The Semi-Parametric Examination of Industry Risk: The Australian Evidence
Juan Yao

This version Feb. 2009

Abstract:
This paper examines the time variation form of the systematic risk measurement, betas, of Australian industry sectors. By using a semi-parametric approach, the variation of the systematic risk measurement, beta, is a combination of one stable parametric component and one varying non-parametric component. Two categories of industries are identified. The Energy, Material, Mining, Industrial, and Property Trust Industries have a generally increasing beta for most of the sample period, while the Consumer Discretionary, Financials Excluding Property Trust, IT and Telecommunications have a decreasing beta for the same period. The betas of Health and Utility industry are more stable than others. The variation of industry risk is linked with the market condition as well as the change of interest rates.

JEL Classification: G11, G12, G15, G32.

Keywords:
Non-parametric approach; Time-varying beta; Industry Risk Analysis; Time-Varying Model.

Finance Discipline, Faculty of Economics and Business, The University of Sydney, NSW 2006, Australia. Email: j.yao@econ.usyd.edu.au. This paper was completed during the author’s study leave at the Economics Department, the University of Adelaide. The author would like to thank Professor Jiti Gao for hosting her study leave and also providing constructive comments and suggestions on the paper.
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1. Introduction

The traditional asset-pricing models imply that the expected returns of securities are determined by their measure of systematic risk, beta or the factor loadings of the associated risk premiums. Thus, the systematic risk measurement, beta, has always been the centre of the scrutiny for any kind of security analysis. The traditional capital asset pricing models such as CAPM and APT assumes the constant linear relationship between risk and returns. In recent time, however, there is extensive empirical evidence documenting the time variation of the systematic risk and risk premiums which has ignited an uprising of discussion on conditional asset pricing models.

The conditional CAPM proposed by Pettengill et al. (1995), Jagannathan and Wang (1996) claims that their models are able to explain the cross-sectional portfolio returns better than the static CAPM. However, other research work such as Ghysels (1998) and Lewellen and Nagel (2006) both argue that the pricing errors with conditional CAPM are actually larger than those with the traditional CAPM’s, thus the conditional CAPM does not explain asset-pricing anomalies. As argued by Ghysels (1998) that despite all the efforts to model time-varying risk, the pricing errors of the conditional asset pricing models are still higher than the constant beta models. Therefore, the conditional asset pricing model cannot replace the constant beta model due to the fact that they are also mis-specified. It seems that the extensive efforts in developing the conditional asset pricing models are still fruitless.

One fundamental question associated with the conditional asset pricing model is the specification of risks. Though it is almost a consensus that the systematic risk, beta, which is defined as the covariance of asset return and market return standardized by the variance of market return, does vary overtime, its time-varying form however remains a mystery. Empirically most of the research of time-varying betas relates beta to its historical or mean values, or a random coefficient, and the Kalman Filter was the popularly used tool to estimate it. Such work includes those of Wells (1994), Faff and Brooks (1998), Brooks, et al. (1998), Groenewold and Fraser (1999), and more
recently Yao and Gao (2004), in which beta is modelled as an ARMA process, a Random Walk, Mean Reverting process or even as a Random coefficient. The practical applicability and efficiency of those methods may remain questionable. Since beta is an unobservable risk measurement and there is no convincing theoretical guide in its variation properties\(^1\), ideally we shall not assume any functional form for it. In this regard, I adopt a fundamentally different approach, a semi-parametric approach, to estimate betas in this study. The advantages of semi-parametric methods are that there is little or no restrictive prior information on functional forms of beta needed, therefore, the unforgiving consequences of parametric misspecification may be avoided. (For detailed introduction of nonparametric econometrics, see Pagan and Ullah 1999; Li and Racine 2007 and Gao 2007).

I build a time-varying-coefficient market model in this study to explain the Australian industry sector returns. In the model, the variation of betas is a combination of one stable parametric component and one varying non-parametric component. The non-parametric variation of beta is a function of time \(t\). This set up of the model conforms nicely to the industry practice that the riskiness of the firm varies over the time as in practice the new or young firms would usually take on low risk projects but when they progress and mature later they are more likely to engage in more high risk projects. Additionally, I also examine whether the variation of betas is related to the market condition as well as the change of interest rate by including market condition dummies and interest rate viable in the model.

