DOW JONES COMPONENTS AND ECONOMIC INDICATORS: A FACTOR ANALYSIS APPROACH

Kaveepong Lertwachara, Ph.D.
and
Pattana Boonchoo
Deprtment of Finance and Banking, ABAC School of Management,
Assumption University

ABSTRACT

This paper explores the relationships between economic indicators and movements in the Dow components returns. There have been numerous attempts to identify these relationships: the Arbitrage Pricing Theory (APT), one of these approaches, contributes directly to the multifactor model. The theory, introduced by Ross in 1976, has been a valuable approach to analyzing security returns because the APT allows analysts to study the effects of multiple influential factors. Factor analysis is then used to analyze these factors, a group of economic indicators, and a group of security returns. Factor analysis identifies a new set of uncorrelated variables for economic indicators, and another new set of uncorrelated variables for stock returns. This study provides additional support to the idea that the returns on securities are influenced both by the market, and by economic conditions.

INTRODUCTION

The objective of this study was to analyze the relationships between economic indicators and movements in the Dow components returns. There have been a great many attempts to identify these relationships over the years: the Arbitrage Pricing Theory (APT), one of the approaches, contributes directly to the multifactor model (Raysonyi, 2004; Chiu & Xu, 2004; Miller, Stone, and Silver, 1998). The theory, introduced by Ross in 1976, has been a valuable approach to analyzing security returns, because the APT allows analysts to study multifactor models. Chen, Roll, and Ross (1986) employed a two-stage regression methodology first introduced by the Fama-MacBeth (1973, 1974). However, both studies failed to utilize a method that mitigates the problem of multicollinearity among economic variables (See also McElroy, Burmeister, & Wall, 1985; Burmeister & McElroy, 1988; Clare, Priestley, & Thomas, 1997; Garrett & Priestley, 1997; and McKiernan, 1997) Cheng (1995) investigated the relationships between the stock market and several economic factors. In his study, which contributes to the U.K. economy, Cheng conducted factor analysis and canonical correlation analysis. Factor analysis was used to analyze a group of economic indicators, as well as a group of security returns. This analysis determines whether a smaller set of uncorrelated variables can explain the relationships that exist between the original variables. The analysis identifies a new set of uncorrelated variables for economic indicators, and another new set of uncorrelated variables for stock returns. Johnson (1998) suggests that these new variables can be utilized in other statistical analysis of the data. One of the advantages of factor analysis is that the method only considers a small number of variables.

The remainder of the paper will be organized as follows: the APT is briefly presented in the second section. Empirical tests and results are presented in the third section. Finally, the fourth section offers a discussion and conclusion to summarize the findings.

THE APT

A general form of APT is as follows:

$$Rit = E(Rit) + \sum_{k=1} biktFikt + 0i$$

where Rit = the random rate of return on the *i*th asset in period *t*

E(Rit) = the expected rate of return on the *i*th asset in period *t*

bikt = the coefficient of factor k

Fikt = the change in the *k*th influential factor in period *t*.

0i = the nonsystematic error of the *i*th asset.

THE EMPIRICAL TESTS

Data

The data was gleaned from the St. Louis Federal Reserve Bank, the Federal Reserve Economic Data (FRED), which contains major macroeconomic indicators, and a Yahoo service offering historical quotes about the Dow components (Federal Reserve Bank of St. Louise, 2001). The sample period was from August 1986 to November 1999. All together, there were 161 completed and continuous monthly observations. The economic indicators were analyzed in nominal terms, as well as in percentage changes. However, the Dow components were analyzed only in terms of percentage changes, in order to incorporate with the APT.

Methodology and Results

One of the difficulties posed by this study is that the APT does not provide any theoretical or empirical explanations for which variables might influence security returns. Therefore, as many economic indicators as possible are included in the model. Maximum-likelihood analysis analysis identifies the number of factors, their factor loadings, and their factor scores. New variables are then computed based on the factor scores. Between four and six new variables are calculated for the percentages change in economic indicators and the chronological Dow components returns. The economic indicators and Dow components are identified using two new, uncorrelated variables.

The Dow Components

The objective of this section is to apply factor analysis to the APT. First, the Dow Components are analyzed. The factor analysis provides a set of new, uncorrelated variables, which represent the Dow components. These new variables are called "Dow factors". The results (Table 1) indicate that six Dow factors. The highest explanatory power of the factor is 38.957%, and the lowest is 3.381%. The difference between the explanatory power of the first Dow factor and the second Dow factor is significant, indicating that the first factor is more important than the other factors.

