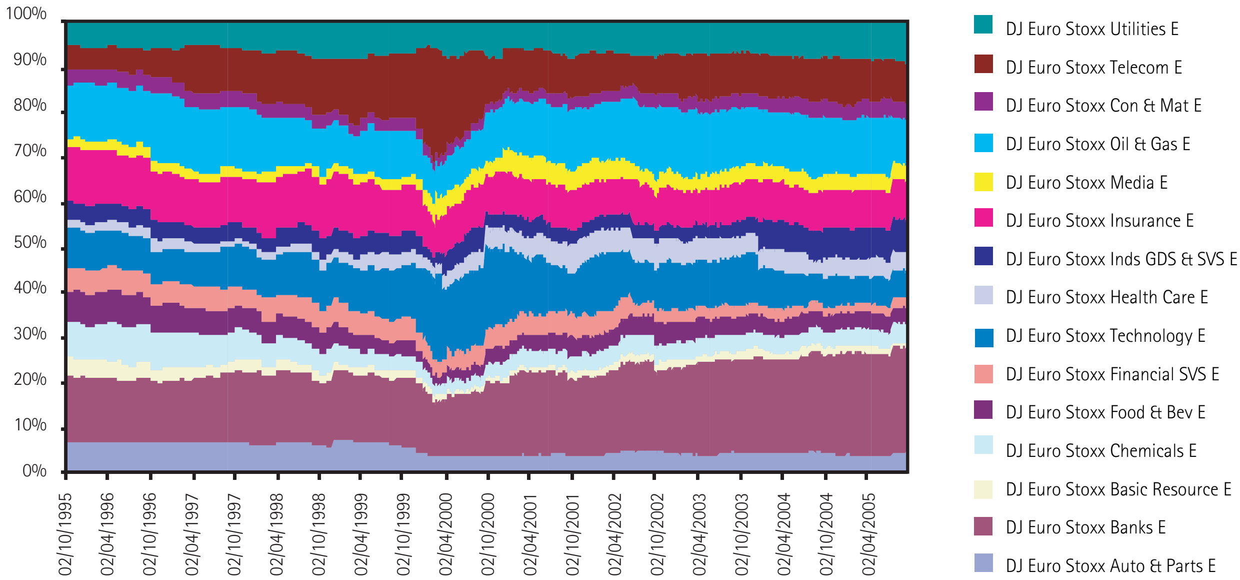
Again, the variation of the telecom sector is the most significant. The basic resources show a somewhat conflicting perspective compared to the analysis for the FTSE. Most sectors show considerable variation with regard to their weight in the global index.

DJ Stoxx 600

The DJ Stoxx 600 is subdivided into the same 18 sector indices as the DJ Euro Stoxx. Again the data were not available for the whole period for the same three sector indices as with the DJ Euro Stoxx (Personal & Household Goods, Retail and Travel & Leisure); we therefore restricted our study to the relative variation of the 15 other indices.

When comparing the sector composition of the two European indices, it appears that they are quite similar. This is a notable difference to the style exposure above, where significant differences occur.

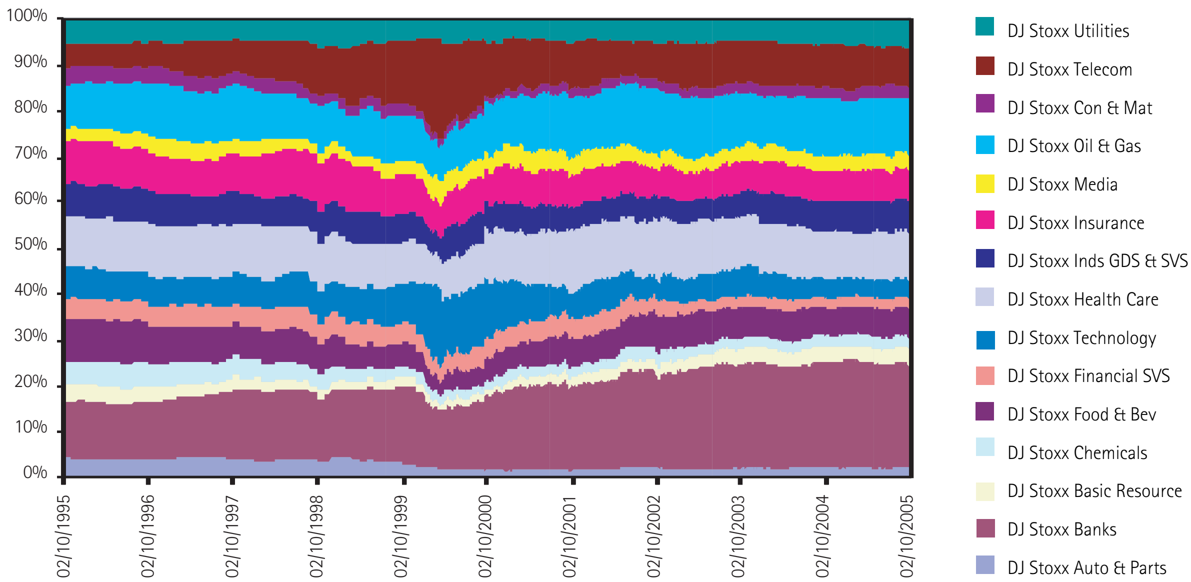
Illustration 10:
Sector composition of the Eurozone index



The graph indicates the sector composition calculated as the relative market capitalisation weight over the entire sample period of 10/1995 to 09/2005. It is based on the daily observations for the market value of sector indices obtained from Datastream Thomson Financial. The industry sectors used are displayed in the legend on the right-hand side of the graph.

2. Lack of Stability

Illustration 11:
Sector composition of the European index



The graph indicates the sector composition calculated as the relative market capitalisation weight over the entire sample period of 10/1995 to 09/2005. It is based on the daily observations for the market value of sector indices obtained from Datastream Thomson Financial. The industry sectors used are displayed in the legend on the right-hand side of the graph.

2.3.4. Japan

Topix

The index for which sector indices are available is the Topix index, which is the largest index in the TOPIX family, which is made up of all domestic common stocks listed on the TSE first section, i.e., 1,666 shares at the time of the analysis. This index is subdivided into 33 sector indices.

The Topix index shows considerable variation of the sector weights. In this index, the banking sector shows a very significant evolution over time, which may be linked to the macroeconomic specificities of the Japanese economy over this period. The expansion and contraction of the weight of the technology sector occurs in this index, comparable to the previous ones.

2.3.5. United States

S&P 500

The S&P 500 is subdivided into 10 sector indices. Illustration 13 gives a graphical overview of the evolution of sector weights over our sample period.

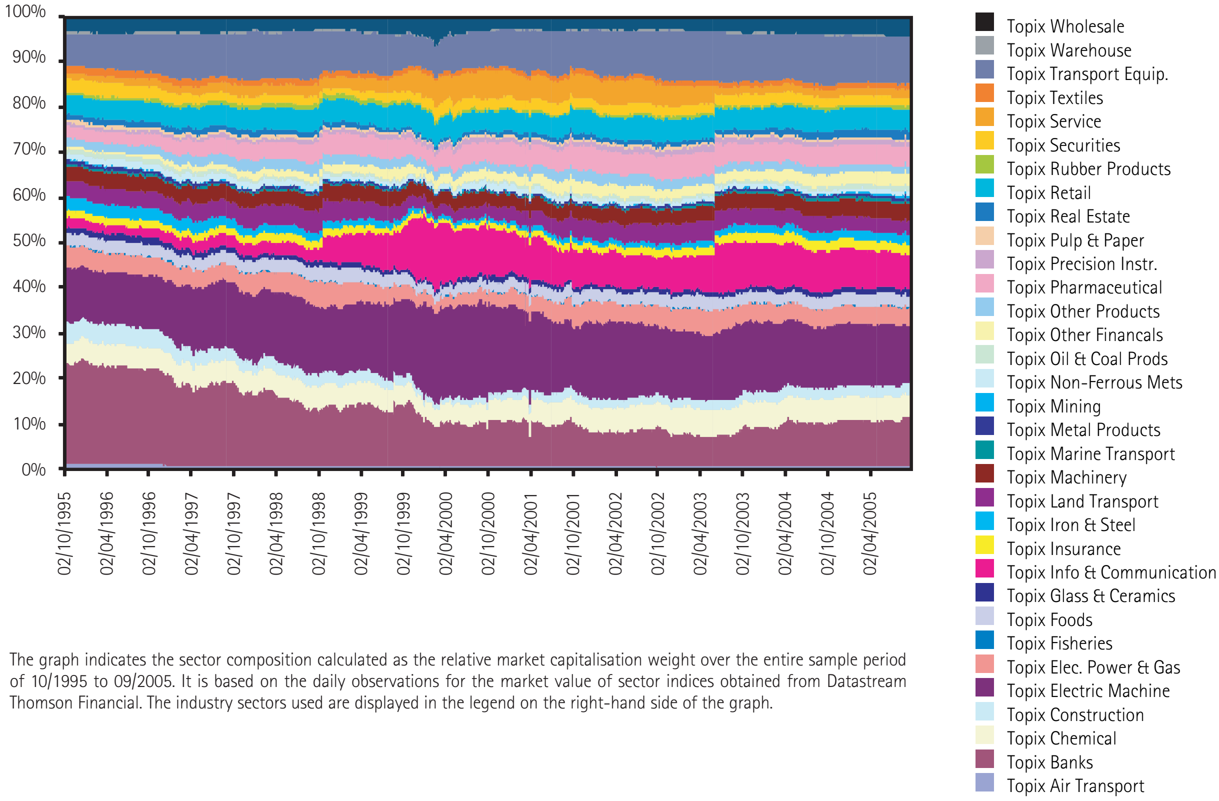
The S&P 500 again shows the evolution of the telecom sectors that was observed for the previous indices. Important changes in weight also occur for the telecom services sector and the materials sector.

2.3.6. Conclusion on sector exposure

Similar to the analysis on style exposure, our sector analysis shows that the risk exposures, this time represented by different industry sectors, vary over time, exposing investors to

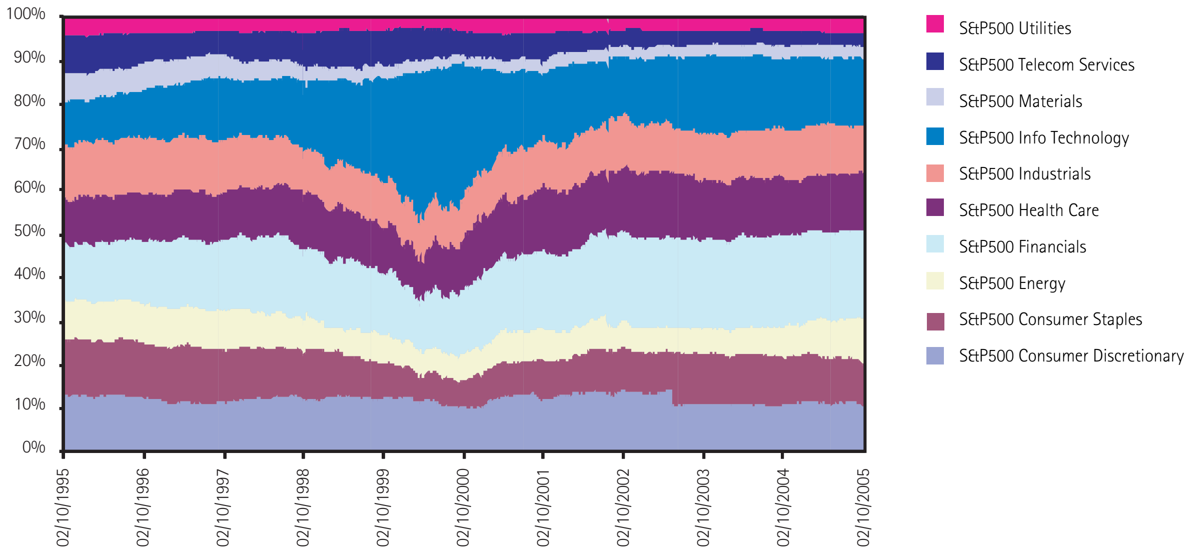
2. Lack of Stability

Illustration 12:
Sector composition of the Japanese index



The graph indicates the sector composition calculated as the relative market capitalisation weight over the entire sample period of 10/1995 to 09/2005. It is based on the daily observations for the market value of sector indices obtained from Datastream Thomson Financial. The industry sectors used are displayed in the legend on the right-hand side of the graph.

Illustration 13:
Sector composition of the American index



The graph indicates the sector composition calculated as the relative market capitalisation weight over the entire sample period of 10/1995 to 09/2005. It is based on the daily observations for the market value of sector indices obtained from Datastream Thomson Financial. The industry sectors used are displayed in the legend on the right-hand side of the graph.

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implicit sector allocation decisions which they do not control. Specifically, significant modifications of exposure can be observed for each sector around the year 2000, when the internet bubble exploded. This was followed by a decrease in the exposure of sectors related to new technology (telecom, internet, software). It should be noted that abrupt changes in sector exposure also occur; this stems from the impact of rebalancing the global index. These abrupt changes can be seen, for example for the Topix index, by the vertical dashes in the graph.

In order to summarise the variability of sector exposure by a single indicator, we apply the style drift score used above to the variation of sector weights. Out of a concern for consistency and comparability of the results with those relating to style exposure, we only consider the capitalisation weight of each sector at the beginning of each month. The following table shows the style drift indicator for the six indices used.

It should be noted that all indices show considerable variability of sector weights. The German index (the Prime All Shares) has the highest variability of sector weights. The remaining indices show comparable variability,

Table 9:
Sector Drift Score based on sector capitalisations

Geographical Zone	Index	Style Drift Score
Germany	Prime All Share Index 380	10.4%
United Kingdom	FTSE All Share Index 700	7.1%
Eurozone	DJ Euro Stoxx 300	7.2%
Europe	DJ Stoxx 600	6.6%
Japan	Topix 1666	7%
USA	S&P 500	7.3%

Table based on the sector capitalisation weights shown in Illustrations 8, 9, 10, 11, 12 and 13. These sector weights are based on the capitalisations for the period of October 1995 to September 2005. The style drift indicator is calculated according to the method of Idzorek and Bertsch described in the text.

with the Stoxx 600 showing the lowest value among all indices. It should be noted that while the technology bubble and its burst have contributed significantly to the instability of sector weights over the period we consider, even in relatively calm periods, variations in sector weights do occur.

2.3.7. Variability of exposures and market volatility

While we observe differences in both style and sector exposures between different indices, it should be noted that our indices cover stock universes that are quite different in terms of regional reference. Therefore, the different style drift scores could stem from inherent differences in the stock market that the index covers rather than from poor index construction. One factor that may cause variability of style exposures is stock market volatility. Therefore, it could simply be the case that the differences in style variability stem from different levels of returns volatility for the indices. In order to assess this question in further detail, we concentrate on the indices used in the style analyses rather than the sector analysis. This allows us to keep a larger population of indices. In addition, it allows for a more direct comparison, since the styles and the number of styles are essentially the same across the indices, whereas the decomposition by sector varies greatly depending on the index. Table 10 below shows the results of this exercise.

Table 10 shows the style drift scores and the returns volatility for the eleven indices in our sample. The table also shows the ranks in terms of style drift score and in terms of returns volatility for those indices. From Table 10, it can be seen that returns volatility does not seem to be sufficient in explaining the differences in style drift scores. For example, the indices that

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Table 10:
Style Drift Score and Returns Volatility

	Style Drift Score from Sharpe RBSA	Returns Volatility	Rank Style Drift Score	Rank Volatility
Cac 40	4.2%	20.4%	8	3
DAX 30	5.5%	24.7%	6	1
FTSE 100	4.2%	13.9%	9	11
DJ Euro Stoxx 50	4.9%	20.7%	7	2
DJ Euro Stoxx 300	2.6%	19.8%	10	5
DJ Stoxx 600	5.5%	16.8%	5	7
Nikkei 225	17.6%	18.9%	2	6
Topix 500	8.2%	16.7%	4	8
S&P 500	2.3%	15.6%	11	10
Russell 2000	11%	20.2%	3	4
Dow Jones Industrials 30	26%	15.9%	1	9

Table based on style weights shown in Illustrations 4, 5, 6 and 7. Volatilities are based on the monthly returns for the period of October 1995 to September 2005.

are ranked 1 to 3 (9 to 11) in terms of volatility have ranks 6, 7 and 8 (1, 11, and 9) in terms of style drift score. Likewise, the indices that are ranked 1 to 3 (9 to 11) in terms of style drift score have ranks 9, 6 and 4 (11, 5 and 10) in terms of volatility.

For a more formal test, we compute the Spearman rank correlation coefficient between the volatility and the style drift score. We obtain a correlation coefficient of 0.055 and a p-value of 44% for the null hypothesis of no correlation against the alternative hypothesis that the correlation is greater than zero. Therefore, we cannot reject the null hypothesis of no correlation at any reasonable level of significance.

2.4. Implicit Views

Throughout the last section we saw how the market capitalisation of the different sub-indices varies over time. Variation of the weights of the sectors in the global market index leads to a problem for the investor, since it emphasises the fact that the sector allocation becomes an implicit decision induced by the choice of an index, as opposed to an explicit choice of the investor. In this sub-section, we show that this implicit choice corresponds to a "view" on the returns of the different sectors, and we argue that holding the global market index is not optimal for investors unless they happen to share these views implied by the market capitalisation weights of different industry sectors.