I concentrate on industrial portfolios in this study rather than the individual stocks to avoid the “background noise” problem when the individual stocks are used. The industry portfolios are usually well diversified thus the over/under estimations of beta due to “sampling error” are reduced. The similarities of firms in each sector enable the industry groups to show more dispersion in their stock market performance. At the industry level, when the economic and business condition changes, the sensitivity of industry sectors to the overall market changes also varies.

\(^1\) Most of parametric studies earlier either assume beta to be mean-reverting, such as in Blume (1975) or being random in Sunder (1980), or related to its historical value in Ohlson and Rosenberg (1982).
In practice, both industry analysis and fund management are conducted at the portfolio level, the information of the systematic risk of different sectors will serve the basis for asset allocation strategies such as the industry rotation or portfolio rebalancing. Thus the industry portfolio betas are also directly useful to fund managers and security analysts who are primarily interested in the industry analysis.

The reminder of the paper is organized as follows. Section 2 introduces the methodology and empirical design of the study. Section 3 discusses the data. The results of the study are presented in Section 4 and Section 5 concludes.

2. Methodology and empirical design

2.1. Empirical design

Similar to Eisenbeiss et al. (2007), this study proposes using a varying-coefficient model to estimate the Australia industry sector betas. I utilize a partially linear model in the form of:

\[ Y_t = X_t^\top B + \sum_{k=1}^{m} \beta_k(t) \gamma_{kt} + e_t, \]  

(1)

where \( Y_t \) is the response variable and \( X_t \) and \( \gamma_{kt} \) are corresponding predictors, possibly in vectors. \( B \) is the coefficient vector of the parametric term while \( \beta_k(t) \) are the nonparametric smooth terms. The \( e_t \) is normal distributed error with zero mean and finite variance \( \sigma^2 \).

The varying-coefficient market model has the following form\(^2\):

\[ r_t = X_t^\top B + r_{m,t} \beta_m(t) + \varepsilon_t. \]  

(2)

Here \( r_t \) is the stock index return for each industry sector, \( X_t = (1, r_{m,t}) \) is a vector, and \( r_{m,t} \) is the market index portfolio return. \( B = (\alpha, \beta)^\top \) is a parameter vector, in which \( \alpha \) is the coefficient of intercept term for each industry, and \( \beta \) is the stable

\(^2\) The time-varying model above can also be written as:

\[ r_t = \alpha + f(\beta) r_{m,t} + \varepsilon_t. \]

Here the smooth function \( f(\beta) \) is being represented by a constant plus a centred smooth. The smooth function also gets multiplied by a covariate \( r_{m,t} \) which is a special case of additive model proposed by Hastie and Tibshirani (1990).
parametric part of the beta. The second term of the model is the key difference between the varying-coefficient model here and the traditional market model. Here $\beta(t)$ is a nonparametric component and a function of time. The $\varepsilon$ is normal distributed with zero mean and finite variance $\sigma^2$. While the parametric component of beta can be considered as the historical mean the nonparametric component captures the time-variation of betas. This formation of the model is consistent with the existing empirical evidence that beta varies around some stable historical values (see Wells 1994; Yao and Gao 2004).

Several previous studies, such as Pettengill et al. (1995), Howton and Peterson (1998), and Faff (2001) have found that beta behaves differently under bull or bear market conditions. Eisenbeiss et al. (2007) find that beta is larger or increasing during the bear market conditions but smaller or decreasing during the bull conditions. They construct the bull and bear market by modelling the market index return as a smooth function of time. To examine whether the variation of Australia industry sector betas are related to the condition of the market, I create a dummy variable in the spirit of dual beta models of Pettengill et al. (1995) and Faff (2001). The periods with positive market excess returns is defined as positive state and the periods with negative market excess returns is defined as the negative market state. I will examine whether the variation of betas depends on the state of the market.

