論　説

Performance Determinants: Investment Policy and Active Management

Yukihiro Asano　and　Junichi Iwamoto

The relative importance of investment policy has been a controversial issue to investors over 20 years. The roles of investment policy and active management for the performance of portfolio have been discussed from a variety of aspects. This article provides the closed form of the determination coefficient for both time series and cross sectional analyses and reconsiders these roles through various simulations. It is shown that investment policy influences the overall performance of portfolios, but, at the same time, active risk level and market conditions also have influence. We analyze US market, although the model is easily applicable to any other markets with insufficient data.

Background of the Controversy

There is no longer any doubt that Brinson et al. (1986) had made a great impact on asset management industry all over the world. It is because the article showed that investment policy explained the volatility of portfolio return by 93.6%, with American pension funds data from 1974 to 1983. The figure is taken as indicating denial of active management, which is expected to add value to investment policy or benchmark. Brinson et al. (1991) got a similar result with data from 1978 to 1987.

A variety of researches have been presented since their first article. For instance, Ibbotson and Kaplan (2000) conducted not only time series analysis for a specific fund return like Brinson et al., but also cross sectional analysis focusing on scattering of the return among funds. They showed that the determination coefficient of cross sectional analysis, the explanatory power of investment policy, was largely different from that of time series analysis. Employing a bootstrap method, Kritzman and Page (2002) examined return volatility by time series data, and concluded that security selection could be more significant in explanatory power of portfolio return volatility. Brinson et al. (1986,1991) has been frequently cited and discussed in both academic field and asset management industry, but heated debate over the article still continues[1].

Although Brinson et al. article is well known globally, its applicability to other markets like

[1] Hood (2005) explains details of the discussion during last 30 years.

Japan has been limited. Two reasons are pointed out; first, it was difficult to conduct an empirical study in other markets because there was no appropriate time series data; secondly, as Brinson et al. didn't show a theoretical background, it might have been hard to convince people the applicability. This article aims to provide the analytical framework of performance determinants, which can be applied to both time series and cross sectional data. The term *performance determinants* refers to the factors that affect the return of portfolio. We can derive a general implication for performance determinants even with insufficient data, because our method enables us to conduct a variety of simulations easily.

Prior Research and Method

Brinson et al. (1986,1991) combined weights and returns for both actual portfolio and benchmark portfolio, and showed the method of attributing the actual returns to each source defined as follows.

Investment Policy $\sum_i w_{pi} R_{pi}$

Active Allocation $\sum_i (w_{ai} - w_{pi}) R_{pi}$

Security Selection $\sum_i w_{pi} (R_{ai} - R_{pi})$

Others $\sum_i \left[(w_{ai} - w_{pi}) \cdot (R_{ai} - R_{pi}) \right]$

where

i asset class

w_{pi} weights in investment policy

R_{pi} benchmark return

w_{ai} weight in actual portfolio

R_{ai} actual return respectively.

Brinson et al. (1986) implemented an attribution analysis by using the performance data of pension funds from 1977 to 1987. Out of 9.02% actual return, they attributed 10.11% to investment policy , -0.66% to active asset allocation, -0.36% to security selection and -0.77% to others respectively. However, it was not the attribution analysis but the determination coefficient of investment policy on actual portfolio returns that provoked interest among both investors and researchers. It is because the determination coefficient exceeded 93%, implying that only investment policy matters and active investment hardly influences returns.

In contrast, Ibbotson and Kaplan (2000) implemented cross sectional analysis among funds, and concluded that the determination coefficient was not so high. They showed that the explanatory powers of investment policy in a time series case and a cross sectional case were materially different. Asano (2005) clearly illustrated the difference of time series analysis and cross sectional analysis in Figure1. Enclosed numbers with circles are the data for time series analysis, where r shows the portfolio return and p shows the return of investment policy in each period. Enclosed numbers with a square is for cross sectional analysis, where R and P

show the average returns of each fund respectively. The purposes of these analyses are quite different, as the time series analysis pays attention to the change of a specific fund return, while the cross sectional analysis does it to the entire group of funds.

Figure1 Time Series Analysis and Cross Sectional Analysis

	Fund A		Fund B		Fund C		…
Period	Port.	Policy	Port.	Policy	Port.	Policy	
t_1	r_{A1}	p_{A1}	r_{B1}	p_{B1}	r_{C1}	p_{C1}	
t_2	r_{A2}	p_{A2}	r_{B2}	p_{B2}	r_{C2}	p_{C2}	
t_3	r_{A3}	p_{A3}	r_{B3}	p_{B3}	r_{C3}	p_{C3}	
⋮							
t_n	r_{An}	p_{An}	r_{Bn}	p_{Bn}	r_{Cn}	p_{Cn}	…
Average	R_A	P_A	R_B	P_B	R_C	P_C	…

Source: Asano (2005)

We present an analytical framework for the extent of determination of investment policy. The structural formulas of determination coefficients by time series and cross sectional data are to be presented respectively in the following two sections. The formulas enable us to conduct various simulations, and examine to what extent specific factors influence the determination of investment policy on portfolio performance in both time series and cross sectional cases.

In this article, we conduct various analyses with a determination coefficient, which is defined for variables X and Y by equation 1 where C is covariance and V is variance. When we calculate the determination coefficient, the variance of investment policy returns, the variance of portfolio returns, and the covariance between them are required.

$$R^2 = \frac{C(X,Y)^2}{V(X)\,V(Y)} \tag{1}$$

Models for Time Series Analysis

Variance of Portfolio. Consider two asset classes, equity and fixed income (bond) in a portfolio. Let $r_{i,j}$ be the return of fund j in time i. In the case of portfolio $n\,(j = n)$, return of investment policy $r^P_{i,n}$ is

$$r^P_{i,n} = w_{i,n}\, r^S_i + (1 - w_{i,n})\, r^B_i \tag{2}$$

where

r^S_i　return of equity index

r^B_i　return of bond index

$w_{i,n}$ equity weight of portfolio n.

