# Geographical Versus Industrial Diversification: A Mean Variance Spanning Approach

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Research Paper N° 80
April 2003

FAME - International Center for Financial Asset Management and Engineering

INTERNATIONAL CENTER FOR
FINANCIAL ASSET MANAGEMENT AND ENGINEERING

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Initial version: February 2002

Current version: April 2003‡

‡ We would like to thank Jean-Pierre Danthine, Vihang Errunza, Christian Gourieroux, Albert Holly, Raymond Kan, Michael Rockinger, Olivier Scaillet, René Stulz, Ernst-Ludwig von Thadden, seminar participants at the FAME Workshops, the 5th Conference of the Swiss Society for Financial Market Research (2002), the Euro Conference at NYU (2002), the University of Geneva seminar, the ECB workshop on Capital Markets and Financial Integration in Europe (2002), the European Investment Review Conference (2002), the NFA Annual Meeting (2002), the Macro Brown Bag Lunch at the Wharton School (2003), MFA Annual Meeting (2003) and CEMAF/ISCTE Lisbon (2003) for helpful discussions and comments. Financial support from the National Center of Competence in Research, "Financial Valuation and Risk Management" (Ehling) and the Fundacao para a Ciencia e Tecnologia (Ramos), is gratefully acknowledged. The National Center of Competence in Research is managed by the Swiss National Science Foundation on behalf of the Swiss federal authorities.

*Abstract*

This paper addresses whether country allocation provides benefits over industry allocation in a sample of European country and industry indexes. Strategy performance is compared using a mean-variance spanning test. We find that, for investors with low risk aversion, industry allocation is as good as investing in the complete set of assets. Moreover, in the most recent subperiod coinciding with the inception of the Euro, country and industry diversification are both effective. By contrast, investors with high risk aversion should always mix country and industry portfolios. A striking aspect of our analysis is that we do not find empirical evidence to support the argument that country diversification is a superior approach.

Keywords: Diversification gains, EMU, mean-variance spanning, portfolio allocation strategies.

JEL classification: G11, G15.

## Executive summary

Stock returns are driven largely by country factors. This fact holds even though recently industry effects become more important. A related stylized puzzle is the much lower correlation within country indexes compared to industry indexes. Not surprisingly, the banking industry adopted the country allocation model as the traditional way for a simplified diversification.

In the present paper, we address the question whether country allocation really offers benefits over industry allocation. Since neither the traditional approach of analyzing the influence of country and industry factors in stock returns nor the naïve comparison of average correlations allows testing for differences in diversification gains, we adopt a different strategy. Namely, we use a simple mean-variance model with constraints and a mean-variance spanning test to address the hypothesis whether a set of industry portfolios can improve the minimum-variance frontier of country portfolios and vice-versa. The idea behind mean-variance spanning is intuitive and works as follows. One simply tests the hypothesis whether the efficient frontier of a set of restricted assets, for instance country indexes, is identical to the efficient frontier of a complete set of assets, country and industry indexes. Furthermore, in case spanning is rejected, we identify exactly which part of the frontier causes the rejection. Either the slopes of the tangency portfolios are (statistically) very different, or the minimum variance portfolios are (statistically) not the same. In view of two-fund separation we can, then, conclude about the location of the frontiers.

The study is based on data of the EMU entrants. To enlighten the influence of industry effects in the most recent period but also to take into account a possible influence stemming from the advent of the EMU we consider three subperiods: Pre-Convergence, Convergence and Euro.

Based on the first part of the spanning test, which compares the composition of tangency portfolios, we find that industry allocation cannot be statistically distinguished from an investment in all indexes. The evidence for countries is mixed, two subperiods favoring industry over country allocation, e.g. adding industry portfolios to country portfolio significantly improves the efficient frontier of the later one.

In contrast the country and industry efficient frontiers do not coincide in the global minimum variance portfolio with the complete set of assets (second part of the spanning test). In other words, mixing country and industry indexes is relevant for investors with high risk aversion, while investors preferring the tangency portfolio can pursue an industry motivated allocation.

It is of interest, however, to notice that in the most recent subperiod, both country and industry tangency portfolios are statistically indistinguishable from the tangency of the complete set of assets.

Overall the two components of the spanning test indicate that neither country portfolios span industry portfolios nor industry portfolios span country portfolios. This finding strongly confirms the superiority of a diversification strategy that is based on country as well as industry motivated portfolios.

Finally, our approach appears interesting for asset management since i) the comparison between country and industry allocation considers different levels of risk aversion and ii) quantifies the eventual contribution of one or several assets, once included into the portfolio.

# I. INTRODUCTION

Diversification and its implication for portfolio choice is a major topic in financial economics. A closely related and thus important matter is to determine the factors driving the covariation in stock returns. From an international perspective, this problem can be reformulated in terms of ascertaining how country and industry factors determine variations in asset returns for a global portfolio. This issue has been addressed in detail in a sequence of papers (King (1966); Lessard (1974, 1976); Heston and Rouwenhorst (1994); and Griffin and Karolyi (1998)) all of which indicate that the country factor takes precedence over the industry factor[1], typically referring to country diversification as a superior strategy.

In this paper, we re-examine the performance of country and industry allocation using a very flexible spanning approach introduced by Kan and Zhou (2001) (henceforth referred to as KZ). In principle, mean-variance spanning tests[2] are used to tackle the hypothesis that the efficient frontier of a set of restricted assets is the same as the efficient frontier of a complete set of assets. Indirectly, spanning tests are also tests of performance of the restricted set comparatively to the complete set of assets (See Jobson and Korkie (1989).). Therefore, in this work, we investigate whether the performance of a set of country portfolios (or industry portfolios) is

[1] There is, however, evidence that industry effects are becoming increasingly important: Baca, Garbe, and Weiss (2000), Cavaglia, Brightman and Aked, (2000), Isakov and Sonney (2003), Carrieri, Errunza and Sarkissian (2002), Brooks and Del Negro (2002).