If we consider each market index as a global portfolio, the efficient market theory allows us to draw a conclusion on the implicit views of the representative agent. The basic idea goes back to Sharpe's (1963) Capital Asset Pricing Model. The observed broad market portfolio represents the aggregated individually efficient portfolios. When markets are efficient, the set of individually efficient portfolios is convex. Hence, as a linear combination of those portfolios, the market portfolio is efficient as well. Under those equilibrium conditions, the observed sub-index returns are the outcome of individual portfolio decisions. Assuming that the CAPM holds, observing the market capitalisation (ω_M) leads to a conclusion on the "implicit" returns (Π) of the representative agent:

$$\Pi = \lambda \Sigma \omega_M$$

where λ is the risk aversion parameter. As you can see from the above formula, the risk aversion parameter λ induces a scale effect but

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does not impact the relative structure of expected (implicit) returns.

Therefore, an arbitrary parameter value choice is justified. We examine the case $\lambda = 3$, in an attempt to match the observed empirical expected returns. Σ denotes the sample covariance matrix associated with the corresponding sub-period.

Extracting views on expected returns from portfolio weights is often referred to as "reverse engineering". This technique was used by Black and Litterman (1990) as the first stage of their Bayesian allocation model (see the box on this topic). In order to show that a given market capitalisation weighting can be interpreted as a set of views on expected returns, we conducted this "reverse engineering" exercise for two indices: the Eurozone index Euro Stoxx and the U.S. index S&P 500.

The weights of different sectors are obtained from the analysis conducted above. We look at the market capitalisation weights over the ten-year period of October 1995 to September 2005. We observe the market capitalisation weights at three points in time – at the beginning of the total period, at the middle of the total period and at the end of the total period – and use the relation described above to extract implicit views. The covariance matrix is calculated over the whole sample period of 10 years and is assumed to be stable. This allows us to focus on the effect on the implied expected returns only. In addition to the capitalisation weights, we also extract the views on returns that are implicit in an equally weighted portfolio of sectors. We also observe the empirical returns for the ten-year period in order to compare the implicit views to the returns actually realised. Finally, we obtain the implied view on the overall index by taking a weighted average of implied views on the sector sub-indices, which we use as a reference for assessing the implicit belief of under- and over-performance that is implied by holding a market cap or equally weighted index. The tables below give the results for both indices.

Table 11 A: Relative market capitalisation and implicit views for the Euro Stoxx (300) index

	Market Capitalisation Weights			Equal weights	Implied views from Market Capitalisation Weights			Implied views from Equal Weights	Empirical Returns over the total period
	Sept-95	Sept-00	Sept-05		Sept-95	Sept-00	Sept-05		
AUTO & PARTS	7%	3.6%	4.7%	6.7%	12.9%	13.2%	12.6%	12.3%	9%
BANKS	14.3%	16.9%	23%	6.7%	12.3%	13.1%	12.4%	11.6%	13.5%
BASIC RESOURCE	4.3%	0.9%	1.3%	6.7%	9%	9%	8.6%	8.8%	5.9%
CHEMICALS	7.4%	2.9%	4.1%	6.7%	10.7%	10.8%	10.3%	10.1%	11.6%
FOOD & BEV	7.1%	3.2%	3.9%	6.7%	7.2%	7.1%	6.9%	6.8%	8.1%
FINANCIAL SVS	5%	4.6%	2.2%	6.7%	10.8%	11.3%	10.7%	10.3%	13.1%
TECHNOLOGY	9.1%	18.2%	5.8%	6.7%	17.4%	20.3%	17.2%	16.7%	13.2%
HEALTH CARE	1.9%	4.5%	4.2%	6.7%	9.3%	9.9%	9.5%	9.3%	12.2%
INDS GDS	4.1%	3%	7%	6.7%	10.2%	11%	10.3%	10%	11.5%
INSURANCE	11.7%	8.4%	8.9%	6.7%	14.6%	15.2%	14.5%	13.7%	9.4%
MEDIA	2.3%	3.1%	3.8%	6.7%	11.8%	13.4%	12.1%	11.8%	7.3%
OIL & GAS	11.7%	10.9%	9.7%	6.7%	9.7%	9.9%	9.4%	8.9%	14.2%
CON & MAT	3.6%	1.8%	3.9%	6.7%	8.3%	8.8%	8.3%	8.2%	11.2%
TELECOM	5.1%	10.4%	8.5%	6.7%	13.2%	15.2%	13.7%	13%	13.3%
UTILITIES	5.4%	7.6%	9.1%	6.7%	8.5%	9.1%	8.7%	8.2%	11.1%

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Table 11 B:
Matrix of relative views for the Euro Stoxx (300) index

	AUTO & PARTS	BANKS	BASIC RESOURCE	CHEMICALS	FOOD & BEV	FINANCIAL SVS	TECHNOLOGY	HEALTH CARE	INDS GDS	INSURANCE	MEDIA	OIL & GAS	CON & MAT	TELECOM	UTILITIES
AUTO & PARTS	1	1.05	1.43	1.21	1.8	1.19	0.74	1.38	1.26	0.88	1.09	1.33	1.55	0.97	1.51
BANKS	0.95	1	1.36	1.15	1.71	1.14	0.71	1.32	1.21	0.84	1.04	1.27	1.48	0.93	1.45
BASIC RESOURCE	0.7	0.73	1	0.85	1.26	0.84	0.52	0.97	0.89	0.62	0.76	0.93	1.08	0.68	1.06
CHEMICALS	0.83	0.87	1.18	1	1.49	0.99	0.61	1.14	1.05	0.73	0.9	1.1	1.28	0.81	1.25
FOOD & BEV	0.56	0.58	0.80	0.67	1	0.67	0.41	0.77	0.7	0.49	0.61	0.74	0.86	0.54	0.84
FINANCIAL SVS	0.84	0.88	1.2	1.01	1.5	1	0.62	1.16	1.06	0.74	0.91	1.12	1.30	0.82	1.27
TECHNOLOGY	1.35	1.42	1.93	1.63	2.43	1.62	1	1.87	1.71	1.19	1.48	1.8	2.09	1.32	2.05
HEALTH CARE	0.72	0.76	1.03	0.88	1.3	0.87	0.54	1	0.92	0.64	0.79	0.97	1.12	0.71	1.1
INDS GDS	0.79	0.83	1.13	0.96	1.42	0.94	0.59	1.09	1	0.7	0.86	1.05	1.22	0.77	1.2
INSURANCE	1.13	1.19	1.62	1.37	2.04	1.35	0.84	1.56	1.43	1	1.24	1.51	1.75	1.1	1.72
MEDIA	0.92	0.96	1.31	1.11	1.65	1.09	0.68	1.27	1.16	0.81	1	1.22	1.42	0.89	1.39
OIL & GAS	0.75	0.79	1.07	0.91	1.35	0.9	0.56	1.04	0.95	0.66	0.82	1	1.16	0.73	1.14
CON & MAT	0.65	0.68	0.92	0.78	1.16	0.77	0.48	0.89	0.82	0.57	0.71	0.86	1	0.63	0.98
TELECOM	1.03	1.07	1.47	1.24	1.84	1.23	0.76	1.42	1.3	0.91	1.12	1.37	1.59	1	1.55
UTILITIES	0.66	0.69	0.94	0.8	1.19	0.79	0.49	0.91	0.83	0.58	0.72	0.88	1.02	0.64	1

Table 12 A:
Relative market capitalisation and implicit views for the S&P 500 index

	Market Capitalisation Weights			Equal weights	Implied views from Market Capitalisation Weights			Implied views from Equal Weights	Empirical Returns over the total period
	Sept-95	Sept-00	Sept-05		Sept-95	Sept-00	Sept-05		
CONS. DISC.	13.2%	10.2%	10.7%	10%	9.2%	10.3%	9.5%	8.7%	10.8%
CONS. STAPLES	12.7%	6.5%	9.6%	10%	5.7%	5.5%	5.7%	5.5%	9.5%
ENERGY	8.8%	6%	10.3%	10%	6.3%	6.1%	6.5%	6.4%	16.9%
FINANCIALS	12.9%	15.6%	20.1%	10%	10.1%	11.3%	10.8%	9.7%	14.5%
HEALTH CARE	9.9%	11.8%	13.3%	10%	7.5%	7.9%	7.9%	7.2%	12.8%
INDUSTRIALS	12.7%	9.8%	11.1%	10%	9%	10%	9.3%	8.6%	11.1%
INFO TECHNOLOGY	10.2%	29%	15.3%	10%	12.4%	17.4%	13.7%	11.8%	13.7%
MATERIALS	6.5%	1.7%	2.9%	10%	7.7%	7.8%	7.7%	7.7%	7.7%
TELECOM SERVICES	8.7%	6.3%	3.1%	10%	8.5%	9.6%	8.4%	8.4%	4.7%
UTILITIES	4.5%	3.1%	3.6%	10%	4.9%	4.8%	4.9%	5.2%	9.3%

Table 12 B:
Matrix of relative views for the S&P 500 index

	CONS. DISC.	CONS. STAPLES	ENERGY	FINANCIALS	HEALTH CARE	INDUSTRIALS	INFO TECHNOLOGY	MATERIALS	TELECOM SERVICES	UTILITIES
CONS. DISC.	1	1.6	1.46	0.9	1.23	1.02	0.74	1.19	1.07	1.88
CONS. STAPLES	0.63	1	0.91	0.56	0.77	0.64	0.46	0.74	0.67	1.18
ENERGY	0.69	1.1	1	0.62	0.84	0.7	0.51	0.81	0.74	1.29
FINANCIALS	1.11	1.77	1.61	1	1.36	1.13	0.82	1.31	1.19	2.08
HEALTH CARE	0.81	1.3	1.19	0.74	1	0.83	0.6	0.97	0.88	1.53
INDUSTRIALS	0.98	1.57	1.43	0.89	1.2	1	0.73	1.16	1.05	1.85
INFO TECHNOLOGY	1.35	2.16	1.97	1.22	1.66	1.38	1	1.6	1.45	2.54
MATERIALS	0.84	1.35	1.23	0.76	1.04	0.86	0.62	1	0.91	1.59
TELECOM SERVICES	0.93	1.49	1.35	0.84	1.14	0.95	0.69	1.1	1	1.75
UTILITIES	0.53	0.85	0.77	0.48	0.65	0.54	0.39	0.63	0.57	1

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There are a number of observations that can be made from these results:

First, the views obtained from the market capitalisation weights show that there is considerable variation between sectors. This means that holding the index does not correspond to an absence of a view on returns. Instead, by buying the market index, the investor subscribes to the market view on the returns of the different sectors. In particular, the bottom parts of the illustrations show the ratio of the implied view for a sector to the implied view for all other sectors. The implied views in this case correspond to the market capitalisation for September 1995. We observe for example that the information technology sector in the U.S. is expected to achieve 2.54 times the performance of the utilities sector and 2.16 times the return that is expected for the consumer discretionary sector. For the Eurostoxx, the technology sector is expected to achieve 2.13 times the performance of the food and beverage sector. It can be seen from the matrices of relative views on different sectors that, in addition to the case of the technology sector, there are considerable variations in the views on sectors. We believe that an investor would benefit from having such implicit views made explicit.

Second, an examination of the views that are implicit in an equally weighted portfolio shows that the overweighting (respectively underweighting) of a given sector in the market capitalisation weighted indices generally results from the fact that the implicit view of the capitalisation weighted index is higher (respectively lower) than the implicit view obtained from the equally weighted portfolio. The financial and the information technology sectors, for instance, constantly have a higher weight than 10% in the S&P, the implicit view from the capitalisation index being higher than the implicit view from an equally weighted portfolio. Overall, this suggests that the choice of a scheme used in the design of an index (e.g., value-weighted versus equally weighted) is not a simple and innocuous technical choice but, rather, is equivalent to an active asset allocation decision.

Third, it can be seen that the variations in relative market capitalisation weights of the sectors correspond to a modification in the expected returns on the respective sector. In fact, the view of the market on the returns of the different sectors may show considerable variation. Thus, the burst of the technology bubble and the corresponding fall in the information technology sector corresponds to a change in view of 20.3% (17.4%) return to 17.2% (13.7%) for the Euro Stoxx (the S&P 500).

2. Lack of Stability

The Black and Litterman Asset Allocation Model

An investor who would like to use Markowitz' mean-variance optimisation is confronted with two major difficulties. First, he has to provide the expected returns for all the assets or all the asset classes under consideration. Second, the results of the optimisation often lead to portfolios that are very extreme, in the sense that they invest heavily in a few assets and these portfolios correspond very little to the actual expectations of investors. These portfolios are also very sensitive to variations in the input data. Thus, in spite of the development of computation tools, the optimisation model of Markowitz remains a model that is rarely used in practice. These observations have led Black and Litterman to develop an approach that allows the investor to construct expected returns that are more robust and thereby obtain portfolios that are more stable and easier to interpret.

The Black and Litterman (1990, 1992)[3] model uses a Bayesian approach that allows the investor to combine his predictions for the mean returns with the values that are implicit in market equilibrium. The equilibrium values are computed in the same way as the market portfolio in Sharpe's CAPM, which has weights that correspond to the market capitalisations of the assets. Investors can then formulate their views for one or more assets. These views can be expressed in absolute terms (by giving a precise value for the expected return) or in relative terms (if the investor has an intuition for the difference in expected returns between two assets without necessarily being able to give a numbered prediction for each asset). What is more, investors may indicate their degree of confidence in their views, which is then translated into a higher or lower weighting being attributed to the views when they are combined with the market equilibrium views. This enables the impact of active views in the construction of the optimal portfolio for the investor to be controlled and limited.

The Black and Litterman model allows for a higher degree of flexibility than a standard optimisation model, because it does not require a view on all the assets. It allows reasonable values for expected returns to be generated and a weight to be allocated to each asset of the optimal portfolio. The portfolios that this optimisation procedure yields can be interpreted as a combination of the market portfolio and portfolios that represent the views of the investor, making them more diversified and thus less sensitive to the problems associated with standard allocation models. It should be noted that if Black and Litterman use the market portfolio as a reference for neutral weights in their model, this portfolio may be replaced by any other portfolio the investor may wish to choose as a reference.

[3] Black, F. and R. Litterman, "Asset Allocation: Combining Investor Views with Market Equilibrium", *Goldman Sachs Fixed Income Research*, September 1990 and Black, F. and R. Litterman, "Global Portfolio Optimization", *Financial Analysts Journal*, September/October, 1992.

3. Lack of Efficiency

This section tests the distance in terms of efficiency between a market index and its alternatives. These alternatives are based on portfolios of individual stocks rather than portfolios of style indices or sector indices in order to avoid a bias linked to a different universe of assets for the style/sector index, as against the market index. The question to determine the efficiency of an index is whether the investor can obtain better results by using the same universe of stocks but a weighting scheme that is different from capitalisation weighting. We assess two weighting schemes: mean-variance optimisation and equal weighting. In order to evaluate the efficiency of the capitalisation-weighted index and of the alternatives, we must first state what we mean by efficiency. We first address this conceptual issue and then provide a description of the data and the results of our efficiency tests.

3.1. Efficiency: Conceptual remarks

The concept of portfolio efficiency was introduced by Markowitz (1952, 1959), who was the first to quantify the link that exists between the risk and return of a portfolio. An efficient (or optimal) portfolio is defined as a portfolio with minimal risk for a given return, or, equivalently, as the portfolio with the highest return for a given level of risk, with the risk being measured by the volatility of asset returns. The complete set of these portfolios forms the mean variance frontier, which constitutes the convex envelope of all the portfolios that can be produced. The portfolios located on the mean variance frontier are said to be mean-variance efficient as they are derived on the basis of the first two moments of the asset returns distribution, i.e., the mean return and the variance of the returns.

To achieve optimal diversification, Markowitz developed a mathematical portfolio selection model. This model enabled him to find the composition of all the portfolios that corresponded to the efficiency criterion he had defined, for a given set of securities, and thereby construct the corresponding mean variance frontier. Taking the definition of portfolio return and portfolio risk into account, this involves minimising the variance for a given return or maximising the return for a given variance. In its simplest version, the model is written as follows:

$$\text{Minimise } var(R_P) = \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \, cov(R_i, R_j)$$

Under the following conditions:

$$E(R_P) = \sum_{i=1}^{n} x_i E(R_i) = E$$

$$\sum_{i=1}^{n} x_i = 1$$

$$x_i \geq 0, i = 1, \ldots, n$$

where X_i denotes the proportion of asset i held in the portfolio;
$E(R_i)$ denotes the expected return of asset i;
and cov(R_i,R_j) denotes the covariance between asset i and asset j.

The variance expression reveals the usefulness of diversification in reducing risk thanks to the correlation that exists between asset returns. The mean variance frontier calculation involves finding the weightings of the assets that make up each portfolio.

In what follows, we use the Markowitz definition of efficiency. Tracing mean variance frontiers of portfolios that are composed of the index components and plotting the capitalisation-weighted index in the mean-variance plane will

3. Lack of Efficiency

allow us to assess the relative efficiency of the index. If the claim of efficiency for the index holds, it should lie on the mean variance frontier. Being located far from this frontier would in turn mean a lack of efficiency. This comparison with the mean variance frontier, however, is faced with an important limitation. The Markowitz method involves obtaining an optimal portfolio as a function of estimates of return parameters (mean) and risk parameters (variance and covariance) for the assets being considered. It has been shown that the portfolio optimisation programme is very sensitive to the parameters. As the mean variance frontier for the composition of the index is derived from historical data, there is no guarantee that the data will be representative of long-term trends. So it is possible that the optimal weights found within the sample will not remain the optimal weights outside of the sample. This also means that the dominance in risk return terms may not hold for the portfolios obtained in the optimisation.