Active asset allocation (timing strategy) is conducted by tilting equity weight by $\beta_{t,j}$ and fixed income weight by $-\beta_{t,j}$. Active excess return by security selection is expressed as $\alpha^S_{i,n}$ for equity and as $\alpha^B_{i,n}$ for fixed income. These variables are assumed to be mutually independent. With these variables, the return of fund n is expressed as follows and decomposed into four terms.

$$\begin{aligned} r^A_{i,n} &= \left(w_{i,n}+\beta_{i,n}\right)\left(r^S_i+\alpha^S_{i,n}\right)+\left(1-w_{i,n}-\beta_{i,n}\right)\left(r^B_i+\alpha^B_{i,n}\right) \\ &= \left(w_{i,n}r^S_i+\left(1-w_{i,n}\right)r^B_i\right)+\left(\beta_{i,n}r^S_i-\beta_{i,n}r^B_i\right)+\left(w_{i,n}\alpha^S_{i,n}+\left(1-w_{i,n}\right)\alpha^B_{i,n}\right)+\left(\beta_{i,n}\alpha^S_{i,n}-\beta_{i,n}\alpha^B_{i,n}\right) \end{aligned} \quad (3)$$

The relation between Brinson paper and equation 3 is obvious; the first term represents investment policy return, the second term active allocation return, the third term security selection return and fourth term their interaction respectively. When correlation is assumed to exist only between equity and fixed income returns, the variance of fund return $r^A_{i,n}$ can be derived as follows.

$$\begin{aligned} V\left(r^A_{i,n}\right) &= V\left[\begin{array}{l}\left(w_{i,n}r^S_i+\left(1-w_{i,n}\right)r^B_i\right)+\left(\beta_{i,n}r^S_i-\beta_{i,n}r^B_i\right) \\ +\left(w_{i,n}\alpha^S_{i,n}+\left(1-w_{i,n}\right)\alpha^B_{i,n}\right)+\left(\beta_{i,n}\alpha^S_{i,n}-\beta_{i,n}\alpha^B_{i,n}\right)\end{array}\right] \\ &= \left[V\left(w_{i,n}r^S_i\right)+V\left(\left(1-w_{i,n}\right)r^B_i\right)+2C\left(w_{i,n}r^S_i,\left(1-w_{i,n}\right)r^B_i\right)\right] \\ &+\left[V\left(\beta_{i,n}r^S_i\right)+V\left(-\beta_{i,n}r^B_i\right)+2C\left(\beta_{i,n}r^S_i,-\beta_{i,n}r^B_i\right)\right] \\ &+\left[V\left(w_{i,n}\alpha^S_{i,n}\right)+V\left(\left(1-w_{i,n}\right)\alpha^B_{i,n}\right)\right] \\ &+\left[V\left(\beta_{i,n}\alpha^S_{i,n}\right)+V\left(-\beta_{i,n}\alpha^B_{i,n}\right)\right] \\ &+2\left[\begin{array}{l}C\left(w_{i,n}r^S_i,\beta_{i,n}r^S_i\right)+C\left(w_{i,n}r^S_i,-\beta_{i,n}r^B_i\right) \\ +C\left(\left(1-w_{i,n}\right)r^B_i,\beta_{i,n}r^S_i\right)+C\left(\left(1-w_{i,n}\right)r^B_i,-\beta_{i,n}r^B_i\right) \\ +C\left(\beta_{i,n}r^S_i,\beta_{i,n}\alpha^S_{i,n}\right)+C\left(\beta_{i,n}r^S_i,-\beta_{i,n}\alpha^B_{i,n}\right) \\ +C\left(-\beta_{i,n}r^B_i,\beta_{i,n}\alpha^S_{i,n}\right)+C\left(-\beta_{i,n}r^B_i,-\beta_{i,n}\alpha^B_{i,n}\right)\end{array}\right] \end{aligned} \quad (4)$$

Equation 4 indicates that the risk of the portfolio is decomposed into five terms, which are the four terms in Brinson paper and their mixture. Obviously, the first term represents investment policy, the second term active allocation, the third term security selection, the fourth term their interaction, and the fifth term their mixture. It should be also noted that the denominator of the determination coefficient is the product of equation 4 and its first term.

Two assumptions are required further to follow the method employed in Brinson et al..

First, equity weight $w_{i,n}$ is fixed through the entire period. This assumption is important as we intend to distinguish the contribution of investment policy from that of active allocation[2]. Secondly, μ^n_β, the average of tilt size $\beta_{i,n}$, is assumed to be zero. It is hard to imagine a bias of tilt size $\beta_{i,n}$ to either positive or negative side for the entire period, where market conditions change randomly. Thus this assumption also seems appropriate[3].

To derive the variance of the entire portfolio return, the variance of the product of two independent variables and the expectation of the product of two mutually dependent variables are required. They are shown in Appendices. Using those expressions, we can derive equation 5 from equation 4, where the variance of the entire portfolio return is expressed by five terms, each of which is made of various factors.

$$\begin{aligned} V\left(r^A_{i,n}\right) &= \left[w_{i,n}{}^2 V\left(r^S_i\right) + (1-w_{i,n})^2 V\left(r^B_i\right) + 2\left(w_{i,n}(1-w_{i,n})\right) C\left(r^S_i, r^B_i\right)\right] \\ &+ \left[V\left(\beta_{i,n}\right) V\left(r^S_i\right) + V\left(\beta_{i,n}\right) V\left(r^B_i\right) + \left(\mu_S - \mu_B\right)^2 V\left(\beta_{i,n}\right) - 2V\left(\beta_{i,n}\right) C\left(r^S_i, r^B_i\right)\right] \\ &+ \left[w_{i,n}{}^2 V\left(\alpha^S_{i,n}\right) + (1-w_{i,n})^2 V\left(\alpha^B_{i,n}\right)\right] \\ &+ \left[V\left(\beta_{i,n}\right) V\left(\alpha^S_{i,n}\right) + \mu^n_{\alpha^S}{}^2 V\left(\beta_{i,n}\right) + V\left(\beta_{i,n}\right) V\left(\alpha^B_{i,n}\right) + \mu^n_{\alpha^B}{}^2 V\left(\beta_{i,n}\right)\right] \\ &+ 2\left(\mu_S - \mu_B\right)\left(\mu^n_{\alpha^S} - \mu^n_{\alpha^B}\right) V\left(\beta_{i,n}\right) \end{aligned} \tag{5}$$

The causality of individual factor to the risk of the entire portfolio can be easily understood through equation 5. The variance of equity return $V\left(r^S_i\right)$ and that of fixed income return $V\left(r^B_i\right)$ have impacts on the investment policy term and the allocation term, while the variance of equity tilt size $V\left(\beta_{i,n}\right)$ on the allocation term, the interaction term and the mixture term. The variances of alphas in equity and fixed income affect the security selection term and the interaction term. Finally, the correlation between equity and fixed income returns $C\left(r^S_i, r^B_i\right)$ affects the investment policy term and the allocation term. However, as their directions are opposite, the total effect of the correlation will be relatively small compared with other factors.