Table 2 illustrates how each of the Dow Components contributes to the Dow factors. Each of the Dow components has a far higher factor loading in the first Dow factor than in the other Dow factors. Again, this indicates that the first Dow factor is the most important factor.

The Dow factors are then used as independent variables to explain the percentage changes in the S&P 500. As expected, the first factor is statistically significant, and its estimated parameter is the largest. The second and fifth factors are also statistically significant, but their estimated parameters are smaller than that of the first factor. Fortunately,

Table 1: Total Variance Explained by the Components of the Dow

Component	Initial Eigenvalues Total	Percentage of Variance	Cumulative %	Extraction Sums of Squared Loadings Total	% of Variance	Cumulative %
1	11.687	38.957	38.957	11.687	38.957	38.957
2	2.124	7.078	46.035	2.124	7.078	46.035
3	1.582	5.272	51.308	1.582	5.272	51.308
4	1.276	4.255	55.562	1.276	4.255	55.562
5	1.139	3.798	59.361	1.139	3.798	59.361
6	1.014	3.381	62.742	1.014	3.381	62.742
7	0.887	2.957	65.699			
8	0.845	2.818	68.517			
9	0.800	2.666	71.183			
10	0.773	2.576	73.759			
11	0.681	2.271	76.030			
12	0.666	2.220	78.250			
13	0.649	2.163	80.413			
14	0.548	1.827	82.240			
15	0.502	1.675	83.915			
16	0.483	1.608	85.523			
17	0.468	1.561	87.084			
18	0.438	1.461	88.545			
19	0.407	1.356	89.900			
20	0.400	1.333	91.233			
21	0.377	1.258	92.491			
22	0.344	1.148	93.639			
23	0.313	1.044	94.683			
24	0.312	1.040	95.723			
25	0.274	0.914	96.637			
26	0.250	0.834	97.471			
27	0.216	0.721	98.192			
28	0.212	0.706	98.898			
29	0.169	0.562	99.460			
30	0.162	0.540	100.000			

Table 2: Component Matrix for The Return on The Dow Components

Ticker Symbol	Component					
	1	2	3	4	5	6
AA	0.5870	0.5720	-0.1040	0.0210	0.0340	0.1440
AXP	0.6930	-0.1070	-0.1100	-0.2050	0.0840	-0.2920
BA	0.6110	0.0640	-0.3370	-0.1520	-0.0680	-0.0420
C	0.7050	-0.1470	-0.1710	-0.2590	0.0640	-0.2270
CAT	0.5660	0.5000	-0.1230	-0.0820	-0.0780	0.1660
DD	0.6890	0.2710	-0.2140	-0.0470	-0.2100	-0.0079
DIS	0.7130	-0.0170	0.2300	-0.1440	-0.0280	0.0220
EK	0.4570	0.1480	0.1910	0.3520	-0.2770	0.1190
GE	0.7760	-0.1610	-0.0110	-0.0910	0.0910	0.0740
GM	0.5410	0.2470	0.0940	-0.4490	0.2660	0.0640
HD	0.5850	-0.1730	0.1120	-0.1890	0.0790	0.4710
HON	0.6710	0.1740	-0.1310	-0.0970	-0.0014	-0.2180
HWP	0.6150	0.1990	0.3370	0.0570	0.2730	-0.0840
IBM	0.4970	0.3780	0.3320	0.1050	0.0820	-0.0550
INTC	0.5780	0.1800	0.5040	0.0180	0.0150	-0.1730
IP	0.6600	0.3850	-0.1110	0.1060	-0.0650	0.1810
JNJ	0.7110	-0.3060	0.0240	0.1720	-0.2270	-0.0190
JPM	0.6750	-0.1710	-0.2290	0.0380	0.0800	-0.2500
KO	0.6390	-0.4040	-0.1490	-0.0280	-0.1270	-0.0180
MCD	0.6690	-0.1990	0.2250	-0.0960	0.0870	-0.1220
MMM	0.6620	0.2510	-0.1890	0.1490	-0.2220	0.1640
MO	0.5170	-0.2240	0.1950	0.3850	-0.0260	0.1010
MRK	0.6180	-0.3650	0.0080	0.0160	-0.2590	0.1570
MSFT	0.5350	-0.0910	0.5940	0.0850	-0.0530	-0.0620
PG	0.6490	-0.3890	0.0560	-0.0360	-0.1560	-0.0560
SBC	0.5030	-0.1100	-0.3470	0.5600	0.2250	0.0110
T	0.3910	-0.1900	-0.1230	0.2490	0.7390	0.2000
UTX	0.7840	0.0240	-0.1880	-0.0420	0.0170	0.0740
WMT	0.6410	-0.3120	0.0041	-0.2220	-0.0190	0.2880
XOM	0.5960	0.1610	-0.1080	0.2490	-0.0070	-0.4310