In view of this problem, the mean variance frontier portfolios can be seen as the portfolios that are obtainable for an investor in hindsight of the assets' expected returns, as well as the covariance matrix of asset returns. In order to obtain results with more practical relevance, we also focus on equally weighted portfolios as an alternative to standard value-weighted market indices, the former being more diversified than the latter, which are concentrated in the larger capitalisations. Moreover, equally weighted indices, which can be regarded as optimal portfolios for an investor with a very simple and modest 'prior' on asset return parameters (i.e., mean returns, variances and covariances are identical for all assets), are very easy to compute and do not include any hindsight bias. It should be noted that constructing and using equally weighted indices as benchmarks is a very easy and low-cost form of portfolio management. Therefore, if these portfolios are more efficient than most of the market indices, this would be a very clear result in favour of the hypothesis of the inefficiency of capitalisation weighted indices.

3.2. Data

In order to test for the efficiency of the set of stock market indices introduced above, we use the following data:

(i) We collected from Datastream the total return indices for the components of the chosen indices and for the indices themselves. For the Nikkei and the Topix, because total return indices were not available, we used price indices both for the components and for the indices. We used daily series to calculate returns with continuous compounding as follows:

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right)$$

(ii) We collected data over a total period of ten years, beginning in October 1995 and ending in September 2005. We divided this total period into two sub-periods. The first one covers the period of October 1995 to September 2000 and the second one covers the period of October 2000 to September 2005. These two sub-periods of five years contain the same number of data points (1,305). The reason for dividing the sample into two sub-periods is twofold. First, so as to check the robustness of our results, we prefer to observe the results in two independent sub-samples. Second, index composition evolves over time, whereas we need a constant set of assets to perform

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optimisations. Given this constraint, in order to take into account that index composition changes over time, we prefer to update the index composition after the first sub-period, which brings us closer to the true composition of the index.

(iii) We obtained the component list of the chosen indices from Datastream for the two sub-periods. As it was necessary to consider a constant composition to perform optimisation in order to derive the mean variance frontier, we retained only one composition per sub-period and chose that of the last day of the period, or the date closest to it, in case historical composition was not available on the date required. For some indices, only the current composition of the index was available. In that case, we kept the same composition for the index in the two sub-periods. Table 13 sums up the composition used for each index.

We calculate returns on equally weighted portfolios, as well as mean-variance frontiers. This is an in-sample analysis: we compute the mean variance frontier portfolios for each of the two five-year sub-periods. Table 14 compares the number of components used to compute these indices to the number of components that make up the corresponding market index.

The reason why our calculations cannot use the total number of shares from each index is that historical data were not available for all the assets; this is because we were considering a constant

Table 13: Index compositions used in the empirical study

Indices	October 1995 – September 2000	October 2000 – September 2005
CAC 40	September 30th, 2000	September 30th, 2005
DAX 30	September 30th, 2000	September 30th, 2005
FTSE 100	March 31st, 2001	September 30th, 2005
Euro Stoxx 50	September 30th, 2000	September 30th, 2005
DJ Euro Stoxx	September 30th, 2000	September 30th, 2005
DJ Stoxx 600	October 31st, 2005	October 31st, 2005
Nikkei 225	October 31st, 2005	October 31st, 2005
Topix 500	November 30th, 2005	November 30th, 2005
S&P 500	October 31st, 2005	October 31st, 2005
Russell 2000	October 31st, 2005	October 31st, 2005
Dow Jones 30	November 30th, 2005	November 30th, 2005

This table gives the dates of composition of the various indices used for index optimisation for each sub-period.

Table 14: Number of components

	October 1995 – September 2000			October 2000 – September 2005		
Indices	Market Index	EW Index	Mean variance frontier	Market Index	EW Index	Mean variance frontier
CAC 40	40	33 to 40	33	40	38 to 40	38
DAX 30	30	23 to 30	23	30	28 to 30	28
FTSE 100	101[4]	82 to 99	82	102[5]	92 to 102	92
Euro Stoxx 50	50	45 to 50	45	50	49 to 50	49
DJ Euro Stoxx	305	220 to 305	220	316	273 to 316	273
DJ Stoxx 600	600	407 to 522	407	600	522 to 600	522
Nikkei 225	225	209 to 214	209	225	214 to 225	214
Topix 500	493[6]	432 to 462	432	493[7]	462 to 492	462
S&P 500	500	438 to 484	438	500	484 to 500	484
Russell 2000	1,998[8]	968 to 1,586	968	1,998[9]	1,586 to 1,998	1,586
Dow Jones 30	30	30	30	30	30	30

This table gives the number of components used for each index to compute the optimisations, compared to the number of components of the corresponding market index.

[4] Number of shares on March 31st, 2001.
[5] Number of shares on September 30th, 2005.
[6] Number of shares on November 30th, 2005.
[7] Number of shares on November 30th, 2005.
[8] Number of shares on October 31st, 2005.
[9] Number of shares on October 31st, 2005.

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composition for each sub-period, corresponding to the index composition at the end of each of the two sub-periods. For equally weighted indices, we introduced the assets in the calculation as soon as they became available. As a result, equal-weighted indices are computed with more assets at the end of each period than at the beginning. The reason why we chose to do this, rather than keeping only the components for which the data were available for the full period, was to get the index which was as close as possible in its composition to the market index to which it related. For the computation of efficient frontiers, we had to restrict ourselves to the components for which the historical data were available for the whole of the optimisation period. It should be noted that mean-variance portfolios are not rebalanced throughout each sub-period. A mean-variance analysis is performed for each sub-period and the composition of the efficient portfolios remains the same during the whole sub-period.

Our methodology implies that we do not conduct any rebalancing of the mean-variance efficient portfolios within each five-year period. This absence of rebalancing also means that our analysis is somewhat conservative, since better results may be achieved when rebalancing is done more frequently. This somewhat reduces the limits of the in-sample analysis conducted.

3.3. Results

In order to compare the relative efficiency of the indices considered in this study, we plot the efficient frontier, beginning with the minimum-variance portfolio and stretching to the maximum return portfolio. We also indicate the equally weighted portfolio and the index in the mean-variance plane. By visually comparing the index with the mean variance efficient frontier, one can get an idea of the efficiency of the index. The conclusion on the efficiency of the index will therefore depend on how close the index lies from the mean variance frontier. In order to compare the market index to portfolios obtained through an allocation between the index components, we also plot another three portfolios in the mean variance plane. These are: i) the portfolio with minimum risk given that it has the same return as the index[10]; ii) the portfolio with the maximum return given that it has the same risk as the index; and iii) the portfolio with the maximum Sharpe ratio. Comparing the distance to these three portfolios allows us to assess the gain an investor can obtain in terms of the risk/return trade-off by deviating from the index using the same stocks. For each market index, we also provide a table summing up the main characteristics, i.e., the risk and return of the five portfolios.

As outlined above, the equally weighted index serves as a robust reference, which is easily obtainable for an investor by a simple investment approach. The portfolios i), ii) and iii) allow for a comparison of the index with alternatives that can be obtained through an allocation between the index components.

3.3.1. European countries

Our results show that equally weighted indices are always located nearer to the mean variance frontier than the corresponding capital weighted market indices. It also appears that during the second period of our study, including years 2000

[10] It should be noted that the portfolio with the same return as the index does not necessarily lie on the efficient frontier. This occurs when the minimum variance portfolio has a higher mean return than the index. However, we still calculate the optimal portfolio given the same level of returns as the index as a reference point. The distance of the index to this portfolio is obviously not a distance to the efficient frontier in this case, but a distance to the mean variance frontier. It is the distance to a portfolio that is not efficient but optimal given the constraint on expected returns.

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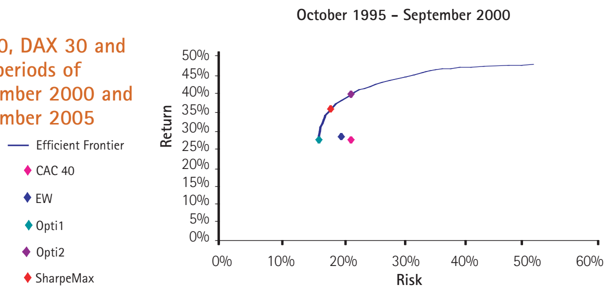
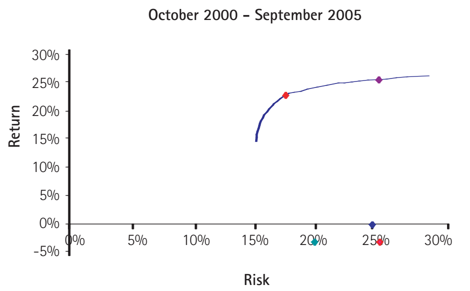
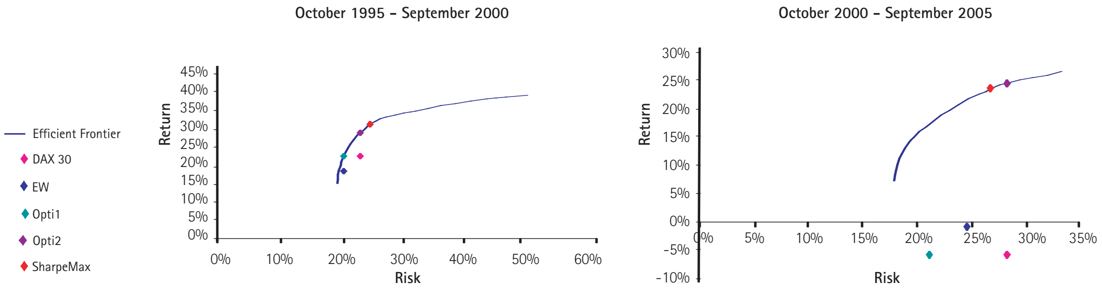
Illustration 14:
Optimization of CAC 40, DAX 30 and FTSE 100 for the two periods of October 1995 to September 2000 and October 2000 to September 2005

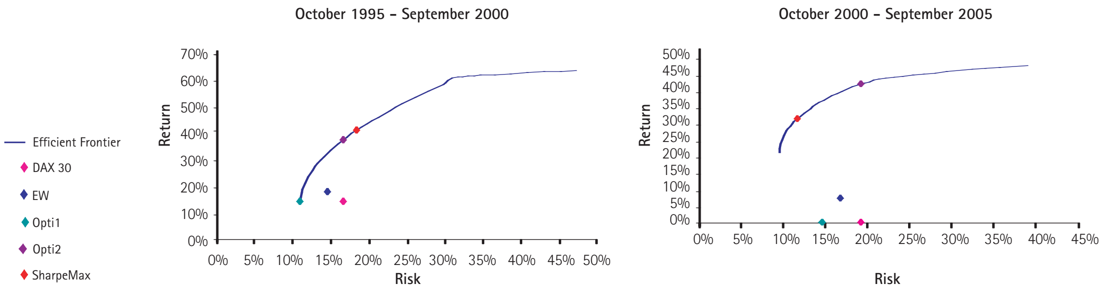




	October 1995 – September 2000			October 2000 – September 2005		
CAC 40	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	136.57%	27.31%	20.93%	-16.96%	-3.39%	24.61%
Equally weighted index	141.11%	28.22%	19.35%	-1.42%	-0.28%	24.03%
Opti 1 (same return)	136.57%	27.31%	15.8%	-16.96%	-3.39%	19.5%
Opti 2 (same risk)	198.15%	39.63%	20.93%	127.63%	25.53%	24.61%
Maximum Sharpe Ratio	178.27%	35.65%	17.7%	113.62%	22.72%	17.2%



	October 1995 – September 2000			October 2000 – September 2005		
DAX 30	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	113.41%	22.68%	22.59%	-29.84%	-5.97%	28.22%
Equally weighted index	92.79%	18.56%	19.97%	-5.02%	-1%	24.54%
Opti 1 (same return)	113.41%	22.68%	20.01%	-29.84%	-5.97%	21.05%
Opti 2 (same risk)	145.57%	29.11%	22.59%	121.93%	24.39%	28.22%
Maximum Sharpe Ratio	156.6%	31.32%	24.19%	117.19%	23.44%	26.69%



	October 1995 – September 2000			October 2000 – September 2005		
FTSE 100	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	73.74%	14.75%	16.68%	1.87%	0.37%	19.18%
Equally weighted index	92.89%	18.58%	14.65%	37.62%	7.52%	16.81%
Opti 1 (same return)	73.74%	14.75%	11.05%	1.87%	0.37%	14.62%
Opti 2 (same risk)	190.01%	38%	16.68%	205.02%	41%	19.18%
Maximum Sharpe Ratio	207.36%	41.47%	18.38%	153.99%	30.8%	11.71%

These graphs and tables compare each of the three European country market indices – the CAC 40, the DAX 30 and the FTSE 100 – with an equally weighted index made up of the constituents of the market index and with the mean variance frontier obtained by a mean-variance optimisation of the components of the index. The graphs also show the position of an optimal index with the same risk as the market index and the position of an optimal index with the same return as the market index. It also locates the portfolio for which the Sharpe ratio is maximised. Each graph covers a five-year period: from 10/1995 to 09/2000 for the first period and from 10/2000 to 09/2005 for the second period.

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to 2002, during which markets encounter a considerable decline, market indices are located very far from the mean variance frontier. Among the three indices, CAC 40, DAX 30 and FTSE 100, it is the DAX 30 that appears to be the nearest to the mean variance frontier during the period of October 1995 to September 2000. Our results also show that it was always possible to construct a portfolio made up of the market index constituents having the same return as the index but with a lower risk (Opti 1), or with the same risk as the index but with a higher return (Opti 2). This is all the more notable during the second period of our study, where market indices showed negative performance. It appears that it was possible to obtain positive performance for a same-risk portfolio, using a different asset weighting.

The portfolio made up of index constituents for which the Sharpe ratio is highest is located at different points on the mean variance frontier, depending on the index. For the CAC 40 index, this portfolio is located between the two optimised portfolios Opti 1 and Opti 2, for both periods, which means that this portfolio has a lower risk and a higher return than the market portfolio. This is the same for the DAX 30 and the FTSE 100, but only during the second period. For these two indices, this point is located over Opti 2 on the mean variance frontier during the first period, which means that its risk is higher than that of the market index.

These three indices – CAC 40, DAX 30 and FTSE 100 – are computed using capital weighting. Our results underline, therefore, that over long periods capital weighted indices appear, on average, to be sub-efficient when compared to their equal-weighted counterparts, even for indices with a restricted number of constituents, such as the CAC 40 and the DAX 30, which are concentrated on large capitalizations.

3.3.2. Eurozone

Inside the Eurozone, the Euro Stoxx 50 index appears to be more efficient than the DJ Euro Stoxx during the period of October 1995 to September 2000. Our results show that the DJ Euro Stoxx is located very far from the mean variance frontier during this period, as well as during the second period (October 2000 - September 2005).

The improvement in terms of efficiency with the equally weighted index, compared to the capital-weighted index, appears to be greater for the DJ Euro Stoxx, which is made up of 300 components, than for the Euro Stoxx 50. This can be explained by the fact that the DJ Euro Stoxx also contains medium and small capitalisation assets, while the Euro Stoxx 50 is concentrated in large capitalisation. As a result, medium and small capitalisations are sub-weighted in the capital-weighted DJ Euro Stoxx and do not have much influence on the performance of this index, while they count for the same proportion as large capitalisations in the equally weighted index, leading to a significant improvement in this index's efficiency.

As for the European countries, it also appears that it was always possible to construct a portfolio made up of the market index constituents with the same return as the index but with a lower risk (Opti 1), or with the same risk as the index, but with a higher return (Opti 2). This is once again all the more notable during the second period of our study, where market indices showed negative performance. It appears that it was possible to obtain positive performance for a same-risk portfolio, using a different asset weighting.

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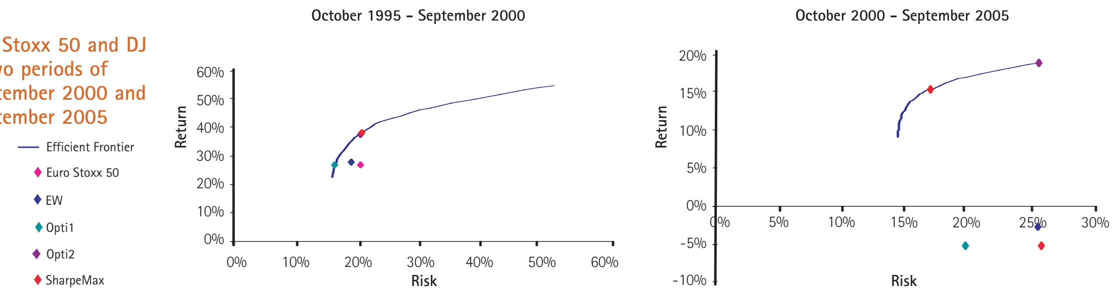
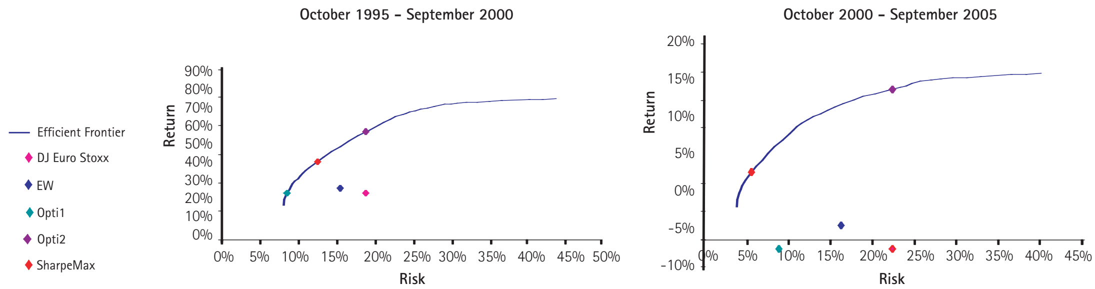
Illustration 15:
Optimization of Euro Stoxx 50 and DJ Euro Stoxx for the two periods of October 1995 to September 2000 and October 2000 to September 2005



	October 1995 – September 2000			October 2000 – September 2005		
EUROSTOXX 50	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	134.11%	26.82%	20.22%	-25.82%	-5.16%	25.7%
Equally weighted index	139.19%	27.84%	18.84%	-13.56%	-2.71%	25.47%
Opti 1 (same return)	134.11%	26.82%	16.23%	-25.82%	-5.16%	19.74%
Opti 2 (same risk)	187.6%	37.52%	20.22%	93.73%	18.75%	25.52%
Maximum Sharpe Ratio	189.71%	37.94%	20.47%	76.85%	15.37%	16.92%



	October 1995 – September 2000			October 2000 – September 2005		
DJ EURO STOXX	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	123.09%	24.62%	18.84%	-17.11%	-3.42%	22.38%
Equally weighted index	137.3%	27.46%	15.46%	25.17%	5.03%	16.26%
Opti 1 (same return)	123.09%	24.62%	8.51%	-17.11%	-3.42%	8.8%
Opti 2 (same risk)	289.78%	57.96%	18.84%	269.6%	53.92%	22.38%
Maximum Sharpe Ratio	208.8%	41.76%	12.51%	120.71%	24.14%	5.56%

These graphs and tables compare each of the two Eurozone market indices – the Euro Stoxx 50 and DJ Euro Stoxx – with an equally weighted index made up of the constituents of the market index and with the mean variance frontier obtained by a mean-variance optimisation of the index components. The graphs also show the position of an optimal index with the same risk as the market index and the position of an optimal index with the same return as the market index. It also locates the portfolio for which the Sharpe ratio is maximised. Each graph covers a five-year period: from 10/1995 to 09/2000 for the first period and from 10/2000 to 09/2005 for the second period.