In the previous section, we assumed that the equity tilt size $\beta_{i,n}$ is affected by neither equity return r^S_i nor fixed income return r^B_i. Nevertheless, the equity tilt size $\beta_{i,n}$ might have correlation with equity return r^S_i or fixed income return r^B_i in the case of a skillful portfolio

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[2] Hensel, Ezra and Iikiw (1991) pointed out that the validity of this assumption depends on whether the benchmark is a pension debt or an investment policy. The decision of investment policy becomes an active judgment as well in the former case, while only the active allocation to investment policy is an active judgment in the latter case. We do not discuss this problem further, and to compare our estimates with that of earlier papers, we choose to analyze issues from a latter aspect.

[3] For reference, the general form of variance and covariance is shown in Appendix B, when the equity weight $w_{i,n}$ changes through time and μ^n_β is not zero, as the two assumptions might not be satisfied with actual data. In other words, the equation A-8 is a general form of equations 7 and 9.

manager. For instance, if a portfolio manager with high skill increases the equity weight predicting a higher equity return, $\beta_{i,n}$ and r_i^S will have positive correlation. Oppositely, a portfolio manager with low skill could not predict an equity return precisely, thus $\beta_{i,n}$ and r_i^S will have no correlation or sometimes even negative correlation. Equation 4 is rewritten as follows, when we consider correlation between $\beta_{i,n}$ and r_i^S, and between $\beta_{i,n}$ and r_i^B.

$$
\begin{aligned}
V\left(r_{i,n}^{A}\right) &= \left[1st\,Term\,of\;Eq.4\right] + \left[2nd\,Term\,of\;Eq.4\right] + \left[3rd\,Term\,of\;Eq.4\right] + \left[4th\,Term\,of\;Eq.4\right] \\
&+ \left[\begin{array}{l} 5th\,Term\,of\;Eq.4 \\ +2\left[\begin{array}{l} C\left(w_{i,n} r_i^S, \beta_{i,n} \alpha_{i,n}^S\right) + C\left(w_{i,n} r_i^S, -\beta_{i,n} \alpha_{i,n}^B\right) \\ +C\left(\left(1-w_{i,n}\right) r_i^B, \beta_{i,n} \alpha_{i,n}^S\right) + C\left(\left(1-w_{i,n}\right) r_i^B, -\beta_{i,n} \alpha_{i,n}^B\right) \end{array}\right] \end{array}\right]
\end{aligned}
\tag{6}
$$

Equation 6 is a little cumbersome. To decompose the equation into various factors, we need two equations beforehand. The first is for the expectation of a product of four mutually dependent variables, necessary for calculating the covariance. The second is for the variance of the product of two variables with correlation. Assuming each variable follows normal distribution, they are given in Appendices. Applying those relations, equation 7 is derived from equation 6.

$$
\begin{aligned}
V\left(r_{i,n}^{A}\right) &= \left[1st\,Term\,of\;Eq.5\right] + \left[2nd\,Term\,of\;Eq.5 \boxed{-4C\left(\beta_{i,n}, r_i^S\right) C\left(\beta_{i,n}, r_i^B\right)}\right] \\
&+ \left[3rd\,Term\,of\;Eq.5\right] + \left[4th\,Term\,of\;Eq.5\right] \\
&+ \left[5th\,Term\,of\;Eq.5 \boxed{+2\left[\begin{array}{l} w_{i,n}\left(\left(\mu_S - \mu_B\right) + \left(\mu_{\alpha^S}^n - \mu_{\alpha^S}^n\right)\right) C\left(\beta_{i,n}, r_i^S\right) \\ +\left(1-w_{i,n}\right)\left(\left(\mu_S - \mu_B\right) + \left(\mu_{\alpha^S}^n - \mu_{\alpha^S}^n\right)\right) C\left(\beta_{i,n}, r_i^B\right) \end{array}\right]}\right]
\end{aligned}
\tag{7}
$$

The difference between equations 5 and 7 is the enclosed part with a dotted line, while other parts are quite the same. The enclosed part will appear only in the denominator of the determination coefficient, thus implying that the determination coefficient decreases when the enclosed part get relatively larger. When $\mu_S \geq \mu_B$ and $\mu_{\alpha^s} \geq \mu_{\alpha^B}$, this part gets larger if following four conditions are satisfied.

- ■High correlation of the tilt size $\beta_{i,n}^S$ and equity return r_i^S.
- ■High correlation of the tilt size $\beta_{i,n}^S$ and fixed income return r_i^B.
- ■Significant difference of the average return of equity μ_S and that of fixed income μ_B.
- ■Significant difference of the average alpha of equity μ_{α^s} and that of fixed income μ_{α^B}.

Covariance of Investment Policy and Portfolio. The covariance of portfolio and investment policy returns, the numerator of the determination coefficient, is given by equation 8, assuming correlation exists only between equity and fixed income returns. The denominator of the determination coefficient is the product of the variance of portfolio and that of investment policy.

$$C\left(r^P_{i,n}, r^A_{i,n}\right) = \left[w_{i,n}{}^2 V\left(r^S_i\right) + (1-w_{i,n})^2 V\left(r^B_i\right) + 2\left(w_{i,n}(1-w_{i,n})\right) C\left(r^S_i, r^B_i\right)\right] \tag{8}$$

The covariance above appears also in the first term of the variance of portfolio return, as shown in equation 5 or 7. It implies that the determination coefficient becomes larger, if the first term in equation 5 or 7, that is equation 8, gets larger than other terms.