[2] Mean-variance spanning tests have been applied to the study of benefits of international diversification, mainly with emerging markets as test assets (Bakaert and Urias (1996), and Errunza, Hogan, and Hung (1999)). Gerard, Hillion and de Roon (2002) also apply a spanning test in a context similar to ours, but using a different time period and data set. Our framework differs from theirs in one important aspect: it considers an investor exclusively investing in risky assets since our focus is on the direct comparison of the mean-variance frontiers of the indexes.

statistically equivalent to that of a complete set of assets. The step-down KZ approach has the advantage that, in case of rejection, one can identify the exact source of the rejection. Either the slopes of the tangency portfolios are different (Test 1), or the minimum variance portfolios are not the same (Test 2).

As a first step, we solve the optimization problem of an investor restricted either to country or industry diversification. Each constrained strategy yields an opportunity cost: the Lagrange multiplier. A major strength of our approach is that we can establish a link between the step-down procedure of KZ with the statistical significance of the Lagrange multipliers. Moreover, since a negative sign of the Lagrange multiplier directly implies a short position for the excluded index on the unconstrained efficient frontier, one can even identify when the out-performance of a strategy is due to short selling.

We focus on weekly country and sector index data of the EMU[3] entrants during 1988-2002. The sample is divided into different subperiods: Pre-Convergence, Convergence and Euro, in order to not only capture time patterns but also to incorporate effects that may stem from actions undertaken by the new monetary authority[4].

Our findings are the following: Taken altogether, the tests indicate that country portfolios do not span industry portfolios, nor do industry portfolios span country portfolios. This finding points towards the

[3] EMU stands for European Monetary Union.

[4] In previous versions of this work we focused basically on all European countries with reasonable developed stock markets, so that, we grouped non-EMU participating countries according to their status with respect to EMU or EU. That analysis was carried out in Euro or synthetic Euro, while in the current version returns are calculated in US dollar. Our results are qualitatively neither affected by the choice of currency nor by the chosen countries. The results are available upon request.

superiority of a simultaneous diversification across geographically and industrially motivated portfolios, over the traditional country model, as also pointed out by research carried out using different methodologies (Adjaouté and Danthine (2001b) and Carrieri, Errunza and Sarkissian (2002)).

The step-down approach of KZ provides additional insights. In analyzing the two components of the spanning test, it becomes clear that the country and industry efficient frontiers do not coincide in the global minimum variance portfolio with the complete set of assets, while intersection around the tangency portfolio[5] is not rejected. Put simply, mixing country and industry indexes is more relevant for investors with high risk aversion, while investors preferring the tangency portfolio can pursue a simplified allocation.

Based on the criteria of the first test, Test 1, which compares the slope of the tangency portfolios, industry allocation cannot be statistically distinguished from an investment in all indexes. The evidence for countries is mixed, two subperiods favoring industry over country allocation, e.g. adding industry portfolios to country portfolio significantly improves the efficient frontier of the later one.

In the most recent subperiod, both allocations are statistically indistinguishable from an investment in the complete set of assets, in contrast to the beginning of the sample[6].

This paper proceeds as follows: In Section II, we set up the mean-variance model with the investment constraints and briefly recall the nature of mean-variance spanning, pointing out the connection between these two

[5] Henceforth, tangency portfolios will refer to portfolios whose tangent line starts from the origin.

[6] We perform the empirical analysis to follow also for the 10 countries with the worldwide largest market capitalization by the end of the year 2002. These are: Germany, France, Italy, the Netherlands, UK, Switzerland, USA, Canada, Japan, and Australia. The results of this analysis are again qualitatively similar and available upon request.

methods as well as their application to our research question. Section III describes the data. Section IV presents our results. Concluding remarks are provided in Section V.

## II. THE SET-UP

### A. THE MODEL

Consider an economy with several countries, each with several risky assets that belong to different industries. Countries are indexed by $j$, and industries by $i$. Stock shares are perfectly divisible, in positive supply and normalized to one. The currency is identical across countries, eliminating the exchange rate as a source of risk. Moreover, there are no taxes, transaction costs, dividends, or capital controls and borrowing and short selling are allowed without restrictions.

Country indexes are denoted by $\tilde{c}_j$ and industry indexes by $\tilde{d}_i$. The vector of expected returns of the indexes follows a normal distribution with mean $\gamma$ and a covariance matrix

$$\Phi = \begin{pmatrix} \Phi_j & \Phi_{ji} \\ \Phi_{ji}' & \Phi_i \end{pmatrix},$$

where $\Phi_j$ and $\Phi_i$ are the covariance matrices of country and industry indexes respectively, $\Phi_{ji}$ is the covariance matrix of both country and industry indexes, and $\Phi_{ji}$' denotes, as usual, the transpose of $\Phi_{ji}$. All the (sub-) matrices are positive definite.

In this one period model, investors make their investment choice at date zero and receive returns on their investment at the terminal date. All individuals have the same negative exponential utility function $U = -e^{-\rho \tilde{W}}$,

where $\widetilde{W}$ is the wealth at the end of the period and $\rho$ ($\rho > 0$) denotes the coefficient of absolute risk aversion. Investors maximize expected utility and the net return for each investor is defined as $\widetilde{R} = w' \begin{pmatrix} \widetilde{c}_j \\ \widetilde{d}_i \end{pmatrix}$, where $w$ is the vector of investment weights in the indexes.

We formulate country and industry allocation as an optimization problem involving a restriction (3) on strategies, which represents the exclusion of industry or country indexes from portfolios. Typically, the decision to follow a constrained strategy is related with some sort of imperfection in capital markets, but we do not further elaborate on the specific source of the friction. Given the form of the utility function, preferences are in fact mean-variance, as expressed in the following problem,

$$(1) \qquad \max_{w} E\left(\widetilde{R}\right) - \frac{1}{2}\rho \operatorname{var}\left(\widetilde{R}\right)$$

$$(2) \qquad s.t. \qquad w'\vec{1} = 1$$

$$(3) \qquad w_l = 0 \text{ for } l = j \vee i,$$

where $\vec{1}$ denotes a vector of ones. The optimal portfolio for constrained investors is (for details, see Ramos (2002)),

$$(4) \qquad w^*_l = (\rho\Phi)^{-1}\left[\left(\gamma - \mu_z \vec{1}\right) - \lambda_l\right], \; l = j \vee i,$$

where $\lambda_l$ is the Lagrange multiplier associated with the exclusion of industry or country indexes, and $\mu_z$ equals the expected return on the zero covariance portfolio[7] of $w^j *$. Note that $\mu_z$ can be interpreted as the intercept of a ray tangent to the portfolio. We interpret the Lagrange multiplier $\lambda_l$ as the shadow cost of excluding an asset from the opportunity set. It also describes,