The portfolio made up of index constituents for which the Sharpe ratio is highest appears to be nearly the same as the Opti 2 portfolio — the optimised portfolio with the same risk as the market index — during the first period for the Euro Stoxx 50 index. During the second period, this portfolio is located between Opti 1 and Opti 2, as is the case for the DJ Euro Stoxx for both periods, which means that this portfolio has a lower risk and a higher return than the market portfolio.

3.3.3. Europe

The DJ Stoxx 600 appears to behave similarly to the DJ Euro Stoxx in terms of efficiency. This index is located far from the mean variance frontier for the two periods considered. The improvement brought about by calculating an optimised portfolio with the same return (Opti 1) and an optimised portfolio with the same risk (Opti 2) is also comparable with the results obtained for the DJ Euro Stoxx. As for the DJ Euro Stoxx, the maximum Sharpe ratio

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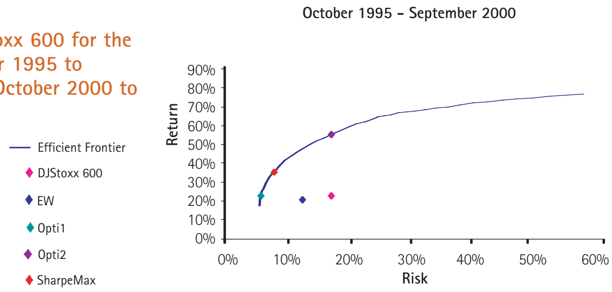
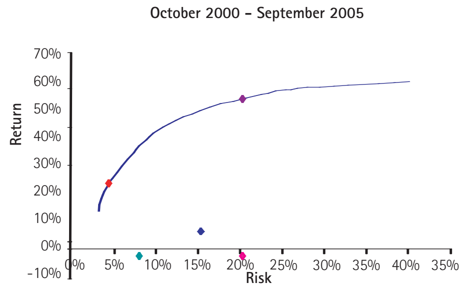
Illustration 16:
Optimization of DJ Stoxx 600 for the two periods of October 1995 to September 2000 and October 2000 to September 2005





	October 1995 – September 2000			October 2000 – September 2005		
DJSTOXX 600	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	113.76%	22.75%	16.96%	-12.27%	-2.45%	20.25%
Equally weighted index	102.17%	20.43%	12.28%	31.64%	6.33%	15.37%
Opti 1 (same return)	113.76%	22.75%	5.75%	-12.27%	-2.45%	8.01%
Opti 2 (same risk)	276.42%	55.28%	16.96%	266.6%	53.32%	20.25%
Maximum Sharpe Ratio	177.48%	35.5%	7.85%	116.15%	23.23%	4.35%

These graphs and tables compare the DJ Stoxx 600 European market index with an equally weighted index made up of the constituents of the market index and with the mean variance frontier obtained by a mean-variance optimisation of the components of the index. The graphs also show the position of an optimal index with the same risk as the market index and the position of an optimal index with the same return as the market index. It also locates the portfolio for which the Sharpe ratio is maximised. Each graph covers a five-year period: from 10/1995 to 09/2000 for the first period and from 10/2000 to 09/2005 for the second period.

portfolio is located between the two optimised portfolio Opti 1 and Opti 2 for both periods, so this portfolio has once again a lower risk and a higher return than the market portfolio.

As for the DJ Euro Stoxx, this index reveals significant improvement in terms of efficiency when computed as equally weighted instead of capital weighted. This can be explained by the same reasons. This index, which is made up of 600 constituents, also contains a significant number of small and medium capitalisations assets. As a result, medium and small capitalisations, which are underweighted in the capital-weighted DJ Stoxx 600, do not have much influence in the performance of this index, while they count for the same proportion as large capitalisations in the equally weighted index, leading to a significant improvement of this index's efficiency.

3.3.4. Japan

The Nikkei and the Topix 500 appear to have similar behaviour in terms of performance and efficiency during the second period of our study. They are both located far from the mean variance frontier. However, they appear to behave more differently during the first period. The Topix 500 exhibits better performance than the Nikkei 225. It appears clearly on the graph that, unlike the Nikkei 225, which exhibits lower returns than the equal-weighted index during this period, the two portfolios from the Topix 500 index and equally weighted index have quite similar returns, but very different risks. The Topix 500 is dominated, in terms of efficiency, by the equally weighted index, which has a lower risk. Contrary to European and U.S. indices, the performance results of the Nikkei 225 are not very different from one period to the other. This index is located far from the mean variance frontier in the first period, as well as in the second. This is a consequence of the decline experienced on Asian markets in 1998. The Nikkei 225 is a price-weighted index, computed as the mean average of the prices of its constituents, while the Topix 500 is a value-weighted index.

Here again, we see that it was possible to construct a portfolio made up of the market

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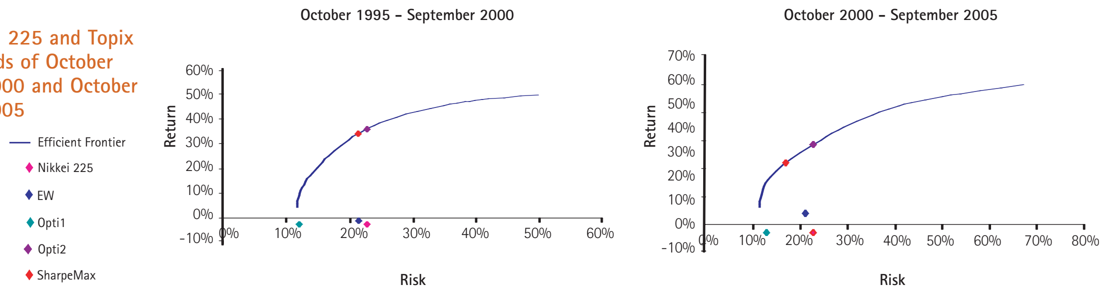
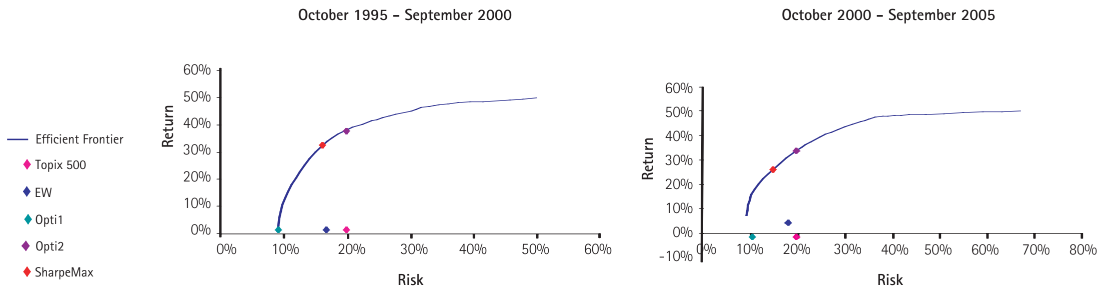
Illustration 17:
Optimization of Nikkei 225 and Topix 500 for the two periods of October 1995 to September 2000 and October 2000 to September 2005



	October 1995 – September 2000			October 2000 – September 2005		
NIKKEI 225	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	-12.89%	-2.58%	22.63%	-14.85%	-2.97%	22.66%
Equally weighted index	-6.07%	-1.21%	21.42%	20.01%	4%	21.07%
Opti 1 (same return)	-12.89%	-2.58%	11.81%	-14.85%	-2.97%	12.75%
Opti 2 (same risk)	180.09%	36.02%	22.63%	142.96%	28.59%	22.66%
Maximum Sharpe Ratio	170.05%	34.01%	21.18%	109.62%	21.92%	16.81%



	October 1995 – September 2000			October 2000 – September 2005		
TOPIX 500	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	7.45%	1.49%	19.82%	-8.56%	-1.71%	19.89%
Equally weighted index	6.63%	1.33%	16.72%	20.75%	4.15%	18.10%
Opti 1 (same return)	7.45%	1.49%	9.09%	-8.56%	-1.71%	10.51%
Opti 2 (same risk)	189.85%	37.97%	19.82%	168.77%	33.75%	19.89%
Maximum Sharpe Ratio	162.73%	32.55%	16.08%	131.02%	26.20%	14.88%

These graphs and tables compare each of the two Japanese market indices, the Nikkei 225 and the Topix 500, with an equally weighted index made up of the constituents of the market index and with the mean variance frontier obtained by a mean-variance optimisation of the components of the index. The graphs also show the position of an optimal index with the same risk as the market index and the position of an optimal index with the same return as the market index. It also locates the portfolio for which the Sharpe ratio is maximised. Each graph covers a five-year period: from 10/1995 to 09/2000 for the first period and from 10/2000 to 09/2005 for the second period.

index constituents with the same return as the index but with a lower risk (Opti 1), or with the same risk as the index but a higher return (Opti 2), which enables positive performance during the second period, despite the market indices showing negative performance.

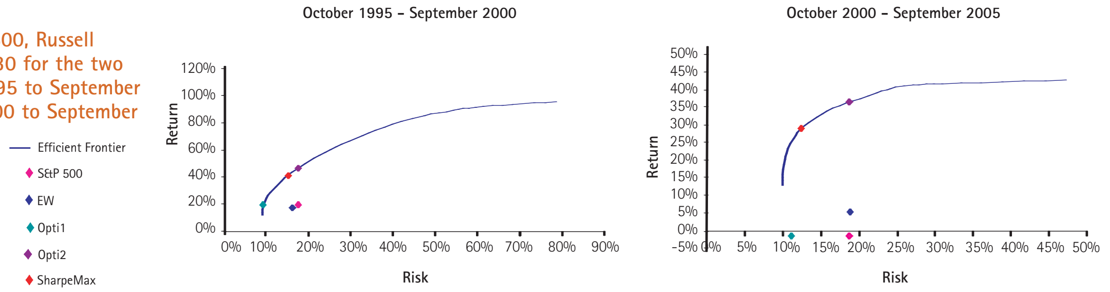
The maximum Sharpe ratio portfolio appears to be located between the two optimised portfolios, Opti 1 and Opti 2, for both indices and both periods, which means that this portfolio has a lower risk and a higher return than the corresponding market portfolio. Concerning the Nikkei 225, during the first period, this portfolio is not far from the Opti 2 portfolio.

3.3.5. United States

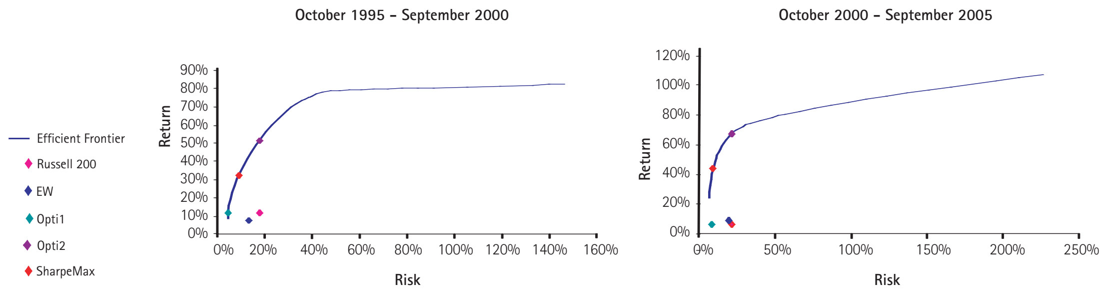
Among the three indices considered — S&P 500, Russell 2000 and Dow Jones 30 — the index which is the farthest from the mean variance frontier during the second period is the S&P 500. During the first period considered,

3. Lack of Efficiency

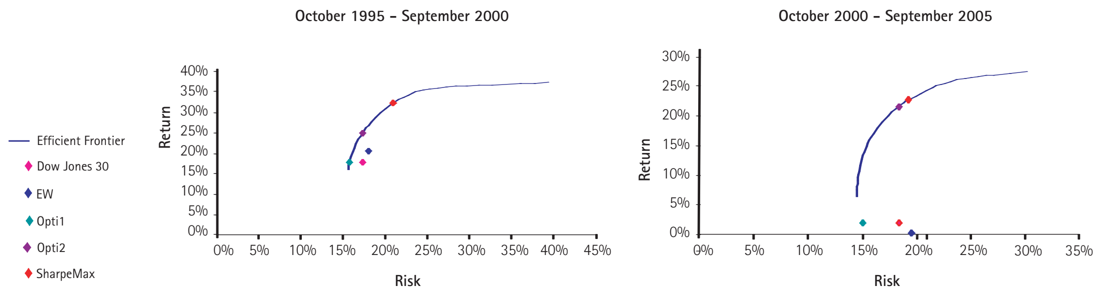
Illustration 18: Optimization of S&P 500, Russell 2000 and Dow Jones 30 for the two periods of October 1995 to September 2000 and October 2000 to September 2005



	October 1995 – September 2000			October 2000 – September 2005		
S&P 500	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	98.14%	19.63%	17.78%	-7.5%	-1.5%	18.79%
Equally weighted index	90.07%	18.01%	16.22%	27.15%	5.43%	18.88%
Opti 1 (same return)	98.14%	19.63%	9.41%	-7.5%	-1.5%	11.15%
Opti 2 (same risk)	233.4%	46.68%	17.78%	182.83%	36.57%	18.79%
Maximum Sharpe Ratio	205.54%	41.11%	15.23%	145.25%	29.05%	12.42%



	October 1995 – September 2000			October 2000 – September 2005		
RUSSELL 2000	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	58.38%	11.68%	17.74%	31.23%	6.25%	21.34%
Equally weighted index	39.2%	7.84%	13.48%	43.76%	8.75%	19.26%
Opti 1 (same return)	58.38%	11.68%	4.54%	31.23%	6.25%	8.29%
Opti 2 (same risk)	257.71%	51.54%	17.74%	337.34%	67.47%	21.35%
Maximum Sharpe Ratio	161.82%	32.36%	9.02%	219.24%	43.85%	9.02%



	October 1995 – September 2000			October 2000 – September 2005		
DOW JONES 30	Return over 5 years	Annualised return	Annualised Sigma	Return over 5 years	Annualised return	Annualised Sigma
Market Index	88.92%	17.78%	17.33%	9.44%	1.89%	18.34%
Equally weighted index	102.95%	20.59%	18%	0.43%	0.09%	19.53%
Opti 1 (same return)	88.92%	17.78%	15.78%	9.44%	1.89%	15.04%
Opti 2 (same risk)	124.37%	24.87%	17.33%	108.05%	21.61%	18.34%
Maximum Sharpe Ratio	161.17%	32.23%	21.01%	113.86%	22.77%	19.24%

These graphs and tables compare each of the three U.S. country market indices – the S&P 500, the Russell 2000 and the Dow Jones 30 – with an equally weighted index made up of the constituents of the market index and with the mean variance frontier obtained by a mean-variance optimisation of the components of the index. The graphs also show the position of an optimal index with the same risk as the market index and the position of an optimal index with the same return as the market index. It also locates the portfolio for which the Sharpe ratio is maximised. Each graph covers a five-year period: from 10/1995 to 09/2000 for the first period and from 10/2000 to 09/2005 for the second period.

3. Lack of Efficiency

the index which appears to be the most efficient is the Dow Jones 30, which is computed as the simple average of the prices of its constituents.

As for all the other indices studied, it appears that it was possible to construct a portfolio made up of the market index constituents with the same return as the index but with a lower risk (Opti 1), or with the same risk as the index but a higher return (Opti 2). Notably, during the second period, we see that it was possible to reach a positive performance with the constituents of the S&P 500, using different asset weighting, while the S&P 500 market index revealed a negative performance.

The maximum Sharpe ratio portfolio obtained with the index constituents appears to be located on the mean variance frontier between the two optimised portfolios, Opti 1 and Opti 2, during both periods for the S&P 500 and the Russell 2000 index – not far from Opti 2 for the S&P 500 index during the first period –, which means that this portfolio has a lower risk and a higher return than the market portfolio. Concerning the Dow Jones 30, the maximum Sharpe ratio portfolio is located over Opti 2 on the mean variance frontier during both periods, which means that this portfolio is obtained with a higher risk than that of the market index.