Another important factor might affect the variation of beta is the interest rate. Merton (1973) argues that the change of interest rate should be used as a single instrumental variable represents the shifts in the investment opportunity set. DeJong and Collins (1985) employ a joint option pricing and Capital Asset Pricing Model to explain the instability of equity beta using risk-free rate changes and leverage effects. They find that highly leveraged firms exhibit greater equity beta instability than firms with lower leverage. Furthermore, the individual equity beta exhibit greater instability during periods of large expected changes in the risk-free rate when compared to period with small unexpected changes in the risk-free rate. Shanken (1990) finds that both the level and volatility of T-bill rates are associated with important shifts in the investment characteristics of industry portfolios, in particular, different industry portfolios have different sensitivity to T-bill rate changes.
Thus, to test how the market conditions and change of interest rates affect the variation of beta, I employ a model of:

\[ r_i = X_i^\top A + r_m(t) + D_t a(t) + CTB_t a(t) + \mu_i, \quad (3) \]

Here \( r_i \) is the stock index return for each industry sector, \( X_i = (1, r_m) \) is a vector, and \( r_m(t) \) is the market index portfolio return. \( A = (\alpha, a) \) is a parameter vector, in which \( \alpha \) is the coefficient of intercept term for each industry, and \( a \) is the stable parametric part. The dummy variable \( D_t \) measures the condition of the market. \( D_t = 1 \) when the excess market returns are positive, and \( D_t = 0 \) when the excess market returns are negative. \( CTB_t \) is the change of the interest rate. The \( a_m(t), a_D(t) \) and \( a_F(t) \) are the smooth terms to the variable of market return, dummy and change of interest rate.

2.2. Estimation and computing

To estimate model (2), the following penalized least square criterion is to be minimized:

\[ f(\beta) = \sum_{i=1}^{T} (r_i - \alpha - \beta r_m(t) r_m) + \lambda \int_{a}^{b} \beta'(t)^2 dt, \quad (3) \]

where the first term measures closeness to the data and the second term penalizes curvature in the function. \( f(\beta) \) is minimized by a natural cubic spline. The \( \lambda \) is the smoothing parameters to control fit-smoothness trade-off. A \( \lambda \) value of 1 gives the function which minimizes the roughness penalty which results a linear regression and a value of 0 gives the function which minimizes the residual error (the interpolating cubic spline). Wood (2000, 2001) presents an algorithm which automatically chooses an optimal level for \( \lambda \) by using prediction error criteria, such as cross validation, GCV, AIC, BIC etc.

The minimizer of (3) has knots at the unique \( t_n, n=1,\ldots,k \). The nonparametric component \( \beta(t) \) of the model (1) can be written in terms of basis functions as:

\[ \beta'(t) = \sum_{n=1}^{k} \beta_{n+1} s_n(t), \] where \( s_n(t) \) is the basis function.

Thus,
\[
\int_\alpha^\beta \beta(t)^2 \, dt = B^\top S B,
\]

where \(B\) is the parameter vector, and \(S\) is a positive semi-definite coefficients matrix depending only on the basis function.

The estimation procedure above can be extended naturally to model (3).

3. Data

To proxy the industry portfolios, the industry index portfolios are natural selections. The industry portfolio returns used in this study are computed from the S&P ASX 300 GICS indexes. In June 2001, S&P launched the end-of-day GICS indexes for S&P ASX 300. In additional to 10 GICS sectors, an extra sector is introduced to the Australia market, the Property Trust sector, to reflect the importance of property trust industry in Australia. Another additional sector was also obtained by fragmenting the financial sector into the Property Trust and the Financials excluding Property Trust (FXPT) sector. Thus there are 12 industry sectors since then and the traditional 24 industrial sector indexes were discontinued in July 2007. The data samples are daily sector index returns from 3rd April 2000 to 9th May 2008. The market return used in the study is daily Australian All Ordinary Return Index for the same sample period. The risk-free rate is the daily observations of the Australian 3-year Treasury bill rate during the sample period. All the industry sector indexes, the stock market index and the interest rate data are obtained from the Datastream.

The summary statistics of the industry sector and market index returns are given in Table 1. The means of the most daily industry sector returns are positive except the Consumer Discretionary, Financials excluding Property Trust (FXPT), IT and Telecommunications. While the Energy and Mining sectors have the higher mean return than other sectors, the Consumer Discretionary, IT, FXPT and Mining sector returns have higher variation. When Kurtosis and Skewness are examined, IT and FXPT exhibit excessive leptokurtosis and left-skewed. Further examination found that the IT sector index was dropped by 28% on 17th April 2000 and the FXPT index was dropped by 12% on 17th Dec 2000. When these two observations are excluded, the Kurtosis and Skewness of these two sector index returns are reduced greatly.
4. Results:
The results of non-parametric estimation of the market model for all industry sectors are provided in Table 2. For each industry sector returns, I provide the estimate for parametric term, smooth term and the model fitting diagnostics. The last two columns present the Breusch-Pagan Test for heteroscedasticity in the residuals and their P-values, as well as the Durbin-Watson statistics for residual serial correlation.