[7] A portfolio *z* is said to be zero covariance with respect to a portfolio *p* if there is no correlation between them.

indirectly, how the optimal value of the utility function changes when there is a slight relaxation of the respective constraint. To facilitate later discussion, it is worth mentioning that the loss (gain) caused by excluding an index can be ranked, so as to enable identifying the country (industry) index which contribution is potentially of more use to an investor whose portfolio is industry- (country-) motivated. Note, however, that the value of the contribution is always relative since it depends on the set of excluded assets and on the specific efficient portfolio, which determines $\mu_z$.

### *B. SPANNING TESTS*

For a given sample of indexes, testing the hypothesis $\lambda = 0$ is of considerable interest, since it conveys the potential contribution of the excluded indexes. Consider an ordinary linear regression, with $X$ and $Y$ containing index returns, $\alpha$ as intercepts, $\beta$ the matrix of the regression coefficients, $\varepsilon$ the error term and $T$ as the size of the time series sample,

$$Y_t = \alpha + \beta X_t + \varepsilon_t, \qquad t = 1,...T. \tag{5}$$

Ramos (2003) shows that the aforementioned Lagrange multipliers $\hat{\lambda}$ are related to the regression parameters $\alpha$ and $\beta$ as follows:

$$\hat{\lambda} = \alpha + \mu_z\left(\vec{1} - \beta\vec{1}\right). \tag{6}$$

Huberman and Kandel (1987), HK hereafter, propose Equation (5) to test mean-variance spanning. The principle of mean-variance spanning is based on a set of $K$ benchmark assets and a set of $N$ test assets. The $K$ assets span a larger set of $N+K$ assets if the minimum-variance frontier of the $K$ assets is identical to the minimum-variance frontier of the $N+K$ assets. Note that in this approach, the debate extends beyond merely country and industry portfolios. The spanning test compares the performance of the

$K$ benchmark assets (country or industry allocation) with the entire spectrum of assets $(N+K)$ using the hypothesis $H_0: \alpha = 0 \times \vec{1}$ and $\vec{1} - \beta\vec{1} = 0$.

In our setting, investors can construct their portfolio either entirely from country indexes or industry indexes, leading to two sets of benchmark assets and two sets of test assets. Define $c_{jt}$ as the vector of raw returns of $j$ countries at time $t$ and $d_{it}$ as the vector of raw returns of $i$ industries at time $t$. Then, adjusting regression (5) to our version of spanning test results in

(7) $$c_{jt} = \alpha_j + \beta_j d_{it} + \varepsilon_{jt}, \qquad t = 1,...T$$

(8) $$d_{it} = \alpha_i + \beta_i c_{jt} + \varepsilon_{it}, \qquad t = 1,...T$$

where $\alpha_j$, $\alpha_i$, $\beta_j$, $\beta_i$ are the parameters to be estimated.

The HK test is very sensitive to the restrictions on the betas, while the restriction on the alphas has much more economical weight. Therefore, KZ propose to analyze separately the two components of the spanning test. That said, they decompose the null into two null hypotheses, $H_0^I: \alpha = 0 \times \vec{1}$ and $H_0^{II}: \vec{1} - \beta\vec{1} = 0$, conditional on $\alpha = 0 \times \vec{1}$, which are denoted by Test 1 and Test 2, respectively. Recall that for mean-variance spanning to hold, both parts of the test have to be accepted. Also important to notice is that the overall significance level of the test is $1 - p_1 p_2$, where $p_1$ denotes the p-value for the first part of the step-down procedure, and $p_2$ is associated with the second part of the test. Refer to KZ for more details on this, specifically, on the power of the tests.

Test 1 focuses on the difference in the slopes of the tangency portfolios between the restricted and complete set of indexes. Roughly speaking, it expresses the risk-return trade-off relation. On the other hand,

the second part of this step-down procedure, Test 2, investigates whether the global minimum variance portfolio has zero weight in the test assets, i.e., whether the assets contained in $X$ are sufficient to achieve all diversification benefits. Again, this approach has the advantage that, in case spanning is rejected, one can identify the exact source of it. Moreover, it prevents the beta term from commanding the overall decision[8].

In dealing with portfolios based on country and industry diversification, we apply the step-down tests of KZ, introduced above, to equations (7) and (8). Therefore, if $H_0^I$ is not rejected for $\alpha_j = 0 \times \vec{1}$ (if $H_0^I$ is not rejected for $\alpha_i = 0 \times \vec{1}$), investors preferring the tangency portfolio can base their strategies on industry (country) portfolios. If $H_0^I$ and $H_0^{II}$ are not rejected, industry (country) diversification is an optimal strategy for any investor since industries (countries) span countries (industries). If $H_0^I$ for both regressions is not rejected, we can conclude that both are statistically equivalent around the tangency portfolio.

Notice that for each portfolio on the mean-variance frontier, there is a corresponding Lagrange multiplier. Hence, we could test for an infinite amount of points, which is somewhat impracticable. We thus restrict our attention to a particular point on the mean-variance frontier, which will prove to provide several advantages.

Proposition 1*: Suppose an investor whose optimal portfolio choice implies* $\mu_z$*=0, i.e. the tangent of the portfolio that passes through the origin,*

[8] Recall that the p-values for Test 1 and Test 2 can be chosen independently. Hence, it is possible and reasonable to put less wait, by decreasing the p-value, on Test 2.

*i) The hypothesis* $H_0^1$*:* $\alpha = 0 \times \vec{1}$ *is equivalent to the hypothesis* $H_0 : \widehat{\lambda} = 0$.