3.3.6. Conclusion

It becomes evident from our results that the broad market indices are dominated in terms of efficiency, not only by an optimal portfolio but also by a naïve portfolio that consists of equally weighted component stocks.[11] This is all the more true for periods during which the market encountered negative returns.

In order to be able to formulate an appreciation about each index efficiency, we computed the Euclidian distance between each stock market index and the various portfolios considered in this study (optimal portfolio with the same return (Opti 1), optimal portfolio with the same risk (Opti 2) and portfolio with maximum Sharpe ratio), which gave us three distances for each stock market index. For each of the three distances, we rank each index from the one with the lowest distance (score 1) to the one with the highest distance (score 11) and also compute the average of the three scores

Table 15 A: Rank of stock market indices based on efficiency criteria for the two periods of October 1995 to September 2000 and October 2000 to September 2005

	October 1995 – September 2000				October 2000 – September 2005			
Indices	Opti 1	Opti2	SharpeMax	Average score	Opti 1	Opti2	SharpeMax	Average score
CAC 40	4	4	2	3.33	3	4	4	3.67
DAX 30	2	1	1	1.33	11	1	7	6.33
FTSE 100	5	5	9	6.33	2	8	9	6.33
EUROSTOXX 50	3	3	3	3	4	3	2	3
DJ EURO STOXX 300	7	7	6	6.67	10	10	10	10
DJSTOXX 600	10	8	5	7.67	8	9	6	7.67
NIKKEI 225	9	10	11	10	7	4	3	4.67
TOPIX 500	8	9	10	9	6	6	5	5.67
S&P 500	6	6	7	6.33	5	7	8	6.67
RUSSELL 2000	11	11	8	10	9	11	11	10.33
DOW JONES 30	1	2	4	2.33	1	2	1	1.33

This table displays the rank of each stock market index corresponding to its Euclidian distance from optimal portfolios for the two periods of October 1995 to September 2000 and October 2000 to September 2005.

[11] That the value-weighted portfolio is dominated by an equally-weighted portfolio is not unrelated to the literature on the performance of buy-and-hold versus fixed-mix asset allocation strategies (see for example Perold and Sharpe (1988), Fernholtz and Shay (1982) or Swensen (2005)).

3. Lack of Efficiency

Table 15 B:
Average rank of stock market indices based on efficiency criteria for the two periods of October 1995 to September 2000 and October 2000 to September 2005 and for the whole period

	Rank		Oct. 1995 – Sept. 2005	
Indices	Oct. 1995 – Sept. 2000	Oct. 2000 – Sept. 2005	Indices	Average Rank
DAX 30	1	6	DOW JONES 30	1
DOW JONES 30	2	1	EUROSTOXX 50	2
EUROSTOXX 50	3	2	DAX 30	3ex
CAC 40	4	3	CAC 40	3ex
FTSE 100	5	6ex	FTSE 100	5
S&P 500	5ex	8	S&P 500	6
DJ EURO STOXX 300	7	10	TOPIX 500	7
DJSTOXX 600	8	9	NIKKEI 225	7ex
TOPIX 500	9	5	DJ EURO STOXX 300	9
NIKKEI 225	10	4	DJSTOXX 600	9ex
RUSSELL 2000	10ex	11	RUSSELL 2000	11

The left side of the table displays the market indices from the most efficient to the least efficient for the period of October 1995 to September 2000, with the corresponding rank in terms of efficiency for the period of October 2000 to September 2005 displayed in the column immediately to the right. The right side of the table displays the market indices from the most efficient to the least efficient, being the result of their average rank during the two periods.

obtained for each index. Results appear in Table 15 A. The lower the distance between the market index and the efficient portfolios, the more efficient the market index.

It should be noted that the efficiency criterion is based on a comparison of the index with an efficient allocation between its component stocks. The fact that the efficiency of the Dow Jones Industrials (which contains only 30 stocks) is higher than that of the S&P 500 is not incoherent. It results from the fact that we compare the Dow Jones Industrials to an efficient allocation among 30 stocks whereas we compare the S&P 500 to an efficient allocation among 500 stocks. The same comment applies to the higher ranking of the Euro Stoxx 50 index when compared to the Euro Stoxx 300.

More generally, it can be seen that the narrower indices tend to be ranked better than the broader indices in terms of efficiency. This may be explained in the following way: it is probably the case that the allocation we implement does not make much difference when the stock universe is strongly reduced. In other words, the drawbacks of capitalisation weighting become more pronounced when the index is large. This stems from the fact that the inclusion of smaller stocks has almost no impact on the capitalisation-weighted index, while it has a strong impact on the mean-variance efficient portfolios.

4. Consequences for Portfolio Management and Remedies

The previous sections have outlined two types of problems associated with broad market indices. In particular, it has been shown that broad stock market indices neither offer stable exposure to sub-categories – and thus risk factors – of the stock market nor constitute an efficient portfolio in the sense of mean-variance efficiency. For an investor, this conclusion poses an obvious problem when such broad stock market indices are used in the investment process. Usage of indices comprises asset allocation (where indices are used in order to make choices on the long term risk exposure or betas of the investor's portfolio) and performance measurement and evaluation where this risk exposure is used in order to separate the normal returns this exposure yields from the abnormal returns that may be due to the investor's skill or luck. The sections below provide further insights into the consequences of the conclusions reached above. Furthermore, given the problem and its consequences, we propose some ways of dealing with the limits of indices.

The consequences and remedies are illustrated using the sector data from section two. As outlined in that section, not all the indices we studied have sector indices that are available. Some indices only have sector indices for larger definitions of the index. In such cases, we take the larger index in order to conduct the sector analysis. The data is summarised in the following table.

Table 16:
Overview of sector data

Geographical Zone	Index	Number of sectors	List of sectors	Sectors excluded due to data restrictions
Germany	Prime All Share Index 380	18	AUTOMOBILE	
			BANKS	
			RESOURCES	
			CHEMICALS	
			CONSTRUCTION	
			CONSUMER	
			FINANCIAL SVS.	
			FOOD & BEV.	
			INDUSTRIAL	
			INSURANCE	
			MEDIA DS-CALC.	
			PHARMA & HLTC.	
			RETAIL	
			TECHNOLOGY	
			TELECOM	
			TRANSPORT & LOG.	
			UTILITIES	
			SOFTWARE	
U.K.	FTSE All Share Index 700	10	OIL & GAS	
			BASIC MATERIALS	
			INDUSTRIALS	
			CONSUMER GOODS	
			HEALTH CARE	
			CONSUMER SVS	
			TELECOM	
			UTILITIES	
			FINANCIALS	
Eurozone	DJ Euro Stoxx 300	15	TECHNOLOGY	
			AUTO & PARTS	
			BANKS	
			BASIC RESOURCES	
			CHEMICALS	

4. Consequences for portfolio management and remedies

Geographical Zone	Index	Number of sectors	List of sectors	Sectors excluded due to data restrictions
			FOOD & BEVERAGES	
			FINANCIAL SVS	
			TECHNOLOGY	
			HEALTH CARE	
			INDUSTRIAL GOODS & SVS	
			INSURANCE	
			MEDIA	
			OIL & GAS	
			CONSTRUCTION & MATERIALS	PERSONAL & HOUSEHOLD GOODS
			TELECOM	RETAIL
			UTILITIES	TRAVEL & LEISURE
Europe	DJ Stoxx 600	15	Same as DJ Euro Stoxx 300	Same as DJ Euro Stoxx 300
Japan	Topix 1666	33	AIR TRANSPORT	
			BANKS	
			CHEMICAL	
			CONSTRUCTION	
			ELECTRIC MACHINE	
			ELEC.POWER & GAS	
			FISHERIES	
			FOODS	
			GLASS & CERAMICS	
			INFO & COMMUNICATION	
			INSURANCE	
			IRON & STEEL	
			LAND TRANSPORT	
			MACHINERY	
			MARINE TRANSPORT	
			METAL PRODUCTS	
			MINING	
			NON-FERROUS METS	
			OIL & COAL PRODS	
			OTHER FINANCIALS	
			OTHER PRODUCTS	
			PHARMACEUTICAL	
			PRECISION INSTR.	
			PULP & PAPER	
			REAL ESTATE	
			RETAIL	
			RUBBER PRODUCTS	
			SECURITIES	
			SERVICES	
			TEXTILES	
			TRANSPORT EQUIP.	
			WAREHOUSE	
			WHOLESALE	
USA	S&P 500	10	CONSUMER DISCRETIONARY	
			CONSUMER STAPLES	
			ENERGY	
			FINANCIALS	
			HEALTH CARE	
			INDUSTRIALS	
			INFO TECHNOLOGY	
			MATERIALS	
			TELECOM SERVICES	
			UTILITIES	

4. Consequences for portfolio management and remedies

4.1. Asset Allocation

4.1.1. Asset allocation and indices

Asset allocation corresponds to a top-down portfolio management approach. While the more traditional bottom-up approach focuses on individual stock picking, the top-down approach gives more importance to the choice of different asset classes as opposed to individual security selection. Asset allocation consists in choosing the weight of different asset classes within the portfolio. There are two separate steps in the asset allocation process. One first defines the long-term allocation, based on estimates of risk and return for each asset class. This is known as "strategic allocation". One can then carry out dynamic adjustments based on short-term expectations. This is known as "tactical allocation". Here, we will focus on the role of indices in long-term (strategic) asset allocation. Strategic Asset Allocation involves choosing an initial portfolio allocation consistent with the investor's objectives and constraints. Optimal asset allocation, which is based on long-term estimates of risk and return for each asset class, can be based on a quantitative approach, with the help of different asset allocation models.

The use of broad stock market indices in asset allocation may take on different forms. First, if an investor chooses to invest his complete wealth or at least his complete allocation to the equity class in a single index, he considers this index to be the best choice of long-term risk exposure. Second, if the investor chooses a number of broad market indices for different regions and conducts an asset allocation between the different indices, he considers that there may be some added value to the choice between different countries, but for a given country the index offers him the best exposure to different sub-categories, such as small cap and large cap stocks or different industry sectors.

The second case may be problematic in view of publications that highlight the benefits of sector or style allocation more than those of geographic allocation decisions. For example, Longin and Solnik (1995) have shown that the correlation of stock market returns in different countries is not constant and that they have a tendency to augment in a volatile market environment. A more recent study by Hamelink, Harasty and Hillion (2002) establishes that the benefits of sector diversification outweigh those of country diversification. Regardless of this problem, we focus on the problem that is common to both forms, namely the assumption that broad stock market indices provide the best possible exposure to long-term risk factors.

In the following section we assess the two classes of problems identified above, namely the lack of stability and the lack of efficiency of broad stock market indices. Before presenting the problems and possible solutions in more detail, it is appropriate to review the conceptual issues involved. We therefore review the literature on fixed-mix investment strategies as opposed to buy-and-hold portfolio strategies.

It should be noted that the standard definition of efficiency stems from the formulation of the portfolio choice problem in a single period framework. Markowitz considers an investor who has expectations over a fixed investment horizon, and chooses a portfolio that will remain unchanged over this period. In practice,

4. Consequences for portfolio management and remedies

investors are of course able to adjust the weights in the portfolio within the total investment period.

In academic publications, the benefits of such dynamic asset allocation strategies have been recognized since the early 1970s (see Hakanson (1971) and Samuelson (1969), in a discrete time setting, as well as Merton (1971), in a continuous time setting, for the development of a multi-period approach to optimal asset allocation decisions). With dynamic asset allocation, portfolio weights change over time, in accordance with newly available information, either on exogenous variables such as price-dividend ratio changes or information on the asset prices themselves. Such dynamic allocation strategies are opposed to a buy-and-hold strategy, where weights evolve according to changes in prices, but also to a fixed-weight strategy, where rebalancing is allowed to revert to the initial weights. Here, we use the term 'fixed-mix' to refer to strategies that readjust the weights to the weight generated as a result of the initial decision without using new information, and the term 'dynamic allocation' for strategies that explicitly take into account new information. Both types of strategy are opposed to the simple buy-and-hold strategy where weights are fixed at the beginning of the initial period and allowed to evolve without control by the investor over the subsequent periods.

Given that an index tries to reflect the entire stock market rather than a particular investment strategy, we focus on the difference between a buy-and-hold strategy and a fixed-mix strategy. The problem the investor faces when following a buy-and-hold strategy is that the weights of the portfolio may deviate considerably from the weights chosen initially, depending on the relative returns of the assets. It has often been argued that the efficient frontier for the re-balanced portfolio outperforms the buy-and-hold strategy (see Fernholtz and Shay (1982) for theoretical results, and Swensen (2005) for a more practical approach to the question). Other studies address the question of how often the investor should rebalance. Simulation-based studies and studies on historical returns typically conclude that a rebalancing delivers the best results (see e.g. Buetow et al (2002), Plaxco and Arnott (2002) or Mulvey, Simsek and Zhang (2006)).

One may be sceptical and argue that the excess returns of a rebalanced portfolio over a non-rebalanced portfolio may actually stem from a risk premium, that is, the investor is accepting higher risks which receive compensation in terms of expected returns. Notwithstanding this general argument, it may be beneficial for investors to control transaction costs by imposing some limit on the deviations from initial weights. However, Booth and Fama (1992) define the diversification return as the return difference between the geometric return of a portfolio and the weighted average of geometric returns of its components. Erb and Harvey (2005) show that fixed-mix strategies are more likely to receive such a diversification return than unrebalanced portfolios.

In the context of our analysis, we explore solutions to the two problems identified above: lack of stability and lack of efficiency. In order to address the problem of the lack of stability, we propose to neutralise the unstable sector exposure by a completeness portfolio that effectively achieves a fixed mix of sector portfolios. The weighting scheme is not

4. Consequences for portfolio management and remedies

fundamentally different from capitalisation weighting, since the final weights are given by the long-term average capitalisation weights.

In order to address the problem of a lack of efficiency, we propose a simple and robust asset allocation solution – the minimum-variance portfolio. One possibility would be to form such a portfolio at the beginning of the period and then let the weights drift as a function of the component returns. This is precisely what happens in the case of capitalisation weighting. However, the portfolio that has minimum-variance weights initially would differ considerably from the capitalisation-weighted portfolio. In addition to the difference in initial weights, we decide to recompute the optimal portfolio weights annually. This is justified by the fact that we want to have observations that are non-overlapping for the estimation of the inputs to the portfolio optimisation. It should be noted that by rolling the sample window, we are actually taking into account new information rather than just rebalancing the weights. Furthermore, we rebalance the weights daily so that we actually hold constant weights within each annual period. Our minimum-variance portfolio is therefore dynamic in the sense that we include new information in a pragmatic manner and conduct rebalancing within each period.

The following two sub-sections include the details on the nature of the problem arising in portfolio management and the methodology employed for a proposed solution.

4.1.2. Coping with indices that lack stability

As outlined in section two of this document, broad stock market indices show considerable variation in exposures to different styles or sectors over time. The investor thus holds an allocation that is not purely static, but which evolves according to the evolution of the capitalisation weights of the different sectors of the stock market.

An obvious way to deal with the lack of stability is to construct portfolios that have constant weights over time. However, if investors choose to construct a portfolio themselves, they will forego some of the implementational advantages of investing in broad stock market indices (such as low management fees, low transaction costs, low information costs and simple implementation of orders dealing with intermediate cash flows). Therefore, we propose to construct completeness portfolios that allow for an investment in broad stock market indices while neutralising the sector shifts inherent in the indices. We concentrate on sector biases (rather than style biases), since sector weights are directly observable from the market capitalisation of sectors. The analysis is done for all portfolios where we performed the sector stability analysis above, using the same dataset.

We will now formalise the concept of the completeness portfolio. In order to obtain returns that correspond to a fixed mix portfolio, the investor has to hold weights that are constant over time. With R_{fix} denoting these returns, and $w_{fix,k}$ denoting the target weights allocated to asset k, we can write this as follows:

$$R_{fix}(t) = \sum_{k=1}^{K} w_{fix,k} R_k(t)$$

Holding a capitalisation weighted index, on the other hand will yield the returns R_{cap}:

$$R_{cap}(t) = \sum_{k=1}^{K} w_{cap,k} R_k(t)$$

where w_{cap} denotes the evolving market cap weights.

4. Consequences for portfolio management and remedies

It can be seen that the completeness portfolio, whose returns may be written as follows:

$$R_{completeness}(t)=\sum_{k=1}^{K}\left(w_{fix,k}-w_{cap,k}\right)R_k(t)$$

is obtained by simply holding the difference between the long term weight and the current capitalisation weight for each asset $W_{fix,k}$ - $W_{cap,k}$ = $W_{completeness}$. As W_{cap} is constant over time, the only source of variation in the weights of the completeness portfolio stems from the changes in market capitalisation.

Given our dataset, we construct completeness portfolios in the following way:

- The long-term sector weights for the broad stock market index are obtained as the mean weight over the ten-year total period from October 1995 to September 2005. These are our W_{fix}. Of course, the completeness portfolio approach may be used more generally in order to implement a weighting scheme different from our long term weights. An obvious alternative is an equal-weighted strategy where $w_{fix,k}$ would be set to equal 1/N where N is the number of sectors, or more generally, the number of assets considered.
- Completeness portfolios are obtained by constructing the long/short portfolio of sector indices in such a way that the sector weights for an investor who holds the completeness portfolio plus the index correspond to the long-term sector weights. The weights in the completeness portfolio are given by $W_{completeness}$. This is a zero investment strategy:

$$\sum_{k=1}^{K}\left(w_{fix,k}-w_{cap,k}\right)=0$$

  We rebalance the completeness portfolio at the beginning of every month.
- The data used is the monthly returns for the sector and the broad market indices.