Similarly, when the correlations between equity tilt size $\beta_{i,n}$ and equity return r^S_i, and fixed income return r^B_i are introduced, the covariance of portfolio and investment policy returns is expressed as equation 9. The part enclosed with a dotted line is now added to equation 8. The part is also included in the mixture term of equation 7. It is the same logic that the determination coefficient become larger as in the previous case with no correlation. That is when the equation 9 gets larger both in the denominator and the numerator.

$$\begin{aligned} C\left(r^P_{i,n}, r^A_{i,n}\right) &= \left[1st\ Term\ of\ Eq.8\right] \\ &+ \left[\begin{array}{l} \left[2nd\ Term\ of\ Eq.8\right] + w_{i,n}\left(\left(\mu_S - \mu_B\right) + \left(\mu_{\alpha^S} - \mu_{\alpha^B}\right)\right) C\left(\beta_{i,n}, r^S_i\right) \\ + (1-w_{i,n})\left(\left(\mu_S - \mu_B\right) + \left(\mu_{\alpha^S} - \mu_{\alpha^B}\right)\right) C\left(\beta_{i,n}, r^B_i\right) \end{array}\right] \end{aligned} \tag{9}$$

Models for Cross Sectional Analysis

Variance of Return among Portfolios. As mentioned earlier, Ibbotson and Kaplan (2000) implemented cross sectional analysis in addition to time series analysis. We now decompose the determination coefficient of investment policy on the difference of returns among funds into various factors as in the case of time series analysis.

Now fix i at t, then the return of portfolio j is

$$r^A_{t,j} = \left(w_{t,j} r^S_t + (1-w_{t,j}) r^B_t\right) + \left(\beta_{t,j} r^S_t - \beta_{t,j} r^B_t\right) + \left(w_{t,j}\alpha^S_{t,j} + (1-w_{t,j})\alpha^B_{t,j}\right) + \left(\beta_{t,j}\alpha^S_{t,j} - \beta_{t,j}\alpha^B_{t,j}\right) \tag{10}$$

As for the cross sectional return, the difference from the time series is that equity return r^S_i and fixed income return r^B_t are given at time t, meaning these returns are the same across funds. Therefore the variance of portfolio return across funds is

$$\begin{aligned} V\left(r^A_{t,j}\right) &= \left[r_t^{S^2} V\left(w_{t,j}\right) + r_t^{B^2} V\left(1-w_{t,j}\right)\right] + \left[r_t^{S^2} V\left(\beta_{t,j}\right) + r_t^{B^2} V\left(-\beta_{t,j}\right)\right] \\ &+ \left[V\left(w_{t,j}\alpha^S_{t,j}\right) + V\left(\left(1-w_{t,j}\right)\alpha^B_{t,j}\right)\right] + \left[V\left(\beta_{t,j}\alpha^S_{t,j}\right) + V\left(-\beta_{t,j}\alpha^B_{t,j}\right)\right] \end{aligned} \tag{11}$$

Note that this variance represents the scattering of fund performance at time t. The variance is different from that in time series analysis, which focuses on the changes of a specific fund performance along with time passage. Moreover, no covariance exists in equation 11, implying correlations between tilt size $\beta_{t,j}$ and equity return r_t^S, and fixed income return r_t^B would not affect the risk of portfolio return at all. The equation 11 can be rewritten as follows[4].

$$
\begin{aligned}
V\left(r_{t,j}^A\right) &= \left[\left(r_t^S - r_t^B\right)^2 V\left(w_{t,j}\right)\right] + \left[\left(r_t^S - r_t^B\right)^2 V\left(\beta_{t,j}\right)\right] \\
&+\left[\left(V\left(w_{t,j}\right)V\left(\alpha_{t,j}^S\right) + \mu_w^{t^2} V\left(\alpha_{t,j}^S\right) + \mu_{\alpha^S}^{t^2} V\left(w_{t,j}\right)\right) + \left(V\left(w_{t,j}\right)V\left(\alpha_{t,j}^B\right) + \mu_w^{t^2} V\left(\alpha_{t,j}^B\right) + \mu_{\alpha^B}^{t^2} V\left(w_{t,j}\right)\right)\right] \\
&+\left[\left(V\left(\beta_{t,j}\right)V\left(\alpha_{t,j}^S\right) + \mu_\beta^{t^2} V\left(\alpha_{t,j}^S\right) + \mu_{\alpha^S}^{t^2} V\left(\beta_{t,j}\right)\right) + \left(V\left(\beta_{t,j}\right)V\left(\alpha_{t,j}^B\right) + \mu_\beta^{t^2} V\left(\alpha_{t,j}^B\right) + \mu_{\alpha^B}^{t^2} V\left(\beta_{t,j}\right)\right)\right]
\end{aligned} \tag{12}
$$

The variance is decomposed into four terms. The first term is related with investment policy, the second term with active asset allocation, the third term with security selection and the fourth term with their interaction respectively.

The equation 12 is fairly simpler than equations 5 and 7. It has two features. First, the variance of the equity weight among funds $V\left(w_{t,j}\right)$ determines the first term (investment policy), while the variance of tilt size among funds $V\left(\beta_{t,j}\right)$ determines the second term (active allocation). Secondly, if the average and the variance of alpha among funds are high, they adequately affect the third term (security selection) and the fourth term (interaction). More precisely, the equity weight $w_{t,j}$ influences the security selection through μ_w^t and $V\left(w_{t,j}\right)$ in the third term, while the tilt size $\beta_{t,j}$ affects the interaction through μ_β^t and $V\left(\beta_{t,j}\right)$ in the fourth term.

Covariance of Investment Policies and Portfolios. Under given equity and fixed income returns at time t, the covariance of portfolio and investment policy returns is derived as shown below. We need not to consider the correlation between equity and fixed income returns, as they are fixed cross-sectionally. The equation is quite the same as the first term (investment policy) in equation 12.

$$
\begin{aligned}
C\left(r_{t,j}^P, r_{t,j}^A\right) &= r_t^{S^2} V\left(w_{t,j}\right) - 2r_t^S r_t^B V\left(w_{t,j}\right) + 2r_t^{B^2} V\left(w_{t,j}\right) \\
&= \left(r_t^S - r_t^B\right)^2 V\left(w_{t,j}\right)
\end{aligned} \tag{13}
$$

Causal relations of individual factors to the determination coefficient are also simpler than the time series case. Comparing equation 12 with equation 13, we can infer that $V\left(w_{t,j}\right)$ plays an important role. The determination coefficient becomes larger as $V\left(w_{t,j}\right)$ gets larger because other variables are set constant.