*ii) The weight of the excluded asset in the optimal portfolio equals*

$$x_l^* = \frac{\alpha}{\rho \sigma_{\varepsilon\varepsilon}^2},$$

*where* $\sigma^2_{\varepsilon\varepsilon}$ *is the variance of the error terms in the univariate regression.*

The proposition illustrates a key result since it relates our analytical framework with mean-variance spanning. More concretely, it establishes a link between the step-down procedure and the test for the Lagrange multiplier, and shows the circumstances whereby Test 1 is also a test of the statistical significance of the Lagrange multiplier. Moreover, we can relate the sign of the intercept with the sign of the optimal weight of the excluded asset on the unrestricted efficient frontier.

Given that returns may exhibit conditional heteroscedasticity, an unadjusted OLS approach to our research question may lead to over-rejection of the null hypothesis. Therefore, all reported p-values are based on external bootstrap simulations, which explicitly avoid over-rejections due to heteroscedasticity[9].

## III. DATA

We use DataStream country and sector indexes for the eleven EMU entrants[10]: Austria, Belgium, Finland, France, Germany, Greece, Ireland,

[9] KZ report that the spanning test is robust against heteroscedasticity. Indeed, we do not observe any over-rejection compared to the standard OLS results.

[10] Note that Greece joined the Euro-zone in 2001 and Luxembourg is not taken into account.

Italy, the Netherlands, Portugal, and Spain. The data provided by DataStream is weekly US dollar denominated ranging from 1 January 1988 through the end of December 2002 (783 return observations). The sample is divided into different subperiods (see Table 1) in order to not only capture time patterns but also to incorporate effects that may stem from actions undertaken by the new monetary authority. The subperiods are labeled Pre-Convergence, Convergence, and Euro. Note that the starting date of the Convergence period is associated with the signing of the Maastricht treaty, while the end of the period (31 December 1998) is associated with the fixing of the conversion rates. However, one can argue that markets already anticipated the future accession of countries. Thus, in one of our robustness tests, we extended the beginning of the Euro period by one year. Since this change did not affect test results, we held the official dates of the EMU.

TABLE 1

**Description of the subperiods**

| Sample | Data Range | Observations |
|---|---|---|
| Pre-Convergence | 01/01/1988-30/12/1994 | 365 observations |
| Convergence | 06/01/1995-25/12/1998 | 208 observations |
| Euro | 01/01/1999-27/12/2002 | 210 observations |

The data provided by DataStream is weekly Euro denominated ranging from January 1, 1988 till the end of December of 2002 (783 return observations). The Convergence period goes from January 1995 to January 1999. The starting date of the Convergence period is associated with the signature of the Maastricht treaty and the end (December 31, 1998) with the fixing of the conversion rates.

We focus our analysis on level three of DataStream sector classification, which corresponds to 10 sectors: Basic Industries (BI), Cyclical Goods (CG), Cyclical Services (CS), Financials (FI), General Industries (GI), Information Technology (IT), Noncyclical Consumer Goods (NCG), Noncyclical Consumer Services (NCS), Resources (RE) and Utilities (UT). Based on this industry classification, we compute industry

indexes by building market-value weighted indexes for each of the groups we consider.

### *A. DESCRIPTIVE STATISTICS*

In Table 2, we report the descriptive statistics of the country indexes for the whole period and the three subperiods. Since the whole sample includes a rather long period during which many important structural changes occurred in Europe, we direct our attention towards the subperiods. The descriptive statistics of the country returns apparently went through different cycles over the time period under consideration. The subperiods show different means: For instance, during the Convergence period for the Euro candidates, almost all stock markets experienced a dramatic increase in value, yielding rather high double digit returns. In contrast, in Pre-Convergence, none of the countries experienced a return higher than 20%, and in the Euro period, there are no countries with positive index returns. The average mean in the Pre-Convergence period is 7.08%, and, in the Euro period, we observe an average mean return of -9.75% whereas, in the Convergence period, the mean is 20.45%.

Again as for means, correlations also show a time variation[11]. For example, in the Convergence period, there is an increase of correlation among countries and between countries and industries. A less pronounced and less uniform drop follows this increase in the Euro period. The surges and drops in correlations, however, occur at different levels. Correlations between countries tend to be lower than correlations between countries and industries. This relationship, however, becomes less pronounced over time.

[11] The instability of correlation matrices is a well-documented fact in the finance literature (Longin and Solnik (1995), Adjoute and Danthine, (2001a,b)). Therefore, small changes in correlation should not be emphasized.

With regard to industries (see Table 3), we find that the correlation within industries is higher than the correlation of an industry with countries. In the Euro period, the level of correlation drops, as also reported by Adjoute and Danthine (2001b), but in contrast to the findings for countries, industry correlations seem to be more stable and greater, on average.

[Tables 2 and 3]

# IV. EMPIRICAL RESULTS

The empirical results presented here refer to the regressions (7), (8), and Test 1 and Test 2.

## *A. LAGRANGE MULTIPLIERS*

In the first type of regressions (equation (7)), the benchmark assets are the industry indexes, and the test assets are the country indexes. Table 4 contains sorted alphas and their p-values, country by country. Recall that we interpret the intercepts as the shadow costs of excluding an asset from the opportunity set[12] which, then, translates into the associated variation in utility. We find the following countries in two out of three subperiods with negative sign for alpha: Belgium, France, Italy, and Portugal. Hence, these countries represent potential candidates for a short position. Notice, however, that the Lagrange multiplier is in none of the cases statistically different from zero. We observe that Germany in the Pre-Convergence

[12] Notice that the Lagrange multiplier can be interpreted as described above if and only if one of the assets is added to the benchmark assets. Any additional asset can change the weight as well as the sign of the first test asset in the optimal portfolio. Another restrictive assumption is that the zero covariance portfolio is hold constant.

subperiod, at a 95% confidence level, and France in the Euro subperiod, at a 90% confidence level, qualify as candidate to improve (statistically) the efficient set based on industry portfolios.