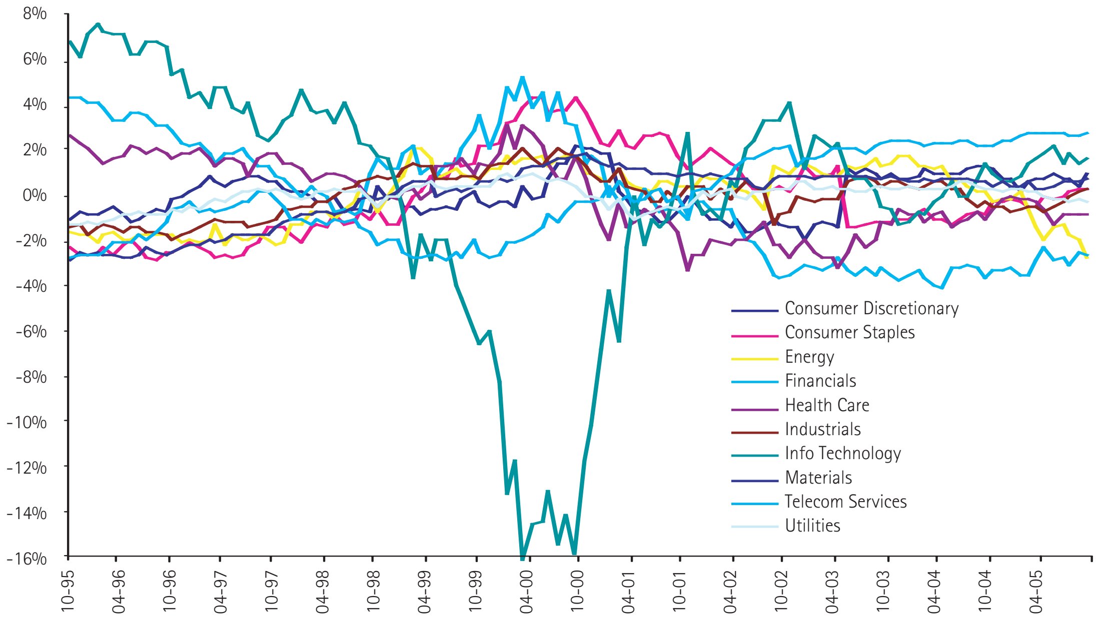
The weights of the sectors in the completeness portfolio can be seen directly from the variation of the sector weights presented in section two. As an illustration, the graph below shows the weights in the completeness portfolio obtained for the S&P 500.

It can be seen that the completeness portfolio is heavily weighted in the defensive sectors — financials and consumer staples — at the height of the technology bubble in the year 2000. The information technology sector, on the other hand, experiences strong negative exposure. This combination therefore smoothed the exposure to the technology sector, and thus the impact of the burst of the bubble. While this period and this sector may be seen as an extreme case, it also becomes apparent that significant long and short weights are held in any period. For example, the Energy and Financials sectors are currently held as negative positions with weights of below -2.5%, while consumer staples and utilities are overweighted with weights of approximately 2.5%.

Adding the completeness portfolio resolves the problem of the investor not being in control of the sector exposures of his equity portfolio. In addition, the investor holds a portfolio whose weights remain fixed, unlike with a buy-and-hold strategy. However, the choice of long-term risk exposure is still the one implied by market capitalisation weights. One may wonder if holding the completeness portfolio in addition to the market index (and thus holding the sector weights constant) has a significant impact on the risk-return statistics associated with the overall position the investor holds. The

4. Consequences for portfolio management and remedies

Illustration 19: Weights in completeness portfolio for the S&P 500



The graph indicates the sector composition of the completeness portfolio over the entire sample period of 10/1995 to 09/2005. The completeness portfolio was calculated as described in the text based on data for the monthly observations for the market value of sector indices obtained from Datastream Thomson Financial. The industry sectors used are displayed in the legend on the right-hand side of the graph.

table below reports the risk return statistics of the buy-and-hold capitalisation weighted portfolio (which corresponds to the broad market index) and of the long-term mean-weighted sector portfolio (which corresponds to the broad market index plus the completeness portfolio). This is done for the six indices where sector weights are available. The buy-and-hold portfolio is indicated by the term "Cap weighted" and the combination of market index and completeness portfolio is indicated by the term "Stable".

Table 17: Stable portfolios versus capitalisation weighted portfolios: Performance statistics

	Risk Dimension					Risk-Adjusted Performance	
	Average Return*	Maximum Drawdown (in %)	Volatility (in %)*	Downside Risk (in %)*	Modified Value-at-Risk (in %)***	Sharpe-Ratio*/**	Sortino Ratio*/**
Prime All Share 380 (Germany) Stable	11.61%	60.61%	21.14%	15.18%	9.61%	0.37	0.52
Prime All Share 380 (Germany) Cap Weighted	8.74%	68.67%	21.44%	15.65%	10.06%	0.24	0.32
FTSE All Share 700 (U.K.) Stable	11%	38.09%	13.74%	11.36%	6.47%	0.53	0.64
FTSE All Share 700 (U.K.)							
Cap Weighted	9.17%	42.62%	13.7%	11.09%	6.58%	0.4	0.49
DJ Euro Stoxx 300 (Eurozone) Stable	13.08%	54.66%	19.73%	14.69%	9.15%	0.48	0.64
DJ Euro Stoxx 300 (Eurozone) Cap Weighted	11.75%	59.7%	20%	14.7%	9.28%	0.4	0.55
DJ Stoxx 600 (Europe) Stable	11.58%	52.74%	17.1%	12.93%	8.07%	0.46	0.6
DJ Stoxx 600 (Europe)							
Cap Weighted	10.23%	56.16%	17.1%	12.84%	8.14%	0.38	0.51
Topix 1666 (Japan) Stable	3.46%	47.63%	16.4%	9.37%	7.41%	-0.01	-0.03
Topix 1666 (Japan)							
Cap Weighted	1.43%	53.2%	16.82%	9.61%	7.86%	-0.13	-0.23
S&P 500 (USA) Stable	12.67%	38.31%	15.51%	10.52%	6.92%	0.58	0.84
S&P 500 (USA) Cap Weighted	10.92%	44.66%	15.64%	10.64%	7.18%	0.46	0.68

The table indicates the performance statistics over the entire sample period of 10/1995 to 09/2005. Based on the monthly observations for the returns of sector indices obtained from Datastream Thomson Financial. * annualized statistics are given, ** risk-free rate and MAR are fixed at 2% *** and non-annualised 5%-quantiles are estimates.

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The most basic performance measures, i.e., the mean return and volatility show that the stable portfolios fare rather favourably compared to the capitalisation weighted portfolios. In particular, the expected return increases for all six cases, while the volatility remains roughly the same (it actually decreases in five cases and increases in one case). The Sharpe ratio states the expected return over the risk-free rate earned per unit of expected risk, where risk is defined as the standard deviation of returns. In order to calculate the Sharpe ratio and the Sortino ratio, we use a reference rate of 3.7%, which corresponds to the average rate for U.S. Treasury bills with three months to maturity over the ten-year period under consideration and is also a close approximation of the Euro interest rate over the same period (Datastream calculated the synthetic interbank Euro rate for three months' lending as 3.6% on average). One observes that all stable portfolios have Sharpe ratios that are slightly superior to the market capitalisation weighted indices. The table also reports downside risk measures, such as estimates of the monthly Value-at-Risk (VaR), i.e., the maximum monthly loss with 95% confidence; these are indicated in column five, the downside deviation in column four and the maximum drawdown in column two. These risk measures confirm the tendency of a slight decrease in risk for the stable portfolios. The Sortino ratio, which replaces the volatility in the Sharpe ratio with a measure of downside deviations, also confirms the results obtained from the Sharpe ratio.

4.1.3. Remedy for lack of efficiency

Section three of this document assesses the efficiency of broad stock market indices. The results of section three show that the market indices are dominated by portfolios that result from a mean-variance optimisation in the mean/variance plane. What is more, the differences in returns and standard deviations are significant in magnitude, which underlines the fact that there is significant potential to do better than those market indices. As outlined in section three, an important caveat is that the mean-variance efficient portfolios are obtained ex post and therefore do not represent true ex ante investment choices. However, it is also shown in section three that, over long periods, a simple equal-weighted portfolio dominates on average the market indices in terms of risk-return properties. In fact, by investing in a market index, the investor does not completely avoid the asset allocation decision, but he simply defers it to the market's choices. These choices are not stable over time and are also inefficient. The equal-weighted portfolios presented in section three represent a very simple way of obtaining better results for the investor.

Should it be said that commercial indices are sub-optimal investment vehicles that should simply be avoided by investors? We actually believe not, as there is evidence that commercial indices can be used as building blocks to design efficient allocation strategies. The idea is to construct a benchmark from sector indices. This benchmark is supposed to reflect the risk inherent in the capitalisation-weighted index, while implementing an optimisation between different sectors in order to obtain a strategic allocation that is more efficient than the index.

In what follows, we provide a very simple example of such an optimization procedure. Our goal here is not to introduce a full-fledged state-of-the-art optimization model, but rather to present evidence that even a

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basic and simple procedure can lead to substantial efficiency gains. The most widely quoted quantitative model in the strategic allocation literature is of course Markowitz's (1952) optimization model. The input data are the means and the variances, estimated for each asset class, and the covariances between the asset classes. The model provides the optimal percentage to assign to each asset class in order to obtain the highest return for a given level of risk, measured by portfolio volatility. The main drawback of the Markowitz model stems from the fact that the optimal proportions are very sensitive to the estimates of expected return values. What is more, the statistical estimates of expected returns are very noisy (see Merton (1980)). As a result, the model often allocates the most significant proportion to the asset class with the largest estimation error. Therefore, the mean variance frontiers obtained in section three are extremely difficult to obtain in practice. While these problems probably explain why the Markowitz model is still not used very often in practice, there is a pragmatic approach that allows these problems to be avoided without abandoning the model.

This approach consists in focusing on the only portfolio on the mean variance frontier for which the estimation of mean returns is not necessary, namely the minimum-variance portfolio. Since the future returns of assets are always difficult to estimate precisely, it is preferable to obtain an efficient portfolio by minimising the risk rather than by optimising the risk/return combination. For more details on the minimum-variance approach, see for example Chan, Karceski and Lakonishok (1999) or Amenc and Martellini (2003). Though this approach avoids the problem of estimation risk for the expected returns, it is still faced with the estimation risk for the covariance matrix. It should be noted that our approach is simpler than the approach taken in these two papers in that we do not impose a model for the covariance matrix. Our forecasts for the covariance matrix are simply derived from the sample estimates. In practice, an investor may choose to implement the noise dressing techniques used by Amenc and Martellini and/or impose some structure by using constant correlations or factor models (see Chan, Karceski and Lakonishok and the references therein).

We choose to deal with the problem of estimation risk, not by imposing a model, but by imposing a maximum constraint of 20% for the weight of a given sector. Imposing constraints has been shown to be a useful option as it increases the performance of asset allocation that uses the sample covariances, as against more sophisticated approaches of modelling the covariance matrix (see Jagannathan and Ma (2003)). This means that our conclusions apply more generally rather than being limited to a certain type of model used for covariance forecasts.

In order to assess the performance of minimum-variance portfolios, we run the following tests:

- The data used are daily returns calculated as in section three, for the broad market indices and for the sector indices. The daily returns are useful in order to improve the precision of the covariance estimates.
- We compute the minimum-variance portfolio based on a calibration period of the daily returns observations for the past year. We obtain the optimal weights and hold this portfolio for the following three months. We then reperform the analysis, rolling the

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sample three months forward and holding the new optimal portfolio for the following three months. Therefore, our analysis is purely out-of-sample.

We thereby obtain the time series of returns for the strategy over the period of 10/1996 to 09/2005 (the total period minus the calibration period). The resulting performance statistics of the minimum-variance ("Min Var") portfolios are given in the following table, which also reports the performance statistics of the corresponding broad market indices ("Cap weighted"). It should be noted that we compare the performance of the portfolios constructed according to our methodology to the index that corresponds to the sector indices used. For the German index, for example, we use the Prime All Share Index rather than the narrower Dax 30. We thus ensure that better performance of the minimum-variance portfolio indicates the value of conducting an active strategic allocation, rather than switching to a broader universe of stocks.

It can be seen that the volatility of the minimum-variance portfolio is always significantly lower than that of the corresponding market index. As opposed to the in-sample results reported in section three, this dominance is not achieved by construction and the portfolios can actually be obtained ex ante by an investor. What may perhaps be more surprising is that the lower risk of the minimum-variance portfolio does not lead to a lower expected return for five out of six indices. This is only the case for the minimum-variance portfolio of sectors composing the S&P 500 index. All other minimum-variance portfolios also have higher expected returns than the corresponding index. Consequently, the Sharpe ratios reported on the right-hand side of the table show strong improvements compared to the market index, except for the S&P 500. Table 19 summarises the results and ranks the indices according to their efficiency when compared with the capitalisation weighted index.

The third column in Table 19 indicates the difference in the Sharpe Ratio between the capitalisation-weighted index and the sector allocation strategy in the minimum-variance portfolio. If the difference is negative (positive), the capitalisation-weighted index shows a loss (gain) in efficiency compared to the minimum-

Table 18: Minimum-variance portfolios versus capitalisation weighted portfolios: Performance statistics

	Risk Dimension					Risk-Adjusted Performance	
	Average Return*	Maximum Drawdown (in %)	Volatility (in %)*	Downside Risk (in %)*	Modified Value-at-Risk (in %)***	Sharpe-Ratio*/**	Sortino Ratio*/**
Prime All Share 380 (Germany) MinVar	7.15%	49.9%	11.58%	9.05%	1.26%	0.3	0.38
Prime All Share 380 (Germany) Cap Weighted	4.07%	77.34%	23.75%	17.18%	2.45%	0.02	0.02
FTSE All Share 700 (U.K.) MinVar	8.76%	40.13%	12.82%	10.17%	1.37%	0.39	0.5
FTSE All Share 700 (U.K.) Cap Weighted	6.56%	50.79%	16.42%	12.16%	1.7%	0.17	0.24
DJ Euro Stoxx 300 (Eurozone) MinVar	10.43%	49.62%	15.96%	12.25%	1.65%	0.42	0.55
DJ Euro Stoxx 300 (Eurozone) Cap Weighted	7.71%	68.12%	21.15%	15.64%	2.17%	0.19	0.26
DJ Stoxx 600 (Europe) MinVar	8.46%	48.8%	14.91%	11.53%	1.56%	0.32	0.41
DJ Stoxx 600 (Europe) Cap Weighted	6.93%	63.21%	19.13%	14.18%	1.97%	0.17	0.23
Topix 1666 (Japan) MinVar	1.69%	35.41%	13.67%	9.49%	1.37%	-0.15	-0.21
Topix 1666 (Japan) Cap Weighted	-2.11%	59.28%	19.64%	13.83%	2.04%	-0.3	-0.42
S&P 500 (USA) MinVar	5.5%	47.63%	14.86%	10.78%	1.5%	0.12	0.17
S&P 500 (USA) Cap Weighted	8.11%	50.78%	18.54%	12.92%	1.85%	0.24	0.34

The table indicates the performance statistics over the out-of-sample period of 10/1996 to 09/2005. It is based on the daily observations for the returns of sector indices obtained from Datastream Thomson Financial. No results are available for the period of 10/1995 to 09/1996, since this data was needed for the initial calibration period. * Annualised statistics are given, ** risk-free rate and MAR are fixed at 2%, *** non-annualised 5%-quantiles are estimates.

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Table 19: Comparison of Minimum-variance portfolios with capitalisation weighted portfolios

	Sharpe-Ratio of Minimum-variance Index	Sharpe-Ratio of Cap Weighted Index	Efficiency Loss (-)/ Gain (+) of cap weighted index	Rank
S&P 500 (USA)	0.12	0.24	0.12	1
Topix 1666 (Japan)	-0.15	-0.3	-0.15	2
DJ Stoxx 600 (Europe)	0.32	0.17	-0.15	3
FTSE All Share 700 (U.K.)	0.39	0.17	-0.22	4
DJ Euro Stoxx 300 (Eurozone)	0.42	0.19	-0.23	5
Prime All Share 380 (Germany)	0.3	0.02	-0.28	6

This illustration summarises information from Table 18. The right-hand column indicates the difference in the Sharpe Ratio between the capitalisation-weighted index and the sector allocation strategy in the minimum-variance portfolio. It can be seen that in all cases, except for the S&P 500, the minimum-variance portfolio obtains a higher Sharpe Ratio than the capitalisation weighted index. It should be noted that for the S&P 500, the average return of the capitalisation weighted index is higher, but the volatility is also higher than that of the minimum-variance portfolio.

variance portfolio. Note that the indices are ranked according to this efficiency loss in descending order. It can be seen that in all cases, except for the S&P 500, the minimum-variance portfolio obtains a higher Sharpe Ratio than the capitalisation weighted index. It should be noted that for the S&P 500, the average return of the capitalisation weighted index is higher, but the volatility is also higher than that of the minimum-variance portfolio.
In this sub-section, we have shown that there are pragmatic remedies for the problems of capitalisation-weighted indices in the area of asset allocation. The following section addresses the consequences of these problems for portfolio performance measurement and evaluation and outlines some solutions accordingly.

4.2. Performance Measurement and Evaluation

4.2.1. The problem of benchmark selection

The choice of the benchmark plays not only an essential part in portfolio choice of allocation, but is also the primary constituent for portfolio performance measurement. It is common practice to present portfolio performance in terms of relative performance to that of a benchmark, even if the portfolio management is said to be benchmark-free.