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[4] As distinguished from time series analysis, the average tilt size $\beta_{t,j}$ is not necessarily zero for cross sectional analysis as it is implemented for each time period.

Determination Coefficient: Simulations

Time Series Case. For the base case, the parameters of the model are set as follows. The equity weight $w_{i,n}$ in investment policy is 60%, the average tilt size $\beta_{t,j}$ is zero and its volatility is 5%. As for alphas, the averages are 1% for equity and 0.5% for fixed income, whereas the volatilities are 3% and 1% respectively. We use S&P500 and City group U.S. Government Bond Index of past 30 years for the benchmark return[5]. The average returns are 13% for equity and 6% for fixed income, while volatilities are 15% and 5% respectively. The correlation of equity and fixed income returns is estimated to be 0.1 from the index data, whereas both of the correlations of tilt size $\beta_{t,j}$ and equity return r_i^S, and fixed income return r_t^B are assumed to be zero. In this base case, the determination coefficient is 0.956. This figure is a little bit higher but near to prior researches like Brinson et al. (1986,1991) and Ibbotson and Kaplan (2000)[6]. We change these parameters, and investigate the difference from the base case.

Simulation results are summarized in Table1 to Table4. The parameters to be changed are shown in the top row of each table. Other parameters are not changed from the base case. The bottom row shows the determination coefficients. Middle rows display the contribution of each term to the entire portfolio variance by percentage.

As for the tilt size $\beta_{t,j}$ in Table1 and the alphas $\alpha_{t,j}^S, \alpha_{t,j}^B$ in Table2, the determination coefficient decreases as their variance increases. In the former case, the proportions of allocation, interaction and mixture terms increase when the volatility of the tilt size $\beta_{t,j}$ increases. In this case the variances of investment policy and security selection terms do not change, but their proportions decrease as the volatility of the entire portfolio increases. Similarly in the later case, the proportions of security selection and interaction terms increase as the variances of the alpha $\alpha_{t,j}^S, \alpha_{t,j}^B$ increase, while the proportions of investment policy and allocation terms decrease without any change of their variance. Such a fund with higher alpha risk that has only 20 to 30 securities out of several thousands contained in the index would have a lower determination coefficient.

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[5] These data are from Ibbotson Associates.

[6] The reasons for the difference from the earlier researches will be different parameter settings and cash whose position is assumed to be zero in our simulation.

Table1 Risk of Active Allocation and R^2

$\sigma\left(\beta_{i,n}\right)$	0.05	0.1	0.15
Investment Policy	95.6%	93.5%	90.2%
Allocation	0.7%	2.7%	6.0%
Security Selection	3.7%	3.6%	3.5%
Interaction	0.0%	0.1%	0.3%
Mixture	0.0%	0.1%	0.1%
R^2	0.956	0.935	0.902

Table2 Risk of Security Selection and R^2

$\sigma\left(\alpha_{i,j}^{S}\right)$	0.03	0.04	0.05
$\sigma\left(\alpha_{i,j}^{B}\right)$	0.01	0.015	0.02
Investment Policy	95.6%	92.8%	89.5%
Allocation	0.7%	0.7%	0.7%
Security Selection	3.7%	6.4%	9.7%
Interaction	0.0%	0.1%	0.1%
Mixture	0.0%	0.0%	0.0%
R^2	0.956	0.928	0.895

Table3 Market Risk and R^2

$\sigma\left(r_i^{S}\right)$	0.15	0.11	0.07
$\sigma\left(r_i^{B}\right)$	0.05	0.04	0.03
Investment Policy	95.6%	92.7%	84.7%
Allocation	0.7%	0.7%	0.8%
Security Selection	3.7%	6.5%	14.3%
Interaction	0.0%	0.1%	0.1%
Mixture	0.0%	0.0%	0.1%
R^2	0.956	0.927	0.847

Table4 Correlation of Market Returns and R^2

$\rho\left(r_i^{S}, r_i^{B}\right)$	-0.3	0	0.3
Investment Policy	94.6%	95.4%	96.0%
Allocation	1.0%	0.8%	0.6%
Security Selection	4.3%	3.8%	3.4%
Interaction	0.0%	0.0%	0.0%
Mixture	0.0%	0.0%	0.0%
R^2	0.946	0.954	0.960

Compared with the previous two cases, Table3 and Table4 are a little difficult to interpret. First, consider the influence of the correlation $\rho\left(r_i^{S}, r_i^{B}\right)$ in Table4. As discussed in the explanation of equation 5,$\rho\left(r_i^S, r_i^B\right)$ is contained in investment policy and allocation terms in the form of covariance, but their signs are opposite. When the correlation changes from negative to positive, the allocation term and its proportion decrease, while investment policy and its proportion increase. The proportion of security selection also decreases because the risk of entire portfolio increases along with the correlation change. Consequently, the determination coefficient increases.

Secondly, in Table3, as market risks of $\sigma\left(r_i^S\right)$ and $\sigma\left(r_i^B\right)$ decrease, the variance of investment policy return and its proportion decease, since the market risks are reflected in the investment policy. The allocation term is also affected by the market risk, directly through the variance and indirectly through the covariance. As the sign of effect of the covariance is negative, this part increases along with decreasing market risk. Consequently, the proportion of allocation term decreases but moderately. The variances of security selection and interaction terms are not affected by the changes in market risk, but its proportions increase as the entire portfolio risk decreases. As such, the determination coefficient decreases as a whole.