[Tables 4 and 5]

In the second round of regressions, equation (8), the benchmark assets are the EMU countries, and the test assets are the 10 industry indexes. Table 5 reports the following results for industries. Noncyclical Consumer Goods and Utilities exhibit (positive) alphas significantly different from zero in the whole period and the Pre-Convergence subperiod. Noncyclical Services shows in the Pre-Convergence and the Convergence subperiod Lagrange multiplier, which are both positive and statistically different from zero. We also observe two Lagrange multipliers with significantly negative sings. These are the Cyclical Consumer Goods in the Convergence subperiod and the Information Technology in the Euro subperiod.

There are some common features to all the regressions in Tables 4-5. Countries tend to have positive intercepts while industries show more negative ones. This can be interpreted as "underperformance" of industry indexes in relation to their mimicking portfolios, and also indicates that these indexes would appear in an unconstrained optimal portfolio with a negative sign. To verify this, we compute the composition of the optimal unconstrained tangency portfolio and, indeed, industries with a negative intercept have a negative weight in the portfolio. Further, only industry indexes appear with significantly negative Lagrange multiplier.

### B. TESTS

The results of Test 1 are reported in Table 6, as well as the conditional test of all betas summing up to one, Test 2. Taken together, the mean-variance spanning hypothesis is always rejected due to the second part of the spanning test, Test 2. Thus efficient frontiers do not coincide in the global minimum variance portfolio and none of the allocation strategies is sufficient to attain all the diversification benefits. Consequently, investors should mix both country and industry portfolios in order to maximize utility.

Given that Test 1 generally has much more economical importance, the following comparison between countries and industries is based on this test only. Adding country indexes to industries leads never to statistically significant diversification gains, while adding industries improves country allocation in the Pre-Convergence and Convergence period at a 95% confidence level.

[Table 6]

To some extent, the surprisingly good performance of industries can be considered puzzling. However, Gerard, Hillion and de Roon (2002)[13] find similar results with MSCI data[14] for G-7 countries. Using the DataStream database, they conclude that country diversification was equivalent to industry diversification.

In examining the differences across time periods, we find that in the beginning of the sample, constrained strategies do not always yield similar

[13] Notice that they do not reject mean-variance spanning, as we do. We believe that this difference of results is due to the inclusion of the risk free rate and therefore they do not evaluate the global minimum variance portfolio.

[14] The MSCI data was removed from the latest version of the paper.

performance, whereas in the most recent period, following a country or industry allocation produces statistically indifferent results.

### C. ROBUSTNESS

To address concerns about the influence of country factors in industry indexes and industry factors in country indexes, which can be relevant for countries having substantial weight in some industries and vice-versa, we re-compute all DataStream indexes. In other words, when country *x* is regressed on a set of industries, these industry indexes do not include any industry that belongs to country *x*. In summary, Test 2 (not reported) is always rejected, while regression (7) contains some changes. That is, Test 1 is rejected for the whole sample as well as for the Convergence period, but we do not observe changes for regression (8). This leads us to conclude that when we eliminate country factors, it is slightly more difficult for industry indexes to replicate country indexes. However, we do not elaborate further on the influence of country factors in industry returns and industry factors in country returns. It should also be noted that the multivariate test is no longer valid to conclude about mean-variance spanning.

## V. CONCLUSIONS

This paper makes contributions in two fields: on the methodological side, we apply the step-down approach of KZ, which provides more discerning insights than the traditional spanning test. In particular, the methodology seems interesting for asset management since the comparison between country and industry allocation considers different risk aversion levels. Additionally, we provide a link between a model of constrained

investment with the step-down approach as well as a way of quantifying the eventual contribution of an asset, once included in the portfolio.

Second, we find that industry allocation is an adequate strategy for investors with low risk aversion. Moreover, in recent times, both types of allocations have been effective. However, a single allocation will not satisfy those who prefer safer strategies, and optimal allocation requires mixing both industry and country portfolios.

It is puzzling that, despite the fact that other studies find country factors to drive returns, our results do not support that country diversification is superior to industry allocation.

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# TABLES

TABLE 2

## Descriptive statistics for EMU countries

| Sample | Whole | | | | Pre-Convergence | | | | Convergence | | | | Euro | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Countries | Mean | Stdv. | Corr(C) | Corr(I) | Mean | Stdv. | Corr(C) | Corr(I) | Mean | Stdv. | Corr(C) | Corr(I) | Mean | Stdv. | Corr(C) | Corr(I) |
| AU | 5.10% | 19.69% | 0.44 | 0.49 | 11.74% | 23.67% | 0.49 | 0.61 | 0.59% | 15.10% | 0.53 | 0.57 | -1.99% | 15.72% | 0.37 | 0.38 |
| BG | 4.79% | 16.74% | 0.55 | 0.64 | 6.05% | 15.14% | 0.55 | 0.70 | 22.37% | 14.86% | 0.58 | 0.66 | -14.83% | 20.41% | 0.54 | 0.58 |
| FI | 8.84% | 29.98% | 0.39 | 0.46 | 3.39% | 22.30% | 0.33 | 0.40 | 28.12% | 25.82% | 0.51 | 0.58 | -0.79% | 42.73% | 0.39 | 0.43 |
| FR | 6.87% | 18.42% | 0.59 | 0.74 | 8.30% | 17.18% | 0.51 | 0.77 | 16.98% | 16.42% | 0.60 | 0.77 | -5.64% | 21.99% | 0.66 | 0.72 |
| GE | 4.17% | 19.35% | 0.62 | 0.76 | 7.82% | 17.84% | 0.56 | 0.80 | 15.88% | 16.37% | 0.64 | 0.77 | -13.79% | 23.93% | 0.68 | 0.72 |
| GR | 12.99% | 32.66% | 0.35 | 0.36 | 18.83% | 34.50% | 0.31 | 0.35 | 31.45% | 29.27% | 0.43 | 0.42 | -15.46% | 32.34% | 0.36 | 0.36 |
| IR | 8.96% | 19.14% | 0.48 | 0.52 | 10.37% | 18.84% | 0.46 | 0.54 | 23.88% | 16.54% | 0.52 | 0.54 | -8.27% | 21.71% | 0.48 | 0.50 |
| IT | 2.88% | 21.97% | 0.51 | 0.62 | 1.50% | 21.90% | 0.42 | 0.60 | 17.88% | 21.08% | 0.49 | 0.58 | -9.57% | 22.87% | 0.64 | 0.69 |
| NL | 6.82% | 16.62% | 0.60 | 0.73 | 8.67% | 12.34% | 0.55 | 0.75 | 21.73% | 16.61% | 0.64 | 0.77 | -11.16% | 22.01% | 0.65 | 0.72 |
| PT | 0.31% | 17.49% | 0.48 | 0.51 | -2.24% | 15.27% | 0.42 | 0.50 | 19.81% | 19.24% | 0.55 | 0.59 | -14.56% | 18.96% | 0.50 | 0.48 |
| SP | 5.57% | 19.01% | 0.58 | 0.67 | 3.39% | 17.70% | 0.50 | 0.65 | 26.30% | 19.30% | 0.63 | 0.74 | -11.19% | 20.61% | 0.64 | 0.65 |
| Average | 6.12% | 21.01% | 0.51 | 0.59 | 7.08% | 19.70% | 0.46 | 0.60 | 20.45% | 19.15% | 0.56 | 0.63 | -9.75% | 23.93% | 0.54 | 0.57 |