The non-parametric model fits reasonable well for most of the industry sector returns. There are no serious serial correlations for all industries as indicated by the Durbin-Watson statistics. However, in three industries, the Materials, IT and Mining there are heteroscedasticity problems with the residuals which might suggest that the algorithm which automatically chooses a level for the smoothing parameter $\lambda$ might not be the optimal.

The estimated smooth terms are Estimated Degree of Freedom (EDF), which indicates the complexity of the smooth function. The smaller EDF indicates a simpler function, and a value closer to 1 implies a linear function. The EDF of Consumer Staples and IT are 1.5, which indicates that the time-varying betas of these two industries are almost linear which can be confirmed by the graphical illustration in Figure 1 in which the curves of betas in these two industries are almost linear. Over all industry sectors, the smooth term is highly significant which confirms the time-variation of the betas. For the parametric term however, some interesting results emerge. The intercepts term of Energy, Consumer Discretionary, FXPT and IT are significant. As the traditional CAPM implies a zero intercept, the results here suggest that market is not the single risk factor to explain the returns in these sectors. For the parametric term betas, surprisingly, the betas in Energy, FXPT, Utility and Property Trust are not significant which indicate that the betas in these industries don’t seem to have a stable mean.

For the time-variation of betas, the estimated smooth terms are depicted in Figure 1a and 1b. The figures clearly show that there is instability in all betas of the industries.
investigated. However, the beta of Health industry appears to be more stable than the rest. Interestingly, the beta of Consumer Staples industry appears to be a linear function of the time.

[Figure 1a, 1b]

The visual inspection of the figures enables us to classify the industries into two categories. The first category has an increasing beta for most of the time period up till 2006, such as the Energy, Material and Mining industry. The Industrial and Property Trust also have an increasing beta over the whole sample period. The second category has a decreasing beta over the same sample period, such as the Consumer Discretionary, FXPT, IT and Telecommunications. The beta of Utility industry decreases till 2003, and reverses and being stabilized after which forms a rough U-shape.

Following Eisenbeiss et al. (2007), I smooth the market index return over time $t$. The smoothed curve is depicted in Figure 2. Over the whole sample period, we can see that the market is mainly divided into two states, the negative state before July 2003, when the average market returns are negative, and the positive state, after July 2003, when the average market returns are positive. I thus draw a vertical line at July 2003 in all figures to separate the positive and negative market conditions.

[Figure 2 and 3]

Additionally, I also smooth the interest rate variable over time $t$. The smoothed curve is presented in Figure 3. Interestingly, during the sample period the smoothed interest rate series is basically a U-shape with turning points at around July 2003. I find that the declining/increasing interest rate period coincides with the negative/positive market state. However, from inspection to all figures, I cannot detect apparent counter-cyclical behaviour of betas documented in previous studies. For all industries I have examined, I can see that for the first category industries, as shown in Figure 1a, the betas are generally increasing during the negative market conditions, the betas in the first four industries are stabilized during the positive market conditions. These industries include the Energy, Industrial, Material, Mining, Property Trust and
Consumer Staples. However, the betas of Property Trust and Consumer Staples have been increasing right trough the positive market conditions. For the second category of industries shown in Figure 1b, betas have a strong decreasing trend all way till 2006. These industries include the Consumer Discretionary and FXPT industries. While betas for the Telecommunications and IT also decline over the negative market conditions, they are almost stabilized over the positive market conditions. Interestingly, the variation of beta for Utility industry is consistent with the change of market conditions as well as the interest rate, that is, declines when market is negative and interest rate goes done and recovers back when market turns to be positive and interest rate goes up.

The results of estimation of model (3) are presented in Table 3, in which I examine whether the form of variation of betas depends on the market condition dummies as well as the change of interest rate. The estimated parameters of parametric terms, and the estimated degrees of freedom for the smooth terms are listed sequentially in Table 3. Across all industries, the time-varying functions of betas to the market return are highly significant except the Industrial industry. For the dummy variables, most of the industries have a significant estimate with at least one dummy. In particular, the variation of betas in the Material and Mining industries significantly depend on the positive market dummy, while the variation of betas in the Industrial, Consumer Discretionary, Health Care FXPT, Telecommunication and Property Trust industries are significantly related to the negative market dummy. The betas of Energy and IT industries have a significant variation in both positive and negative market. Interestingly, the variation of betas in the Consumer Staples and Utility Industries has no relationship with different market conditions. The finding here are consistent with dual-beta literature that the variation of betas differ with different market conditions. For most of the industries, the betas are more variable in negative market conditions.