Table5 Portfolio Manager Skill and R^2

$\rho\left(\beta, r_i^S\right)$	0.3	0	-0.3	0.3	-0.3
$\rho\left(\beta, r_i^B\right)$	-0.3	0	0.3	0.3	-0.3
Investment Policy	94.3%	95.6%	96.7%	93.8%	97.6%
Allocation	0.8%	0.7%	0.8%	0.6%	0.6%
Security Selection	3.6%	3.7%	3.7%	3.6%	3.7%
Interaction	0.0%	0.0%	0.0%	0.0%	0.0%
Mixture	1.2%	0.0%	-1.2%	1.9%	-2.0%
R^2	0.956	0.956	0.955	0.957	0.956

Table6 Market Return Difference, Alphas Difference and R^2

μ_S (difference with μ_B)	0.13(0.05)	0.15(0.07)	0.17(0.09)
$\mu^n_{\alpha^S}$ (difference with $\mu^n_{\alpha^B}$)	0.01(0.005)	0.015(0.01)	0.02(0.015)
Investment Policy	93.8%	92.9%	92.0%
Allocation	0.6%	0.7%	0.8%
Security Selection	3.6%	3.6%	3.5%
Interaction	0.0%	0.0%	0.0%
Mixture	1.9%	2.8%	3.7%
R^2	0.957	0.957	0.956

Table5 presents the influences of the correlations between tilt size $\beta_{t,j}$ and equity return r_t^S, and fixed income return r_t^B. As apparent from the table, the correlation hardly affects the determination coefficient. It is because the additional parts shown in dotted lines in equations 7 and 9 are very small compared to other parts. For instance, let both of the correlations be

0.3. While the covariance, the numerator of the determination coefficient, is 0.895%, the additional part is 0.011%. Similarly, while the variance of the entire portfolio return included in the denominator is 0.916%, the additional parts in allocation and mixture terms are very small, with -0.001% and 0.021% respectively. Therefore, the changes in these parameters don't affect the determination coefficient significantly.

Table6 presents the influence of the differences of market returns and alphas[7]. As shown in the table, the determination coefficient hardly changes. It is because the difference of market returns and the alphas are present both in the numerator and the denominator of the determination coefficient, as shown in equations 7 and 9.

Statman (2000) conducted simulations with historical data, and concluded that a determination coefficient told nothing about a portfolio manager's skill. Our simulation above supports his argument.

Cross Sectional Case. As for the base case, the parameters are first specified as follows. The equity weight in investment policy $w_{t,j}$ is 60% on average, with 10% volatility among funds, different from time series analysis. Equity return r_t^S and fixed income return r_t^B are fixed at 25% and 5%. Finally, the alpha of equity is assumed to be 1% on average with standard deviation of 3% among funds, while the alpha of fixed income is 0.5% on average with standard deviation of 1%. The equations 12 and 13 suggest that the absolute difference between r_t^S and r_t^B is most crucial among the parameters. The average of five years' absolute differences is a little below 20% as shown in Table7, thus r_t^S and r_t^B being specified as above[8]. The determination coefficient of the base case is 0.343, that is a little lower but near to 0.40 of Ibbotson and Kaplan (2000). However, different from time series analysis, the coincidence with prior researches is not so important. The determination coefficient changes substantially, depending on parameters.

Table7　Absolute Difference between Market Returns

	Average			R^2
	S&P500	City U.S. Govern.	Abs. Diff.	
2001	-10.75	6.67	17.42	0.403
2002	-22.75	11.21	33.96	0.635
2003	26.07	2.48	23.59	0.520
2004	10.61	3.56	7.05	0.114
2005	5.07	2.83	2.24	0.013
Average	1.65	5.35	16.85	0.337

[7] Both correlation coefficients of $\beta_{t,j}$ and r_t^S, and r_t^B are assumed to be 0.3.

[8] Because Ibbotson and Kaplan(2000) used accumulated return, their analysis is not a precisely cross sectional. We chose parameters so as to implement cross sectional analysis like Ibe (2006).

Table8 to Table11 summarize the result of simulations. Causal relations are simpler than in time series analysis. Overall, the determination coefficient increases when the variance of investment policy increases in equation 12, while it decreases when the variances of other terms increase. In Table8, the left side investigates the effect of changes in average weight of equity in investment policy, while the right side investigates the effect of changes in scattering of equity weight among funds. Both average and scattering have substantial effects on the determination coefficient. The increase in average equity weight brings lower determination as it induces higher selection variance because of higher alpha risk in equity than in fixed income. The increase in scattering of equity weight also brings higher determination as the different equity weights induce different returns among funds. Table9 examines the case where the difference between equity and fixed income returns gets larger. In this case, the investment policy term gets larger in equation 12, which brings a higher determination coefficient.

Table8 Equity Weight and R^2

$w_{t,j}$	Average			Standard Deviation		
	0.5	0.6	0.7	0.05	0.1	0.15
Investment Policy	41.3%	34.3%	28.7%	11.8%	34.3%	53.3%
Allocation	10.3%	8.6%	7.2%	11.8%	8.6%	5.9%
Security Selection	47.9%	56.7%	63.8%	75.9%	56.7%	40.5%
Interaction	0.5%	0.4%	0.4%	0.6%	0.4%	0.3%
R^2	0.413	0.343	0.287	0.118	0.343	0.533

Table9 Market Return Difference and R^2

r_t^S (difference with r_t^B)	0.05(0)	0.2(0.15)	0.4(0.35)
Investment Policy	0.0%	34.3%	64.3%
Allocation	0.0%	8.6%	16.1%
Security Selection	99.2%	56.7%	19.5%
Interaction	0.8%	0.4%	0.1%
R^2	0.000	0.343	0.643

In Table10 and Table11, we change the parameters that have nothing to do with investment policy. First, as for the average and the volatility of the equity tilt size $\beta_{t,j}$, Table10 shows that the average hardly matters, while the increase in the volatility brings lower determination as it increases the variance of allocation return among funds. Table11 examines the changes in averages and volatilities of alphas $\alpha_{t,j}^S$, $\alpha_{t,j}^B$. In each case, the proportion of investment policy decreases along with increasing parameters, thus bringing a lower determination coefficient.