By columns: Annualized mean (Mean), standard deviation (Stdv.), average correlation with all the other sample countries (Corr(C)), and average correlation with the 10 sectors (Corr(I)). The weekly returns are calculated in US dollar for the period January 1988 until December 2002. Mean and standard deviation are in percentages. Notice that the correlation of each index with itself is excluded from Corr(C). Pre-Convergence period goes from January 1988 until December 1994. The Convergence period ranges from January 1995 until December 1998. Euro period ranges from January 1999 until December 2002. The overall sample size is 783. The Pre-Convergence subperiod contains 365 observations, the Convergence subperiod has 208 observations, while the Euro subperiod includes 210 observations. The time series with returns for Finland, 771 observations, starts in 04/01/88 and for Portugal, 678 observations, in 01/12/90. The countries are Austria (AU), Belgium (BG), Finland (FI), France (FR), Germany (GE), Greece (GR), Ireland (IR), Italy (IT), Netherlands (NL), Portugal (PT) and Spain (SP).

TABLE 3

## Descriptive statistics for industries within the EMU region

| Sample | Whole | | | | Pre-Convergence | | | | Convergence | | | | Euro | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industries | Mean | Stdv. | Corr(I) | Corr(C) | Mean | Stdv. | Corr(I) | Corr(C) | Mean | Stdv. | Corr(I) | Corr(C) | Mean | Stdv. | Corr(I) | Corr(C) |
| BI | 3.12% | 17.49% | 0.71 | 0.64 | 4.70% | 16.32% | 0.82 | 0.66 | 8.08% | 14.53% | 0.74 | 0.67 | -4.55% | 21.68% | 0.62 | 0.64 |
| CCG | 4.40% | 17.58% | 0.72 | 0.65 | 7.28% | 14.92% | 0.82 | 0.65 | 18.06% | 13.16% | 0.75 | 0.68 | -14.14% | 24.23% | 0.63 | 0.66 |
| CS | 3.94% | 18.98% | 0.74 | 0.66 | 7.09% | 16.96% | 0.81 | 0.62 | 11.84% | 15.80% | 0.78 | 0.69 | -9.35% | 24.38% | 0.66 | 0.68 |
| FI | 3.46% | 18.52% | 0.72 | 0.68 | 3.53% | 15.26% | 0.81 | 0.66 | 19.83% | 17.64% | 0.72 | 0.71 | -12.89% | 23.64% | 0.67 | 0.69 |
| GI | 9.27% | 31.23% | 0.55 | 0.52 | 10.67% | 20.00% | 0.71 | 0.53 | 30.82% | 28.52% | 0.61 | 0.57 | -14.50% | 46.11% | 0.45 | 0.51 |
| IT | 8.59% | 15.15% | 0.64 | 0.57 | 9.45% | 13.92% | 0.81 | 0.63 | 20.34% | 14.26% | 0.77 | 0.67 | -4.53% | 17.74% | 0.44 | 0.45 |
| NCG | 7.92% | 21.65% | 0.61 | 0.58 | 11.51% | 16.05% | 0.77 | 0.61 | 27.54% | 17.42% | 0.73 | 0.65 | -17.76% | 31.36% | 0.46 | 0.54 |
| NCS | 6.22% | 14.62% | 0.59 | 0.56 | 8.33% | 13.71% | 0.72 | 0.61 | 21.94% | 13.73% | 0.60 | 0.54 | -13.02% | 16.56% | 0.48 | 0.52 |
| RE | 7.99% | 19.03% | 0.49 | 0.43 | 8.74% | 14.61% | 0.58 | 0.47 | 13.58% | 18.52% | 0.58 | 0.48 | 1.15% | 25.34% | 0.40 | 0.38 |
| UT | 1.07% | 20.35% | 0.69 | 0.61 | 3.16% | 17.21% | 0.77 | 0.60 | 10.06% | 19.54% | 0.74 | 0.67 | -11.45% | 25.50% | 0.60 | 0.60 |
| Average | 5.60% | 19.46% | 0.64 | 0.59 | 7.45% | 15.90% | 0.76 | 0.60 | 18.21% | 17.31% | 0.70 | 0.63 | -10.11% | 25.65% | 0.54 | 0.57 |

By columns: Annualized mean (Mean), standard deviation (Stdv.), average correlation with all the other industries (Corr(I)), and average correlation with the 11 EMU countries (Corr(C)). The weekly returns are calculated in US dollar for the period January 1988 until December 2002. Mean and standard deviation are in percentages. Notice that the correlation of each index with itself is excluded from Corr(I). Pre-Convergence period goes from January 1988 until December 1994. The Convergence period ranges from January 1995 until December 1998. Euro period ranges from January 1999 until December 2002. The overall sample size is 783. The Pre-Convergence subperiod contains 365 observations, the Convergence subperiod has 208 observations, while the Euro subperiod includes 210 observations. The industries are Basic Industries (BI), Cyclical Consumer Goods (CCG), Cyclical Services (CS), Financials (FI), General Industrials (GI), Information Technology (IT), Noncyclical Consumer Goods (NCG), Noncyclical Services (NCS), Resources (RE), and Utilities (UT). Industry indexes are computed by building market-value weighted indexes based on level three of DataStream sector classification.