[Table 3]

In the examination of interest rate variable, the result shows that there is a significant non-linear relationship between the industry returns and the change of interest rate. All EDFs are highly significant except the Health Care. Additionally, the variation in the Consumer Staples, and the Telecommunication industries are less significant.
Figure 4 to 13 depict the form of time variation of each smooth terms of model (3) for each industry sector. The top left panel is the variation form to the market return. The top right panel and the lower left panel are the variations to the market conditions\(^3\). The lower right panel is the variation form to the change of the interest rate. As the Consumer Stapler and the Utility sectors don’t have a significant smooth term of dummies as shown in Table 3, these two industries are not included here. There are four smooth terms for each industry, which are variation of betas to market return \(R_{me}\), positive market dummy \(fac.1\), negative market dummy \(fac.2\) and change of interest rate \(CRF\). Several interesting findings can be discovered from visual inspection of figures. Firstly, one group of industry sectors has a decreasing beta function when the market is positive and an increasing beta function when the market is negative. Such industries include the Material in Figure 4, the Consumer Discretionary in Figure 5, the Health Care in Figure 6, the Financials Exclude Property Trust in Figure 7, the IT in Figure 8, the Mining in Figure 9, and the Telecommunication in Figure 10. Another group of industries do not have such pattern. Figure 11 shows that the Energy sector beta has a rather flat form in positive market, and “wave-like” function in negative market, so does the Industrial sector in Figure 12. Interestingly, the Property Trust beta has a strong increasing trend in positive market and a decreasing trend in negative market, which is contrary to most of other industry sectors as shown in Figure 13. Across all industry sectors, it is quite obvious that betas have a more variable form in negative market conditions.

How the change of interest rates affects the industrial returns can be seen from the bottom right panel of Figures above. Except the Health Care industry in which the smooth component of interest rate is not significant, there are three kinds of patterns of relationship can be detected. Four industry returns have a general decreasing relationship with change of interest rates, which are the Material in Figure 4, Mining in Figure 9, Telecommunication in Figure 10 and the Energy in Figure 11. Another four industry returns have a general increasing relationship with the change of interest rate, which are the Industrial in Figure 12, Property Trust in Figure 13, Consumer Stapler in Figure 14, and the Utility industry in Figure 15. Three of the industry

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\(^3\) In the estimation procedure, two factors are generated from the dummy. The factor 1 represents the positive market condition and the factor 2 represents the negative market condition.
returns have a “cyclical-like” relationship with the interest rate and they are the Consumer Discretionary in Figure 5, FXPT in Figure 7 and the IT industry in Figure 8.

[Figure 4-15]

5. Conclusion
By using a semi-parametric partial linear model, I examine the time-variation of systematic risk of Australian industry sectors. The risk measurement, beta is decomposed into a stable parametric component and a varying non-parametric component. I find that overall industry sectors, the varying components are highly significant, which lends support to the previous literature of time-varying betas and conditional asset pricing models. Further more, I also find that the systematic risk of Health and Utility industry are relatively stable than other industries. Two categories of industries are identified. The Energy, Material and Mining, Industrial and Property Trust Industry have a generally increasing risk for most of the sample period, while the Consumer Discretionary, FXPT, IT and Telecommunications have a generally decreasing risk for the same period despite the market condition being negative or positive. I also find that the risk variation of Utility industry seems to coincide with the market condition.

The variation form of the betas is significantly related to the market condition in most of industry sectors except the Consumer Stapler and the Utility industry. The variation form of betas is more complicated when the market is in negative states. Most of the industry betas have a general decreasing trend in positive market conditions but an increasing trend in negative market which is consistent with previous findings of Faff (2001) and Eisenbeiss et al. (2007). However, the beta of Property Trust industry seems to be an outlier as it has a contrary variation form compared to the rest of the groups.

The change of interest rate has also a significant impact on the returns in most of the industries except the Health Care industry. The Material, Mining, Telecommunication and the Energy industry returns have a negative relationship with change of interest rates and the Industrial, Property Trust, Consumer Stapler and the Utility industry returns have a positive relationship with change of interest rates. The returns in the
other three industry of Consumer Discretionary, FXPT and IT industry seem to have a cyclical relation with change of interest rate.