However, benchmark selection is often not given all the attention it requires. Despite the development of techniques for constructing customised benchmarks or normal portfolios, which reflect the manager's asset allocation strategy, most investment managers still use simple market indices. Meanwhile, the use of benchmark indices has grown in sophistication since the 1990s. Managers who were previously using broad market indices began to turn to more specialised indices. This has led to an increase in index providers and considerable development of the indices on offer, with indices of different sizes and styles now available.

The broad market indices include a very large number of stocks. Indices based on a more restricted number of stocks are made up of the main stocks in the listing only. These indices are less representative of the market. Mid-sized indices, created more recently, make it possible to find a compromise between exhaustiveness and liquidity. With the arrival of the euro and the disappearance of the notion of domestic markets, the development of index management on a European scale has required the creation of new indices to focus on European securities and to reflect the evolution

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of the European Markets, and more particularly of the euro zone, in order to reflect the new economic and monetary context.

Market indices are quoted on stock exchanges and are therefore simple to use. However, they may not be sufficiently representative of the managed portfolio. For example, equity indices contain large capitalisation stocks and do not therefore allow the performance of a portfolio that contains small capitalisation stocks to be evaluated. The broad indices are intended for institutions that do not often act directly on the markets. These indices include securities with a low level of liquidity. Investors who face the markets more frequently require more liquid indices. They use indices that are based on a more restricted number of stocks. However, these indices may appear too narrow for investors who wish to build an index portfolio. Mid-size indices may be a solution.

Generic investment style indices are very specific indices and are appropriate for a manager who has a well-defined investment style. Other managers can use Sharpe benchmarks[11] that allow managers to define their style in a more appropriate way.

It is widely accepted that the choice of the benchmark plays an important part in explaining portfolio performance. It would not be fair to compare the performance of a manager who follows a very precise style to that of a benchmark representing the whole of the market, or which corresponds to a style that is different from his. A manager may for example produce a performance that is worse than the performance of the market as measured by a broad index, if the style that he employs is not the most favourable over the period under consideration. He could nevertheless display particular skill within his style, by producing a performance that is better than the benchmark that corresponds to his specific style; we should not consider in this case that the manager has performed badly. The opposite situation may also arise. A manager may produce a performance that is better than the broad index, but worse than the index corresponding to his style; he should not in this case be considered to be a good manager in the style that he employs. Studying performance in comparison with a specific benchmark allows us to avoid such errors.

While the published indices may provide good benchmarks for some investment strategies, they are not suited for sophisticated investment managers employing specialized investment strategies and requiring thorough analysis of their portfolios against a specialised benchmark. Choosing a benchmark means fixing objectives in terms of the systematic risk exposure of the portfolio. The benchmark must therefore be chosen to reflect the diversity of the assets contained in the portfolio and the investment strategy employed. A benchmark must be representative of all the risks supported by the portfolio during the analysis period. If the manager decides to track very closely an index he has chosen as a benchmark, allowing only for marginal tracking error, then this index can be considered a good benchmark. However, if the manager obtains his performance from a choice of systematic risks that are different from those of the index, this will not constitute a good benchmark. In this case, the use of customized benchmarks is more appropriate.

Another point to take into account in the choice of benchmark is related to benchmark

[11] Sharpe benchmarks will be described in the following subsection.

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efficiency, i.e., where the chosen benchmark is the best investment choice that it is possible to make. It clearly appears from our study that market indices are not efficient.

Bailey, Richards and Tierney (1990)[12] and Bailey (1992)[13] set out rules that are commonly accepted today on what a valid benchmark should be. It must be unambiguous, investable, measurable, appropriate, provide a reflection of investors' current views and, finally, it must be specified in advance. In order to respect these conditions, managers must define a benchmark for which the securities weightings are a true reflection of the neutral or "normal" weights of their portfolio for the analysis period. This is not compatible with the choice of an index that is not neutral but corresponds to specific risks. Broad market indices do not reflect characteristics of managed portfolios and are not suitable for evaluating their performance, because they contain securities not included in the manager's portfolio. In addition, the proportions of each security in the indices are generally different from those chosen by the manager. Moreover, index style composition is not stable over time, as is shown by our study. Managers that select a market index as their benchmark can see their risk exposure being modified through over time. As a result, it may happen that this risk exposure no longer corresponds to their initial choices.

We explained that portfolio managers can obtain more sophisticated benchmarks by choosing a combination of indices, instead of a single index. A benchmark can be any portfolio. Kuenzi (2003) proposes to use what he calls strategy benchmarks. Kuenzi chooses to use the term "strategy benchmarks", while many practitioners use the term "custom benchmark", to emphasise the fact that these benchmarks are related to a manager's specific strategy and universe of securities. Kuenzi underlines that broad market indices have long been used as benchmarks by investors and fund managers. Nevertheless, with the development of numerous sophisticated investment styles, such broad indices do not accurately reflect the specific features of certain strategies. Since benchmarks play a central role in portfolio risk management and portfolio attribution analysis, investors and fund managers may be compelled to construct strategy benchmarks to ensure a robust implementation of the investment process. Kuenzi's point of view is that the use of strategy benchmarks is not only important for clients but is also important in order for the investment process to work efficiently, whenever the manager's strategy produces a universe of securities that differs by rule from available published indices. This point represents an evolution in comparison to previous studies. He also explains that the choice of an inappropriate benchmark may distort the risk and performance analysis, and does not ensure the integrity of more recently employed performance measures, such as the information ratio.

By relying on a decomposition of a portfolio's active management holding, a manager's strategy and a published index derived by Bailey, Richards and Tierney (1990), Kuenzi shows why it is so important to use strategy benchmarks. Bailey, Richards and Tierney

[12] Bailey, J.V., T. M. Richards and D.E. Tierney, "Benchmark Portfolios and the Manager/Plan Sponsor relationship", *Current Topics in Investment Management*, Frank J. Fabozzi and T. Dessa Fabozzi (eds.), Harper Collins, New York, 1990, pp. 349-363.
[13] Bailey, J.V., "Are Manager Universes Acceptable Performance Benchmarks?", *Journal of Portfolio Management*, 1992, pp. 9-13.

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(1990) decompose a manager's portfolio holding P in the following way:

$$P = B + (P - B) = B + A$$

where "B" indicates the benchmark's exposures or the portfolio's "normal weights" and A is the active position (equal to the portfolio exposures "P" minus the benchmark exposures "B").

Defining M as an available published index gives us:

$$P = M + (B - M) + A = M + S + A$$

where S is the style exposure of the manager, which is equal to the manager's benchmark minus some published index. By doing this, the authors make a distinction between the normal weights represented by B and a published index represented by M. This difference is the manager's strategy S. The final equation $P = M + S + A$ provides powerful intuitions concerning the relationship between active management, a manager's strategy and a published index. It shows that the only time a strategy benchmark is unnecessary is when $B = M$, or when the manager's normal weights are equal to those of a published benchmark, so that $B - M = 0$ and $P = M + A$. If a manager's strategy is such that the manager's average exposures through time B differ from those of a published benchmark M, then it is crucial to create a strategy benchmark, rather than using a published benchmark and just assuming that $B = M$.

Kuenzi argues that the performance of a portfolio is driven by three components: the publicly available index, the extent to which the benchmark deviates from the publicly available index (i.e., manager's style exposure) and the extent to which the portfolio deviates from the benchmark (i.e., manager's active position). A manager's benchmark should represent "normal" or "neutral" portfolio weights. So if one cannot find any publicly available index representing neutral weights for the strategic portfolio, a customized or strategy index must imperatively be constructed. As a result, a strategy benchmark will generally be needed as soon as a manager has a style bias with respect to the different indices available on the market. Like all benchmarks, the strategy benchmark must be unambiguous, investable, measurable, appropriate, and reflect the portfolio manager's current investment philosophy.

According to Bailey, a benchmark is appropriate if "it is consistent with the manager's investment style" and a benchmark is reflective of current investment opinions if "the manager has current investment knowledge of the securities that make up the benchmark". This points out the necessity of using a strategy benchmark for which securities are truly reflective of neutral weights in the manager's universe. Whenever the manager's strategy is such that his universe of investable securities differs from the closest fit published index components, then a strategy benchmark is appropriate.

Kuenzi underlines that while investors are prepared to bear the benchmark risk, portfolio managers are supposed to bear the active risk. Consequently, the concept of risk controls becomes distorted if the manager employs a benchmark that is not representative of true neutral weights. Moreover, using a strategy benchmark enables one to perform active management in a rational way and to take decisions to overweight or underweight factor exposure compared to the benchmark. If the

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publicly available index does not represent neutral weights for the portfolio, it is a poor benchmark for both the purposes of gauging active risk and attributing performance. Moreover, using an inappropriate benchmark leads to built-in tracking error, which in turn distorts the information ratio and makes manager evaluation much more difficult.

Finally, benchmarks serve in a returns-based attribution that indicates the amount of total return that can be attributed to asset allocation, timing, and security selection. As such, returns-based attribution is highly dependent on which benchmark is used. If the manager is using a non-representative index, then the attribution model will interpret the weight difference between the portfolio and the benchmark as an overweight or underweight, thereby attributing outperformance to an active decision. This renders the attribution analysis almost worthless. On the contrary, if a strategy benchmark that accurately represents a neutral position is used, any overweighting or underweighting of a particular factor provides valuable information to the manager concerning active investment decisions and risk management.

Kuenzi has performed a study comparing the use of a strategy benchmark to two published indices in performance measurement. It shows that direct comparison of the manager's results with inappropriate benchmarks provides little useful information. It appears that performance comparisons can be grossly distorted when using unrepresentative benchmarks. Results are similar when returns are adjusted for risk. Moreover, using an inappropriate benchmark leads to built-in tracking error, which will in turn distort the information ratio and make evaluation of a manager much more difficult. The formulation of the information ratio — alpha divided by the tracking error — shows that the lower the residual risk, all things being equal, the higher the information ratio. The use of an inappropriate benchmark, therefore, could have the impact of reducing the information ratio of a very skilled manager. Additionally, all things being equal, a manager outperforms if alpha is higher. If a strategy contains style risk against an inappropriate benchmark, then a favourable environment for that style can lead to a high information ratio when the supposed outperformance is really just a function of the manager's particular style being in favour. Thus, it appears that tracking error and the information ratio can give spurious results if the benchmark used in the analysis is not truly representative of the manager's particular style.

From the perspective provided by Kuenzi, it appears that the use of strategy benchmarks is not only important in the investor's interests, but also equally and perhaps more important from the investment manager's point of view. The choice of an appropriate benchmark enables the investment processes to be continuously improved and gives managers a higher probability of providing investors with superior results.

Meanwhile, the construction of a strategy benchmark may not be straightforward. In the following sub-section, we describe a method to obtain a custom benchmark for a portfolio.

4.2.2. Remedies: Style analysis

As explained above, the most common error made when measuring a manager's performance is the selection of an improper benchmark. In order to solve this problem, in 1992, the Nobel Prize winner William Sharpe

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proposed the construction of a benchmark by performing multiple regressions on several specialised indices in order to obtain an index that was a linear combination of the different style indices available. The chosen indices represent the different asset classes and describe the market in which the portfolio is invested in the most complete manner possible. By analysing the portfolio returns alone, the style analysis allows the indices that are truly representative of the fund's allocation to be selected, resulting in the construction of a customised benchmark that is appropriate for the management style of each portfolio. The result, which is called a Sharpe benchmark, is made up of a linear combination of style indices whose coefficients represent the portfolio's exposure to the different management styles, thus enabling the manager's style to be explained, no longer from a single index, but from a series of indices. This corrects the problem of the style indices being too specific and leads to a benchmark that best fits the management style to be evaluated. William Sharpe introduced this model to provide an objective breakdown of the manager's real style, which may appear to be different from the style announced by the manager himself. This method is known as returns-based style analysis.

Using a multifactor model drawn from Sharpe's style analysis model, it is possible to measure and analyse the performance of investment funds, and more specifically, to evaluate a fund's alpha, which is the outperformance or "abnormal return", with regard to the risk taken by the manager. As the magnitude alpha is not directly observable, its value is obtained by establishing the difference between the returns of the portfolio and the "normal" returns rewarding all of the portfolio's risks.

We believe that Sharpe's style analysis is a useful tool for the investor when evaluating the manager's performance. In particular, the method we propose makes it possible to avoid the use of a market index, which is an inappropriate benchmark in all cases except for the case where the manager takes no systematic risk exposures that differ from the market index. In particular, we propose a two-step approach: first, find the appropriate benchmark and then compute the abnormal return, or alpha, of a manager or a fund, with respect to that benchmark. The details of this process are outlined in what follows.

A style analysis is performed to analyse each fund's investment style in order to select the style indices that best describe the style of each fund. For that purpose, the periodic returns of each fund are compared with those of a set of style indices, as stated in Sharpe's multifactor model (1988,1992). The model is written as:

$$R_{Pt} = b_{P1} F_{1t} + b_{P2} F_{2t} + \ldots + b_{PK} F_{Kt} + e_{Pt}$$

where the notation is as follows:

R_{Pt} is the portfolio's return;

F_{kt} is the return of index k;

b_{Pk} is the portfolio's sensitivity to index (factor) *k*. This exposure can be interpreted as the weighting of class *k* in the portfolio. The sum of weights must be equal to 1:

$\sum_{k=1}^{K} b_{Pk} = 1$, and each weighting must be positive (no short sales);

finally, e_{pt} is the error term.

The indices used in the regression analysis represent distinct investment styles such as large cap value, large cap growth, small cap, short-term government bonds, long-term government bonds, corporate bonds, high yield

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bonds, cash equivalent asset class, etc. A minimum of a three-year history of returns is required and total return indices with regard to the equity-based reference portfolios, i.e., dividends included, are used.

The weightings are determined by a quadratic programme that aims to minimise the difference in weekly[14] returns between a mutual fund and a range of portfolio weightings for the style indices under consideration. The set of resulting exposures determines what is called the "customised benchmark", or the underlying passive portfolio with which the mutual fund's performance will be compared.

The best possible combinations of indices[15] are tested for each investment category (e.g., Equity Euro Zone, Equity North America, Equity Asia, Short-Term T-Bond Euro Zone, Convertible Euro Zone, etc.) encompassing the analysed funds.

The purpose is to select mutually exclusive indices that provide coverage of the basic investment styles and are relevant to the investment category being studied. From this perspective, the system checks the presence of multi-colinearity through a cross-correlation indicator. This task is particularly important to make sure that we can reliably determine the relative influence of the independent variables and avoid a robustness problem (coefficient estimates becoming sensitive to the block of data used in the case of multi-colinearity).

We propose to perform the regression analysis for each eligible fund and check whether the regression coefficients (portfolio weights for the style indices) are significant using a Lobosco & DiBartolomeo test[16].

The adequacy between the fund's returns and the benchmark's returns is controlled with the adjusted R-squared. The higher the adjusted R-squared coefficient, the greater the ability of the passive style portfolio (the "customised" benchmark) to explain the fund's performance. If this coefficient of determination is lower than the predetermined acceptable threshold, then the fund's style analysis is invalidated and the fund is linked to another investment category (i.e., another set of style indices that is likely to provide a better representation of its investment style).

Then, using the set of style indices adapted to each fund with their relative weights (customised benchmark), it is possible, using a multi-index model, to compute the fund's excess performance while taking into account the risks to which it is really exposed. In view of constraints imposed on the regression to define the benchmark (the exposure coefficients are obtained through a constrained regression, in such a way that they are positive and that they sum to one, since they represent a portfolio allocation), the model's excess return term cannot be directly interpreted as the portfolio's abnormal return. In order to calculate the fund's alpha, or abnormal return, one must carry out a new unconstrained regression, employing a multifactor model that uses all the risk factors (style indices), selected during the first phase of benchmark construction, as risk factors. An unconstrained regression for each three-year

[14] Using weekly returns is a good trade-off. The problem with daily returns is noise and the more noise you get the poorer your estimates are. Monthly returns could meet the requirements but necessitate a significant extension of the minimum analysis period in order to have enough data for the regression analysis.
[15] Several factors are considered when selecting style indices, in particular their types and their number.
[16] Lobosco, A. and D. DiBartolomeo, "Approximating the confidence intervals for Sharpe style weights", *Financial Analysts Journal*, July/August, 1997, pp. 80-85.

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rolling window of data is performed using the following equation:

$$R_{Pt} - R_{ft} = \alpha_P + \sum_{k=1}^{K} \beta_{Pk} (F_{kt} - R_{ft}) + \zeta_{Pt}$$

where:
R_{Pt} is the portfolio's return;
F_{kt} is the return of index k;
R_{ft} is the risk-free rate;
and β_{Pk} is the portfolio's sensitivity to index (factor) *k*.

Alpha measures the difference between a fund's actual returns and its expected performance, given its level of risk (as measured by the "customised" benchmark). A positive alpha figure indicates that the fund has performed better than its underlying passive portfolio would predict. Investors see alpha as a measurement of the manager's value added (or subtracted), i.e., his ability as a stock picker or market timer. The decomposition of performance between alpha and risk rewarding is suited to each fund. Alphas do not depend on either economic patterns or category groupings and they can be easily compared.

The decomposition of the performance between the alpha and the reward for risks is specific to each fund. The use of this type of benchmark allows the manager's value-added to be measured independently from the performance of the investment style, and therefore allows the true value of alpha to be identified. The alphas thus obtained have a greater chance of being persistent over time, because they do not depend on the prevailing market situation.