TABLE 4

## Ranking of Lagrange multipliers (LM) for countries

| Sample | Whole | | | Pre-Convergence | | | Convergence | | | Euro | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Countries | $\alpha_C$ | *p-value* | Countries | $\alpha_C$ | *p-value* | Countries | $\alpha_C$ | *p-value* | Countries | $\alpha_C$ | *p-value* |
| AU | -0.05% | 0.51 | SP | -0.12% | 0.18 | AU | -0.16% | 0.15 | GR | -0.16% | 0.58 |
| PT | -0.04% | 0.63 | PT | -0.12% | 0.33 | IT | -0.07% | 0.63 | BG | -0.08% | 0.44 |
| BG | -0.03% | 0.59 | BG | -0.08% | 0.32 | FR | -0.02% | 0.79 | PT | -0.06% | 0.61 |
| FR | -0.01% | 0.80 | FR | -0.06% | 0.31 | SP | 0.02% | 0.82 | NL | -0.05% | 0.41 |
| IT | -0.01% | 0.93 | IT | -0.03% | 0.80 | FI | 0.02% | 0.91 | IR | -0.04% | 0.82 |
| GE | 0.01% | 0.80 | IR | 0.01% | 0.97 | NL | 0.04% | 0.57 | GE | -0.04% | 0.55 |
| SP | 0.01% | 0.85 | NL | 0.04% | 0.31 | GE | 0.04% | 0.48 | SP | 0.02% | 0.82 |
| NL | 0.03% | 0.45 | AU | 0.05% | 0.72 | PT | 0.07% | 0.65 | AU | 0.03% | 0.80 |
| IR | 0.06% | 0.40 | GE | 0.09% | 0.04 | BG | 0.09% | 0.37 | IT | 0.08% | 0.35 |
| FI | 0.10% | 0.34 | FI | 0.15% | 0.44 | IR | 0.20% | 0.11 | FR | 0.11% | 0.06 |
| GR | 0.20% | 0.19 | GR | 0.45% | 0.11 | GR | 0.25% | 0.34 | FI | 0.15% | 0.24 |

This table presents results from the OLS regression (7) specified also below. $c_t$ is the weekly continuously compounded return on the countries, $\alpha_C$ is the intercept of the regression, $\beta_C$ is the slope coefficient of the industries, $d_t$ is the weekly continuously compounded return on the industries, and $\varepsilon_{Ct}$ are zero mean disturbance terms. Each of the equations is estimated separately. The countries are Austria (AU), Belgium (BG), Finland (FI), France (FR), Germany (GE), Greece (GR), Ireland (IR), Italy (IT), Netherlands (NL), Portugal (PT) and Spain (SP). The industries are Basic Industries (BI), Cyclical Consumer Goods (CCG), Cyclical Services (CS), Financials (FI), General Industrials (GI), Information Technology (IT), Noncyclical Consumer Goods (NCG), Noncyclical Services (NCS), Resources (RE), and Utilities (UT). Industry indexes are computed by building market-value weighted indexes based on level three of DataStream sector classification. Pre-Convergence subperiod goes from January 1988 until December 1994. The Convergence subperiod ranges from January 1995 until December 1998. Euro subperiod ranges from January 1999 until December 2002. The overall sample size is 678. The Pre-Convergence subperiod contains 260 observations, the Convergence subperiod has 208 observations, while the Euro subperiod includes 210 observations. The time series with returns for Finland, 771 observations, starts in 04/01/88 and for Portugal, 678 observations, in 01/12/90. The table reports the ranking of $\alpha_C$, i.e. the sorted values of the LM, and their p-values for each of the countries for the whole period and the three sub-periods. The Lagrange multipliers represent the shadow costs of excluding countries from a portfolio with industry allocation. The reported p-values are based on 5000 external bootstrap simulations. The OLS equation is

$$c_t = \alpha_C + \beta_C d_t + \varepsilon_{Ct}, \qquad t = 1,...T.$$

TABLE 5

## Ranking of Lagrange multipliers for industries

| Sample | Whole | | Pre-Convergence | | | Convergence | | | Euro | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Industries | $\alpha_I$ | *p-value* | Industries | $\alpha_I$ | *p-value* | Industries | $\alpha_I$ | *p-value* | Industries | $\alpha_I$ | *p-value* |
| CCG | -0.07% | 0.24 | GI | -0.05% | 0.15 | CCG | -0.22% | 0.02 | IT | -0.23% | 0.07 |
| GI | -0.05% | 0.17 | FI | -0.05% | 0.13 | BI | -0.11% | 0.14 | NCS | -0.13% | 0.39 |
| BI | -0.03% | 0.42 | RE | -0.04% | 0.54 | FI | -0.07% | 0.29 | CS | -0.08% | 0.40 |
| IT | -0.03% | 0.71 | CCG | -0.04% | 0.55 | GI | -0.06% | 0.20 | UT | -0.08% | 0.46 |
| CS | -0.03% | 0.48 | BI | -0.04% | 0.38 | RE | 0.00% | 0.97 | GI | 0.01% | 0.96 |
| FI | -0.03% | 0.39 | CS | 0.00% | 0.92 | CS | 0.03% | 0.70 | CCG | 0.01% | 0.97 |
| RE | 0.03% | 0.66 | NCG | 0.07% | 0.09 | NCG | 0.06% | 0.29 | FI | 0.01% | 0.86 |
| NCS | 0.05% | 0.38 | IT | 0.07% | 0.47 | IT | 0.10% | 0.54 | NCG | 0.03% | 0.78 |
| UT | 0.08% | 0.09 | UT | 0.13% | 0.01 | UT | 0.13% | 0.19 | RE | 0.11% | 0.48 |
| NCG | 0.09% | 0.07 | NCS | 0.14% | 0.01 | NCS | 0.15% | 0.08 | BI | | |