The results of this study highlight the necessity to implement the time-varying beta models in industry practice. However, there are some interesting issues should be pursued further. First of all, what are the sources of beta variation? Abell and Krueger (1989) examine the influence of macroeconomic variables on the beta. They find that the interest rate, budget deficit, trade deficits, inflation, and oil prices are important factors that influence changes in betas. It would be interesting to examine further whether it is the sensitivity to macroeconomic news causes the different time-variation of betas.

Secondly, this study only examines the time-series variation of betas. However, the final goal of a successful asset pricing model is to explain the cross-sectional returns. Thus further research effort should be devoted to investigate how the time-varying model can be applied to explain the cross-sectional risk-return relationships. Additionally, same industry indexes exist for S&P Global, S&P UK, S&P Japan, S&P Europe and S&P Asia 50. It would be interesting to do a cross-country study to compare the time-variation of industry risks across different markets. All these issues are left for future research.
References:


Table 1 Summary Statistics

<table>
<thead>
<tr>
<th>Industry</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample Variance</th>
<th>Kurtosis</th>
<th>Skewness</th>
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Note: it*: removed the 17/04/2000, on which the index dropped by 28.19%. pt*: removed the 17/12/2000, on which the index dropped by 11.7%.
Table 2. Semi-Parametric estimation of the market model

The model is: \( r_t = X_t^\top B + r_{mt}, \beta_m(t) + \epsilon_t \)

Here \( r_t \) is the excess return of the industry portfolio while \( r_{mt} \) is the excess market index return. \( \beta_m(t) \) is the non-parametric smooth function.

<table>
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<tr>
<th>Industry</th>
<th>Parametric term</th>
<th>Smooth term</th>
<th>Model</th>
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<th>DW</th>
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<td>( \hat{\beta} )</td>
<td>EDF</td>
<td>P-value</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>0.047</td>
<td>0.408</td>
<td>8.683</td>
<td>&lt;0.001***</td>
<td>0.756</td>
</tr>
<tr>
<td>Materials</td>
<td>0.025</td>
<td>1.075</td>
<td>8.751</td>
<td>&lt;0.001***</td>
<td>0.670</td>
</tr>
<tr>
<td>(2-step)*</td>
<td>-0.046</td>
<td>0.842</td>
<td>7.332</td>
<td>&lt;0.001***</td>
<td>0.144</td>
</tr>
<tr>
<td>Industrials</td>
<td>0.002</td>
<td>0.624</td>
<td>7.873</td>
<td>&lt;0.001***</td>
<td>0.606</td>
</tr>
<tr>
<td>Consum Discre.</td>
<td>-0.057</td>
<td>0.648</td>
<td>9.265</td>
<td>&lt;0.001***</td>
<td>0.629</td>
</tr>
<tr>
<td>Consum Staples</td>
<td>0.023</td>
<td>0.319</td>
<td>1.500</td>
<td>&lt;0.001***</td>
<td>0.461</td>
</tr>
<tr>
<td>Health care</td>
<td>0.008</td>
<td>0.668</td>
<td>4.887</td>
<td>&lt;0.001***</td>
<td>0.381</td>
</tr>
<tr>
<td>Finan. ex property</td>
<td>-0.066</td>
<td>0.693</td>
<td>9.279</td>
<td>&lt;0.001***</td>
<td>0.573</td>
</tr>
<tr>
<td>IT</td>
<td>-0.090</td>
<td>0.538</td>
<td>1.500</td>
<td>&lt;0.001***</td>
<td>0.307</td>
</tr>
<tr>
<td>(2-step)</td>
<td>-0.049</td>
<td>0.710</td>
<td>6.397</td>
<td>&lt;0.001***</td>
<td>0.361</td>
</tr>
<tr>
<td>Metals &amp; Mining</td>
<td>0.023</td>
<td>1.178</td>
<td>8.407</td>
<td>&lt;0.001***</td>
<td>0.610</td>
</tr>
<tr>
<td>(2-step)</td>
<td>0.014</td>
<td>0.893</td>
<td>8.841</td>
<td>&lt;0.001***</td>
<td>0.639</td>
</tr>
<tr>
<td>Teleco.</td>
<td>-0.044</td>
<td>1.145</td>
<td>8.540</td>
<td>&lt;0.001***</td>
<td>0.294</td>
</tr>
<tr>
<td>Utilities</td>
<td>0.020</td>
<td>0.242</td>
<td>7.068</td>
<td>&lt;0.001***</td>
<td>0.296</td>
</tr>
<tr>
<td>Property Trust</td>
<td>0.013</td>
<td>0.259</td>
<td>7.967</td>
<td>&lt;0.001***</td>
<td>0.416</td>
</tr>
</tbody>
</table>

Note: significance code: “***” 0.001, “**” 0.01, “*” 0.05.