Table10 Tilt Size and R^2

$\beta_{t,j}$	Average			Standard Deviation		
	0	0.1	0.2	0.05	0.1	0.15
Investment Policy	34.3%	33.8%	32.4%	34.3%	27.0%	20.0%
Allocation	8.6%	8.5%	8.1%	8.6%	27.0%	44.9%
Security Selection	56.7%	55.8%	53.4%	56.7%	44.6%	32.9%
Interaction	0.4%	1.9%	6.2%	0.4%	1.4%	2.2%
R^2	0.343	0.338	0.324	0.343	0.270	0.200

Table11 Alpha and R^2

	Average			Standard Deviation		
$\alpha^S_{t,j}$	0.01	0.015	0.02	0.03	0.04	0.05
$\alpha^B_{t,j}$	0.005	0.01	0.015	0.01	0.015	0.02
Investment Policy	34.3%	34.2%	34.0%	34.3%	23.4%	16.5%
Allocation	8.6%	8.6%	8.5%	8.6%	5.8%	4.1%
Security Selection	56.7%	56.7%	56.9%	56.7%	70.3%	78.8%
Interaction	0.4%	0.5%	0.6%	0.4%	0.5%	0.6%
R^2	0.343	0.342	0.340	0.343	0.234	0.165

Conclusion

No one would object to the importance of investment policy. The extent of its influence on portfolio performance have been discussed widely. The definite answer, however, remains yet to be attained. We provided an analytical framework for the influence both in a specific fund and among funds, even when the detailed data is not available. By giving several parameters of investor's risk and market condition it enables us to investigate the influence through simulation regardless of markets.

Brinson et al. (1986) showed that the investment policy explained more than 90% of return of a pension fund, which tends to be considered to deny active investment either by active allocation or security selection. We made clear that the determination coefficient of investment policy on actual return could have various figures depending on investor's active risk taking and market conditions.

In each fund, investors can control active risks of asset allocation and security selection. We showed that the determination coefficient decreased as these risks increased. It means that the investment policy does not determine everything. The importance of investment policy as a performance determinant depends on active risk taking. Similarly, the determination coefficient changes depending on market conditions, the volatilities and the correlation of equity and fixed income returns.

As for the difference of returns among funds, the average and the volatility of the equity weight in investment policy affect the determination coefficient greatly. We showed that the scattering of active allocation and security selection factors among funds had some influence on the determination coefficient. In addition, the market condition, specifically the difference between equity and fixed income returns, is important for the determination coefficient.

The influence of investment policy on performance is certainly large either in each fund (time series) or among funds (cross section). However, this means neither that investment policy is an only factor to determine performance, nor that active risk taking cannot contribute to the performance at all. If the active risk increases, it will certainly have important influence on fund performance.

Appendix A: Calculation

Expectation of Product of Random Variables

When $\Omega(k)$ is the variance-covariance matrix of k variables with means μ, the characteristic function of k dimension normal distribution is given by the following equation, where i is an imaginary number.

$$\phi(\mathbf{t}) = \exp\left[i\mathbf{t}'\boldsymbol{\mu} - \frac{1}{2}\mathbf{t}'\Omega(k)\mathbf{t}\right] \tag{A.1}$$

The $(m+n)$ th moment of random variable X_k and X_l is

$$E\left(X_k^m X_l^n\right) = \frac{1}{i^{m+n}}\left[\frac{\partial^{m+n}}{\partial t_k^m \partial t_l^n}\phi(\mathbf{t})\right]_{\substack{t_k=0\\ t_l=0}} \tag{A.2}$$

In the case of four-dimension normal distribution, the characteristic function is

$$\phi(t_1,\dots,t_4) = \exp\left[i\sum_{k=1}^{4} t_k\mu_k - \frac{1}{2}\sum_{k=1}^{4}\sum_{l=1}^{4} t_k t_l C(k.l)\right] \tag{A.3}$$

Therefore, the expectation of the four variables product with correlation is

$$E(X_1X_2X_3X_4) = \left[\frac{\partial^4}{\partial t_1\partial t_2\partial t_3\partial t_4}\phi(t_1,\dots,t_4)\right]_{\substack{t_j=0\\ j=1,2,3,4}} \tag{A.4}$$

After some manipulation, the following equation is derived. If the distribution is not normal, the term of the fourth cumulant $k_4(X_1X_2X_3X_4)$ is added to this equation, though this part is assumed zero (normal distribution) in this article.

$$\begin{aligned}
E(X_1X_2X_3X_4) &= \mu_{X_1}\mu_{X_2}\mu_{X_3}\mu_{X_4} + \mu_{X_1}\mu_{X_2}C(X_3,X_4)\\
&+\mu_{X_1}\mu_{X_3}C(X_2,X_4) + \mu_{X_1}\mu_{X_4}C(X_2,X_3)\\
&+\mu_{X_2}\mu_{X_3}C(X_1,X_4) + \mu_{X_2}\mu_{X_4}C(X_1,X_3) + \mu_{X_3}\mu_{X_4}C(X_1,X_2)\\
&+C(X_1,X_2)C(X_3,X_4) + C(X_1,X_3)C(X_2,X_4) + C(X_1,X_4)C(X_2,X_3)
\end{aligned} \tag{A.5}$$

Variance of Product of Random Variables

When X_1 and X_2 are independent,

$$V(X_1X_2) = V(X_1)V(X_2) + \mu_{X_1}{}^2V(X_2) + \mu_{X_2}{}^2V(X_1) \tag{A.6}$$

When X_1 and X_2 are not independent,

$$V\left(X_1 X_2\right)=E\left(\left(X_1 X_2\right)^2\right)-2\mu_{X_1}\mu_{X_2}E(X_1 X_2)+\mu_{X_1}{}^2\mu_{X_2}{}^2$$

From the expectation of four variables product, if X_1 and X_2 follow normal distribution,

$$E\left(\left(X_1 X_2\right)^2\right)=\mu_{X_1}{}^2\mu_{X_2}{}^2+\mu_{X_1}{}^2V(X_2)+\mu_{X_2}{}^2V(X_1)+V(X_1)V(X_2)$$
$$+4\mu_{X_1}\mu_{X_2}C\left(X_1,X_2\right)+2C\left(X_1,X_2\right)^2$$

Therefore,

$$V\left(X_1X_2\right)=\mu_{X_1}{}^2V(X_2)+\mu_{X_2}{}^2V(X_1)+V(X_1)V(X_2)+2\mu_{X_1}\mu_{X_2}C\left(X_1,X_2\right)+2C\left(X_1,X_2\right)^2 \quad (A.7)$$

Appendix B: General Forms of Variance and Covariance

In realty, the equity weight $w_{i,n}$ in investment policy may change through time, and the average of equity tilt may not be zero. The general form of portfolio variance in theses cases is given by the following equation. The equations 7 and 9 are the special cases setting $V\left(w_{i,n}\right)$ =0, μ_β^n =0, and μ_w^n =$w_{i,n}$.