This table presents results from the OLS regression (8) specified below. $d_t$ is the weekly continuously compounded return on industries, $\alpha_I$ is the intercept of the regression, $\beta^1$ is the slope coefficient of the countries, $c_t$ is the weekly continuously compounded return on the countries, and $\varepsilon_{It}$ are zero mean disturbance terms. Each of the equations is estimated separately. Countries are Austria (AU), Belgium (BG), Finland (FI), France (FR), Germany (GE), Greece (GR), Ireland (IR), Italy (IT), Netherlands (NL), Portugal (PT) and Spain (SP). The industries are Basic Industries (BI), Cyclical Consumer Goods (CCG), Cyclical Services (CS), Financials (FI), General Industrials (GI), Information Technology (IT), Noncyclical Consumer Goods (NCG), Noncyclical Services (NCS), Resources (RE), and Utilities (UT). Industry indexes are computed by building market-value weighted indexes based on level three of DataStream sector classification. Pre-Convergence subperiod goes from January 1988 until December 1994. The Convergence subperiod ranges from January 1995 until December 1998. Euro subperiod ranges from January 1999 until December 2002. The overall sample size is 678. The Pre-Convergence subperiod contains 260 observations, the Convergence subperiod has 208 observations, while the Euro subperiod includes 210 observations. The time series with returns for Finland, 771 observations, starts in 04/01/88 and for Portugal, 678 observations, in 01/12/90. The table reports sorted $\alpha_I$, i.e. the values of the LM, and their p-values for each of the industry indexes in whole period and the three subperiods. The Lagrange multipliers represent the shadow costs of excluding industries from a portfolio with country allocation. The reported p-values are based on 5000 external bootstrap simulations. The OLS equation is

$$d_t = \alpha_I + \beta_I c_t + \varepsilon_{It}, \qquad t = 1,...T.$$

# TABLE 6

## Summary of Test 1 and Test 2 for regression (7) and (8)

| | Regression (7) | | | | | Regression (8) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Group I | Av. $R^2$ | Test 1 | *p-value* | Test 2 | *p-value* | Av. $R^2$ | Test 1 | *p-value* | Test 2 | *p-value* |
| Whole | 0.65 | 5.23 | 0.92 | 122.93 | 0.00 | 0.78 | 13.37 | 0.24 | 253.16 | 0.00 |
| Pre-Convergence | 0.64 | 14.80 | 0.22 | 37.40 | 0.00 | 0.88 | 24.92 | 0.01 | 41.63 | 0.00 |
| Convergence | 0.68 | 9.20 | 0.70 | 87.86 | 0.00 | 0.81 | 22.75 | 0.04 | 161.95 | 0.00 |
| Euro | 0.72 | 9.49 | 0.65 | 125.39 | 0.00 | 0.78 | 8.27 | 0.66 | 84.73 | 0.00 |

This table presents results from the OLS regressions (7) and (8) specified below. $c_t$ is the weekly continuously compounded return on the countries, $\alpha_C$ is the intercept of regression (7), $\beta_C$ is the slope coefficient of the industries, $d_t$ is the weekly continuously compounded return on the industries, $\varepsilon_{Ct}$ are zero mean disturbance terms, $\alpha_I$ is the intercept of regression (8), $\beta^I$ is the slope coefficient of the countries, and $\varepsilon_{It}$ are zero mean disturbance terms. Each of the equations is estimated separately. The countries are Austria (AU), Belgium (BG), Finland (FI), France (FR), Germany (GE), Greece (GR), Ireland (IR), Italy (IT), Netherlands (NL), Portugal (PT) and Spain (SP). The industries are Basic Industries (BI), Cyclical Consumer Goods (CCG), Cyclical Services (CS), Financials (FI), General Industrials (GI), Information Technology (IT), Noncyclical Consumer Goods (NCG), Noncyclical Services (NCS), Resources (RE), and Utilities (UT). Industry indexes are computed by building market-value weighted indexes based on level three of DataStream sector classification. Pre-Convergence subperiod goes from January 1988 until December 1994. The Convergence subperiod ranges from January 1995 until December 1998. Euro subperiod ranges from January 1999 until December 202. The overall sample size is 678. The Pre-Convergence subperiod contains 260 observations, the Convergence subperiod has 208 observations, while the Euro subperiod includes 210 observations. The time series with returns for Finland, 771 observations, starts in 04/01/88 and for Portugal, 678 observations, in 01/12/90. The table reports average $\mathbf{R^2}$, Test 1, Test 2, and their p-values. The reported p-values are based on 5000 external bootstrap simulations. The null hypothesis for Test 1 is: $H_0^I : \alpha = 0 \times \vec{1}_N$ and for Test 2 is: $H_0^{II} : \vec{1}_N - \beta \vec{1}_K = 0$ conditional on $\alpha = 0 \times \vec{1}_N$. Test 1 measures the difference in the slopes of the tangency portfolios between the restricted (country or industry) and complete set of indexes. Test 2 measures whether the global minimum variance portfolio has zero weight in the test assets (country or industry). Countries (industries) mean-variance span industries (countries) if and only if for both Test 1 and Test 2 the null cannot be rejected. The overall significance level of the spanning test is $1 - p_1 p_2$, where $p_1$ and $p_2$ denote the respective p-values. The OLS equations are

(7) $$c_t = \alpha_C + \beta_C d_t + \varepsilon_{Ct}, \qquad t = 1,...T$$

(8) $$d_t = \alpha_I + \beta_I c_t + \varepsilon_{It}, \qquad t = 1,...T.$$

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More than 13'000 students, the majority being foreigners, are enrolled in the various programs from the licence to high-level doctorates. A staff of more than 2'500 persons (professors, lecturers and assistants) is dedicated to the transmission and advancement of scientific knowledge through teaching as well as fundamental and applied research. The University of Geneva has been able to preserve the ancient European tradition of an academic community located in the heart of the city. This favors not only interaction between students, but also their integration in the population and in their participation of the particularly rich artistic and cultural life. ***http://www.unige.ch***

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Founded as an academy in 1537, the University of Lausanne (UNIL) is a modern institution of higher education and advanced research. Together with the neighboring Federal Polytechnic Institute of Lausanne, it comprises vast facilities and extends its influence beyond the city and the canton into regional, national, and international spheres.

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