BP\# is the Breusch-Pagan Test for heteroscedasticity in the residuals. DW\# is the Durbin-Watson statistics for residual serial correlation.
Table 3. Varying-Coefficient market model with dummy and interest rate.

The model is: $r_t = X_t^\prime A + r_m(t) + D_t a_D(t) + CTB a_F(t) + \mu_t$

Here $r_t$ is the excess return of the industry portfolio while $r_m(t)$ is the excess market index return. $a(t)$ are the non-parametric smooth functions. $D_t$ is the dummy variable which takes value of 1 when the market excess return is positive, 0 when the market excess return is negative. $CTB_t$ is the change of the interest rate.

<table>
<thead>
<tr>
<th></th>
<th>$a(t):r_m$</th>
<th>$a_D(t):D1(positive)$</th>
<th>$a_D(t):D2(negative)$</th>
<th>$a_F(t):CTB$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\alpha$</td>
<td>P-value</td>
<td>$\alpha$</td>
<td>P-value</td>
</tr>
<tr>
<td>Energy</td>
<td>-0.487</td>
<td>0.003**</td>
<td>0.446</td>
<td>0.001**</td>
</tr>
<tr>
<td>Materials</td>
<td>-0.083</td>
<td>0.266</td>
<td>0.915</td>
<td>&lt;0.001***</td>
</tr>
<tr>
<td>Industrials</td>
<td>0.218</td>
<td>0.161</td>
<td>0.773</td>
<td>&lt;0.001***</td>
</tr>
<tr>
<td>Consum Discre.</td>
<td>0.180</td>
<td>0.190</td>
<td>0.477</td>
<td>0.105</td>
</tr>
<tr>
<td>Consum Staples</td>
<td>0.257</td>
<td>0.027*</td>
<td>0.326</td>
<td>&lt;0.001***</td>
</tr>
<tr>
<td>Health care</td>
<td>-0.133</td>
<td>0.283</td>
<td>0.615</td>
<td>&lt;0.001***</td>
</tr>
<tr>
<td>Finan. ex. prop.</td>
<td>-0.006</td>
<td>0.891</td>
<td>0.454</td>
<td>0.209</td>
</tr>
<tr>
<td>IT</td>
<td>-0.037</td>
<td>0.942</td>
<td>2.899</td>
<td>&lt;0.001***</td>
</tr>
<tr>
<td>Metals &amp; Mining</td>
<td>-0.070</td>
<td>0.320</td>
<td>0.951</td>
<td>0.001**</td>
</tr>
<tr>
<td>Teleco.</td>
<td>0.030</td>
<td>0.738</td>
<td>1.136</td>
<td>&lt;0.001***</td>
</tr>
<tr>
<td>Utilities</td>
<td>0.011</td>
<td>0.826</td>
<td>-0.122</td>
<td>0.484</td>
</tr>
<tr>
<td>Property Trust</td>
<td>0.009</td>
<td>0.436</td>
<td>0.254</td>
<td>0.208</td>
</tr>
</tbody>
</table>

Note: significance code: "***" 0.001, "**" 0.01, "*" 0.05.
Figure 1 a. Increasing Time-varying Betas
Figure 1 b. Decreasing or Stable Time-varying Betas
Figure 2. Smooth of market return

Figure 3. Smooth of interest rate
Figure 4. Material industry

![Graphs of varying-coefficient model for material industry]

Figure 5. Consumer Discretionary Industry

![Graphs of varying-coefficient model for consumer discretionary industry]
Figure 6. Health Care Industry

Figure 7. Financials Exclude Property Trust Industry
Figure 8. IT Industry

Figure 9. Metals and Mining Industry
Figure 10. Telecommunication Industry

Figure 11. Energy Industry
Figure 12. Industrial Industry

Figure 13. Property Trust Industry
Figure 14. Consumer Stapler Industry

Figure 15. Utility Industry