$$V\left(r_{i,n}\right)=\begin{bmatrix}V\left(w_{i,n}\right)V\left(r_i^S\right)+\mu_w^{n^2}V\left(r_i^S\right)+V\left(w_{i,n}\right)V\left(r_i^B\right)+\left(1-\mu_w^n\right)^2V\left(r_i^B\right)+\left(\mu_S-\mu_B\right)^2V\left(w_{i,n}\right)\\+2\left(\mu_w^n\left(1-\mu_w^n\right)-V\left(w_{i,n}\right)\right)C\left(r_i^S r_i^B\right)\end{bmatrix}$$

$$+\begin{bmatrix}V\left(\beta_{i,n}\right)V\left(r_i^S\right)+\mu_\beta^{n^2}V\left(r_i^S\right)+V\left(\beta_{i,n}\right)V\left(r_i^B\right)+\mu_\beta^{n^2}V\left(r_i^B\right)+\left(\mu_S-\mu_B\right)^2V\left(\beta_{i,n}\right)\\-2\left(\mu_\beta^{n^2}+V\left(\beta_{i,n}\right)\right)C\left(r_i^S,r_i^B\right)\\-2\mu_\beta^n\mu_B C\left(\beta_{i,n},r_i^S\right)-2\mu_S\mu_\beta^n C\left(\beta_{i,n},r_i^B\right)-4C\left(\beta_{i,n},r_i^S\right)C\left(\beta_{i,n},r_i^B\right)\end{bmatrix}$$

$$+V\left(w_{i,n}\right)V\left(\alpha_{i,n}^S\right)+\mu_w^{n^2}V\left(\alpha_{i,n}^S\right)+\mu_{\alpha^S}{}^2V\left(w_{i,n}\right)+V\left(w_{i,n}\right)V\left(\alpha_{i,n}^B\right)+\left(1-\mu_w^n\right)^2V\left(\alpha_{i,n}^B\right)+\mu_{\alpha^B}{}^2V\left(w_{i,n}\right)$$
$$+V\left(\beta_{i,n}\right)V\left(\alpha_{i,n}^S\right)+\mu_\beta^{n^2}V\left(\alpha_{i,n}^S\right)+\mu_{\alpha^S}{}^2V\left(\beta_{i,n}\right)+V\left(\beta_{i,n}\right)V\left(\alpha_{i,n}^B\right)+\mu_\beta^{n^2}V\left(\alpha_{i,n}^B\right)+\mu_{\alpha^B}{}^2V\left(\beta_{i,n}\right)$$
$$+2\begin{bmatrix}\mu_w^n\mu_\beta^n V\left(r_i^S\right)+\mu_\beta^n\left(1-2\mu_w^n\right)C\left(r_i^S,r_i^B\right)-\left(1-\mu_w^n\right)\mu_\beta^n V\left(r_i^B\right)\\+\left(\mu_S^n-\mu_B^n\right)\left(\mu_{\alpha^S}^n-\mu_{\alpha^B}^n\right)V\left(w_{i,n}\right)+\left(\mu_S^n-\mu_B^n\right)\left(\mu_{\alpha^S}^n-\mu_{\alpha^B}^n\right)V\left(\beta_{i,n}\right)\\+\mu_w^n\left(\mu_S-\mu_B\right)C\left(\beta_{i,n},r_i^S\right)+\left(\mu_w+\mu_\beta^n\right)\left(\mu_{\alpha^S}-\mu_{\alpha^B}\right)C\left(\beta_{i,n},r_i^S\right)\\+\left(1-\mu_w^n\right)\left(\mu_S-\mu_B\right)C\left(\beta_{i,n},r_i^B\right)+\left(1-\mu_w-\mu_\beta^n\right)\left(\mu_{\alpha^S}-\mu_{\alpha^B}\right)C\left(\beta_{i,n},r_i^B\right)\end{bmatrix} \quad (A.8)$$

The general form of covariance of investment policy and portfolio returns is

$$
\begin{aligned}
&C\left[\begin{array}{l} w_{i,n} r_i^S + (1 - w_{i,n})\, r_i^B, \left(w_{i,n} r_i^S + (1 - w_{i,n})\, r_i^B\right) + \left(\beta_{i,n}, r_i^S - \beta_{i,n}, r_i^B\right) \\ + \left(w_{i,n} \alpha_{i,n}^S + (1 - w_{i,n})\, \alpha_{i,n}^B\right) + \left(\beta_{i,n} \alpha_{i,n}^S - \beta_{i,n} \alpha_{i,n}^B\right) \end{array}\right] \\
&= \left[\begin{array}{l} V(w_{i,n})\, V\left(r_i^S\right) + \mu_w^{n^2} V\left(r_i^S\right) + V(w_{i,n})\, V\left(r_i^B\right) + \left(1 - \mu_w^n\right)^2 V\left(r_i^B\right) \\ + \left(\mu_S - \mu_B\right)^2 V(w_{i,n}) + 2\left(\mu_w^n \left(1 - \mu_w^n\right) - V(w_{i,n})\right) C\left(r_i^S, r_i^B\right) \end{array}\right] \\
&+ \left[\begin{array}{l} \mu_w^n \mu_\beta^n V\left(r^S\right) + \left(1 - 2\mu_w^n\right) \mu_\beta^n C\left(r^S, r^B\right) - \left(1 - \mu_w^n\right) \mu_\beta^n V\left(r_i^B\right) + \left(\mu_S - \mu_B\right)\left(\mu_{\alpha^S} - \mu_{\alpha^B}\right) V(w_{i,n}) \\ + \mu_w^n \left(\mu_S - \mu_B\right) C\left(\beta, r^S\right) + \mu_w^n \left(\mu_{\alpha^S} - \mu_{\alpha^B}\right) C\left(\beta, r^S\right) + \left(1 - \mu_w^n\right)\left(\mu_S - \mu_B\right) C\left(\beta, r^B\right) \\ + \left(1 - \mu_w^n\right)\left(\mu_{\alpha^S} - \mu_{\alpha^B}\right) C\left(\beta, r^B\right) \end{array}\right]
\end{aligned}
\tag{A.9}
$$

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〔Yukihiro Asano, Professor, Faculty of Business Administration, Yokohama National University〕

〔Junichi Iwamoto,The Sumitomo Trust&Banking Co., Ltd〕

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