4.3 References

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Conclusion

The analysis conducted in this study has outlined the problems of broad market indices. In order to summarise the information from this study, we propose to provide a ranking of existing indices by using our results from sections two and three. In these sections, it was shown that broad stock market indices neither offer stable exposure to sub-categories of the stock market nor constitute an efficient portfolio in terms of mean-variance efficiency. It would be interesting to map the existing indices according to how far they deviate from the required properties of stable risk exposure and efficient allocation. Table 20 below ranks the indices studied, according to the stability of style exposure and the efficiency in terms of mean variance. We have focused on the style exposure rather than sector exposure in order to avoid reducing the number of indices covered. For the efficiency criterion, we focus on the analysis based on index components in section three rather than the sector analysis from section four for the same reason. One notable advantage of using the results obtained with the larger number of indices is that we can assess different indices covering the same geographical region.

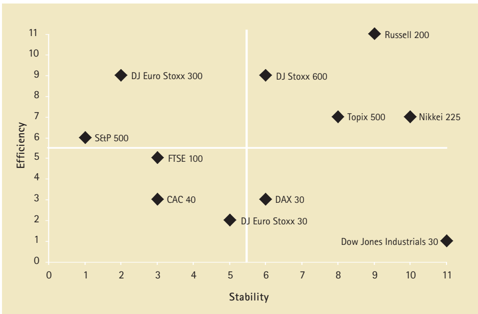
Table 20:
Indices Ranking

	Rank for Stability (SDS from Sharpe RBSA)	Rank for Efficiency (from Mean-variance Analsysis)
CAC 40	3	3
DAX 30	6	3
FTSE 100	3	5
DJ Euro Stoxx 50	5	2
DJ Euro Stoxx 300	2	9
DJ Stoxx 600	6	9
Nikkei 225	10	7
Topix 500	8	7
S&P 500	1	6
Russell 2000	9	11
Dow Jones Industrials 30	11	1

These rankings are based on Table 7 (section two) and Table 15 B (section three). The indices are ranked in ascending order for the style drift scores from Table 7. The ranks for efficiency are taken directly from Table 15 B.

Illustration 20 below maps the indices according to their ranks for the style stability and the efficiency criterion. It contains the same information as Table 20, but shows visually what the profile of each index is. The indices in the "south-westerly" quarter of the graph have high ranks in terms of both efficiency and stability. The indices in the "north-westerly" quarter, have low ranks for efficiency, but are in the upper half of the indices studied in terms of the style stability criterion. Likewise, the indices in the "south-easterly" quarter are poor in terms of stability of style, but are among the most efficient. Finally, the "north-easterly" quarter contains indices that have low ranks according to both criteria.

Illustration 20: Indices Ranking



This illustration is based on Table 20. The rank obtained for the efficiency criterion is indicated on the vertical axis while the rank obtained for style stability is indicated on the horizontal axis. The lines at the centre indicate a rank of 5.5 which corresponds to the average rank among the 11 indices. The ranks are based on Table 7 (section two) and Table 15 B (section three). The indices are ranked in ascending order for the style drift scores from Table 7. The ranks for efficiency are taken directly from Table 15 B.

As outlined in section three, the fact that the narrower indices are actually better in terms of efficiency than the broader indices may be explained in the following way: it is probably the case that the allocation we implement does not make much difference when the stock universe is strongly reduced. In other words, the drawbacks of capitalisation weighting become more pronounced when the index is

Conclusion

large. This stems from the fact that the inclusion of smaller stocks has almost no impact on the index, while it has a strong impact on the mean-variance efficient portfolios.

It should also be noted that indices for the same geographic regions obtain quite dissimilar profiles in this plot. For the U.S. stock market, for example, the S&P 500 ranks well in terms of style stability and poorly in terms of efficiency, the Dow Jones Industrials ranks well in terms of efficiency but very poorly in terms of stable style exposure. The Russell 2000 index obtains low ranks with respect to both criteria. The picture for European and indices is equally disparate, while the Japanese indices map each other more closely.

While our findings show that commercial indices pose serious challenges for an investor who wishes to use them in the investment process, these drawbacks do not necessarily mean that an investor should not use indices at all. Quite to the contrary, we have shown that there are straightforward remedies for the problems associated with commercial stock market indices. We have looked at such solutions for both asset allocation and performance measurement.

In order to deal with the problem of an exposure to risk factors that vary over time, we propose to build completeness portfolios that neutralise the sector biases of an index. These completeness portfolios do not only have more stable sector exposure, but also dispose of more favourable performance in terms of risk and return, as shown in section four. Thus, investors seeking the most attractive risk return profile for their portfolio could benefit from implementing a simple neutralisation strategy by holding a global index and a completeness portfolio made up of sector indices. In the same vein, for purposes of performance measurement, an investor can construct benchmarks that are more sophisticated than a global index by choosing a combination of indices. Such a benchmark is often called a "customised benchmark", to emphasise the fact that it is not simply a global index.

The fact that the global indices show a pronounced lack of efficiency is probably the most interesting result of this study. The remedy we proposed for the asset allocation phases of the investment process is to construct efficient portfolios, for example from sector indices. These sector indices can be used as building blocks in an optimisation procedure that allows the drawbacks of the global indices to be avoided. The approach we proposed avoids estimation risk by focusing on the minimum risk portfolio and shows significant enhancement of efficiency in an out-of-sample exercise. For the purposes of performance measurements, optimisation between indices may be used in order to construct a style benchmark that reflects the actual risks inherent in a manager's strategy. Such a benchmark allows the manager's value-added to be measured independently from the performance of the investment style, and therefore allows the genuine value of alpha to be identified.

As a conclusion, it can be stated that this study identifies numerous problems in relation to commercial stock market indices. However, we propose a number of pragmatic solutions to these problems. All of these solutions are based

Conclusion

on indices that reflect finer sub-segments of the equity market such as investment styles or industry sectors. The main drawback of global stock market indices may actually be that they imply a somewhat confused allocation by sub-segments, rather than allowing a precise and explicit definition of the asset allocation. Sector indices and style indices seem to be appropriate tools that allow investors to gain control over the investment process, while focusing on its most rewarding phase — the asset allocation decision.

EDHEC Risk and Asset Management Research Centre

EDHEC is one of the top five business schools in France and was ranked 12th in the *Financial Times* Masters in Management Rankings 2005 owing to the high quality of its academic staff (over 100 permanent lecturers from France and abroad) and its privileged relationship with professionals that the school has been developing since it was established in 1906. EDHEC Business School has decided to draw on its extensive knowledge of the professional environment and has therefore concentrated its research on themes that satisfy the needs of professionals. EDHEC is one of the few business schools in Europe to have received the triple international accreditation: AACSB (US-Global), Equis (Europe-Global) and AMBA (UK-Global). EDHEC pursues an active research policy in the field of finance. Its "Risk and Asset Management Research Centre" carries out numerous research programmes in the areas of asset allocation and risk management in both the traditional and alternative investment universes.

The choice of asset allocation

The **EDHEC Risk and Asset Management Research Centre** structures all of its research work around asset allocation. This issue corresponds to a genuine expectation from the market. On the one hand, the prevailing stock market situation in recent years has shown the limitations of active management based solely on stock picking as a source of performance. On the other, the appearance of new asset classes (hedge funds, private equity), with risk profiles that are very different from those of the traditional investment universe, constitutes a new opportunity in both conceptual and operational terms. This strategic choice is applied to all of the centre's research programmes, whether they involve proposing new methods of strategic allocation, which integrate the alternative class; measuring the performance of funds while taking the tactical allocation dimension of the alphas into account; taking extreme risks into account in the allocation; or studying the usefulness of derivatives in constructing the portfolio.

An applied research approach

In a desire to ensure that the research it carries out is truly applicable in practice, EDHEC has implemented a dual validation system for the work of the **EDHEC Risk and Asset Management Research Centre**. All research work must be part of a research programme, the relevance and goals of which have been validated from both an academic and a business viewpoint by the centre's advisory board. This board is made up of both internationally recognised researchers and the centre's business partners. The management of the research programmes respects a rigorous validation process, which guarantees both the scientific quality and the operational usefulness of the programmes.

To date, the centre has implemented six research programmes:

Multi-style/multi-class allocation

This research programme has received the support of Misys Asset Management Systems, SG Asset Management and FIMAT. The research carried out focuses on the benefits, risks and integration methods of the alternative class in asset allocation. From that perspective, EDHEC is making a significant contribution to the research conducted in the area of multi-style/multi-class portfolio construction.

Performance and style analysis

The scientific goal of the research is to adapt the portfolio performance and style analysis models and methods to tactical allocation. The results of the research carried out by EDHEC thereby allow portfolio alphas to be measured not only for stock picking but also for style timing. This programme is part of a business partnership with the firm EuroPerformance (part of the Fininfo group).

Indices and benchmarking

EDHEC carries out analyses of the quality of indices and the criteria for choosing

EDHEC Risk and Asset Management Research Centre

indices for institutional investors. EDHEC also proposes an original proprietary style index construction methodology for both the traditional and alternative universes. These indices are intended to be a response to the critiques relating to the lack of representativity of the style indices that are available on the market. EDHEC was the first to launch composite hedge fund strategy indices as early as 2003. The indices and benchmarking research programme is supported by AF2I, Euronext, BGI, BNP Paribas Asset Management and UBS Global Asset Management.

Asset allocation and extreme risks

This research programme relates to a significant concern for institutional investors and their managers – that of minimising extreme risks. It notably involves adapting the current tools for measuring extreme risks (VaR) and constructing portfolios (stochastic check) to the issue of the long-term allocation of pension funds. This programme has been designed in co-operation with Inria's Omega laboratory. This research programme also intends to cover other potential sources of extreme risks such as liquidity and operations. The objective is to allow for better measurement and modelling of such risks in order to take them into consideration as part of the portfolio allocation process.

Asset allocation and derivative instruments

This research programme focuses on the usefulness of employing derivative instruments in the area of portfolio construction, whether it involves implementing active portfolio allocation or replicating indices. "Passive" replication of "active" hedge fund indices through portfolios of derivative instruments is a key area in the research carried out by Edhec. This programme is supported by Eurex and Lyxor.

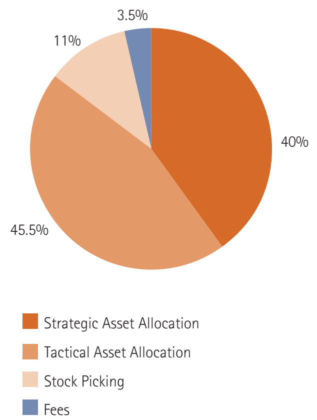
ALM and asset management

This programme concentrates on the application of recent research in the area of asset-liability management for pension plans and insurance companies. The research centre is working on the idea that improving asset management techniques and particularly strategic allocation techniques has a positive impact on the performance of Asset-Liability Management programmes. The programme includes research on the benefits of alternative investments, such as hedge funds, in long-term portfolio management. Particular attention is given to the institutional context of ALM and notably the integration of the impact of the IFRS standards and the Solvency II directive project. This programme is sponsored by AXA IM.

Research for business

To optimise exchanges between the academic and business worlds, the Risk and Asset Management Research Centre maintains a website devoted to asset management research for the industry: www.edhec-risk.com, circulates a monthly newsletter to over 55,000 practitioners, conducts regular industry surveys and consultations, and organises annual conferences for the benefit of institutional investors and asset managers.

Percentage of variation between funds



EDHEC Risk and Asset Management Research Centre

The centre's activities have also given rise to the business offshoots EDHEC Investment Research and EDHEC Asset Management Education.

EDHEC Investment Research supports institutional investors and asset managers in the implementation of the centre's research results and proposes asset allocation services in the context of a 'core-satellite' approach encompassing alternative investments.

EDHEC Asset Management Education helps investment professionals to upgrade their skills with advanced risk and asset management training across traditional and alternative classes.

Association française des Investisseurs Institutionnels
Association governed by French legislation dated 1 July 1901
8, rue du Mail, 75002 Paris –Tel: +33 (0)1.42.96.25.36 – www.af2i.org

The aim of the Association française des Investisseurs Institutionnels is to provide a common structure for all economic entities affected by the procedures and techniques used in institutional asset management, regardless of the sector to which they belong (pensions, life assurance and providence schemes, private health insurance and other insurance policies, foundations, specialised institutions, etc.). In particular, its work includes: think tanks, information and support services and the representation of members' interests. The association has 61 members, with a total of €700bn in managed assets.

The objectives of Af2i:

- **Represent its members** in terms of the problems facing institutional investors with regard to financial management, and perform lobbying in France and abroad (group authorities, governing bodies and similar associations in other countries);
- Define and standardise **best practices** for institutional investors with regard to management techniques, markets and financial instruments, etc. and thereby:
- **Monitor future regulatory changes**;
- Establish an **institutional classification system** mapping those bodies that may be deemed eligible and an annual members' survey with a view to compiling a reference database.

The methods used by Af2i:

- Regularly hold meetings for French institutional investors from various sectors, with a subject matter related to **financial management** that affects them on a **daily basis**;
- Involve members in the establishment of best practices within Working Groups;
- Use various channels (correspondence, Internet, etc.) to address real issues relating to the procedures and techniques used in asset management, with a practical approach adopted by practitioners.

Af2i members:

- The association's active members hold financial management positions in French institutions with an active role in the long-term management of capital reserves.

BNP Paribas Asset Management

BNP Paribas Asset Management is a leader in the European asset management industry, with Euro 286 billion of assets under management*, half of which managed for institutional clients.

With 1,600 staff servicing clients in 66 countries, it builds on its expertise, competencies and services to design fine-tuned solutions for its clients through a multi-specialist approach.

BNP Paribas Asset Management has developed a range of management capabilities with a shared focus on excellence, robustness and consistency of investment processes as well as accuracy of risk control:

- European fixed income: BNP Paribas Asset Management
- Global fixed income: Fischer Francis Trees and Watts
- Equities: BNP Paribas Asset Management
- Indexed and structured investments: BNP Paribas Asset Management
- Alternative strategies: Fauchier Partners and Cooper Neff
- Currency management: Overlay Asset Management
- Multi-management solutions: FundQuest
- Asset allocation solutions : BNP Paribas Asset Management

Specialised fund management teams are active in the world's major financial centres including Paris, London, New York, Tokyo and Hong Kong.

Responsible Investment is one of BNP Paribas Asset Management's key investment themes, and the company is a globally recognised player in this field. With a dedicated team and a range of Responsible Funds across all asset classes, it holds Novethic's top rating (aaa).

BNP Paribas Asset Management is also a preferred partner on the "New Markets", with a strong presence on the emerging markets, which has been built up over the last ten years and achieved through internal development (Brazil, Argentina, Morocco) or strategic partnerships with local asset managers: Sundaram BNPP AM (India), Shinhan BNP Paribas (South Korea), Shenyin & Wanguo BNPP AM (China) and TEB AM (Turkey).

Parvest, BNP Paribas Asset Management's flagship fund, is one of the leading Luxembourg-domiciled umbrella funds. With more than 70 sub funds, it covers all markets and asset classes and is registered for sale in 25 countries.

Over and above the quality of fund management, BNP Paribas Asset Management's commitment to satisfying client needs is reflected by a strong local presence of client relationship managers in 26 countries.

The overall excellence of BNP Paribas Asset Management is reflected by Fitch's second-highest rating: AM2+

The Structured and Indexed Investments Team, partner of this study, comprises 32 experts organised into 4 different specialised units : quantitative research, asset management, business solutions and product structuring.

EasyETF, their range of trackers developed in partnership with AXA IM, is one of the most innovative range on the market and enables all categories of investors to establish strategies for exposure to different asset classes or sectors of the economy. 15 years of success, Euro 20 billion of assets under management and some 200 managed funds make this team a leading actor in its field of expertise in Europe and Asia.

* Figures as at 30 June 2006, assets under advisory included

UBS

UBS is one of the world's leading financial firms, serving a discerning global client base. As an organization, it combines financial strength with a global culture that embraces change. As an integrated firm, UBS creates added value for clients by drawing on the combined resources and expertise of all its businesses. UBS is the world's leading wealth management business, a global investment banking and securities firm with a strong institutional and corporate client franchise, a key asset manager and, with roughly a quarter of the Swiss lending market, the market leader in Swiss corporate and individual client banking. On 31 March 2006, UBS employed more than 70,000 people. With headquarters in Zurich and Basel, Switzerland, UBS operates in over 50 countries and from all major international centers. UBS is managed through three Business Groups each of which is described below:

Global Wealth Management & Business Banking

With more than 140 years of experience, our global wealth management business provides a comprehensive range of products and services individually tailored for wealthy clients around the world. With roughly 11,600 client advisors and more than EUR 1.2 trillion in invested assets, the business consistently delivers high-quality, individually tailored solutions through a global network of 110 offices in Switzerland and 67 offices worldwide. In the US, it is one of the top wealth managers. Business Banking Switzerland is the market leader in Switzerland, providing a complete set of banking and securities services for individual and corporate clients. It also has relationships institutional investors, public entities and foundations based in Switzerland, as well as 3,000 financial institutions worldwide.

Global Asset Management

The Global Asset Management business is one of the world's leading asset managers, providing traditional and alternative investment solutions to financial intermediaries and institutional investors. The breadth, depth and scope of its varied investment capabilities enable it to offer innovative solutions in nearly every asset class. Invested assets totaled EUR 507 billion on 31 March 2006, making it one of the largest global institutional asset managers, the second largest mutual fund manager in Europe, and the largest mutual fund manager in Switzerland.

Investment Bank

UBS's Investment Bank is one of the world's leading firms in the investment banking and securities business, providing a full spectrum of services to institutional and corporate clients, governments and financial intermediaries. Its salespeople, research analysts and investment bankers provide products and services to the world's key institutional investors, intermediaries, banks, insurance companies, corporations, sovereign governments, supranational organizations and private investors. For both its own corporate and institutional clients and the individual clients of other parts of UBS, the Investment Bank provides product innovation, research and advice, and comprehensive access to the world's capital markets.

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