Table 3: Regression Results

Variable Estimate	Parameter Error	Standard Parameter = 0	T for Ho	Prob. > abs (T)
Bo	1.211	0.077	15.661	0
b1	4.227	0.078	54.471	0
b2	-0.311	0.078	-4.003	0
b3	0.077	0.078	0.995	0.321
b4	0.048	0.078	0.623	0.534
b5	0.479	0.078	6.167	0
b6	-0.025	0.078	-0.321	0.749
R-square	0.976	F-value	503.768	
Adj-R-Square	0.952	Prob > F	0	

the factors explain 95% of the variability of the S&P 500.

The Economic Indicator

The objective of this section is to use the factor analysis to examine a new set of uncorrelated variables, which represent a variety of US economic indicators. The factor analysis examines both the economic indicators, and their monthly changes. Thus, the factor analysis provides two new sets of uncorrelated variables. The new set of variables, representing the nominal value of the economic indicators, are called the "nominal economic factors". Another set of uncorrelated variables is called the "delta economic factors". Table 4 illustrates the degree to which each nominal economic factor explains the original US economic indicators.

There are only two nominal economic factors needed to explain 93.88% of the variability in the original US economic indicators. Table 5 shows how each economic indicator contributes to the nominal economic factors. Undoubtedly, discount rates and federal funds contribute less to nominal economic factor 1 than they do to nominal economic factor 2. In addition, they contribute the most to the second factor. This fact implies that these two factors are highly correlated, based on factor analysis criteria. Discount rates and federal funds represent the business sector of the economy, while other economic indicators represent the consumer sector and the monetary base. Therefore, we may assume that the first factor represents the consumer sector and the monetary base, while the second factor represents the business sector of the economy. Table 6 illustrates the degree to which each delta economic factor explains the changes in the original US economic indicators. There are four delta economic factors needed to explain 61.9% of the variability in the original US economic indicators. The low explanatory rating may be due to the fact that the relationships amongst US economic indicators are non-linear.

The results in Table 4 and Table 6 affirm two points: first, the first derivative has reduced serial correlation problems in the data set. Factor analysis gathers highly correlated original variables in each factor. Thus, a smaller number of factors implies a higher correlation between original variables. Second, the first derivative would free up some degree of the stationary problem. Since the percentage changes are analyzed instead of the nominal value, the relationship does not depend on the economic indicators' nominal values.

Table 7 shows how changes in each economic indicator contribute to the delta economic factors. The results in this table reaffirm the fact that the discount rate and the federal fund are highly correlated. Their contributions to the four factors are approximately the same in both magnitude and direction. Furthermore,

Table 4: Total Variance Explained by the nominal economic factors

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.939	74.488	74.488	8.939	74.488	74.488
2	2.327	19.394	93.881	2.327	19.394	93.881
3	0.353	2.944	96.825			
4	0.168	1.396	98.221			
5	0.140	1.170	99.391			
6	0.034	0.284	99.675			
7	0.020	0.169	99.844			
8	0.009	0.079	99.923			
9	0.005	0.044	99.967			
10	0.003	0.024	99.991			
11	0.001	0.006	99.997			
12	0.000	0.003	100.000			

Table 5: Component Matrix for the nominal economic factors

	Component	
Economic Indicator	1	2
CPI	0.97500	-0.00141
Currency and Demand Deposit M1	0.98000	0.00954
Discount Rate	-0.51800	0.82200
FEDFUN	-0.56900	0.79900
M1	0.89200	-0.26200
M2	0.96700	0.15000
Monetary Base	0.99300	0.04614
AAA bond yield	-0.90300	0.20800
Disposable Income	0.97800	0.17800
Unemployment rate	-0.49500	-0.82900
SP500	0.91500	0.29200
NYSE	0.93100	0.26900

Table 6: Total Variance Explained by the delta economic factors

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.482	20.684	20.684	2.482	20.684	20.684
2	2.343	19.525	40.209	2.343	19.525	40.209
3	1.455	12.129	52.338	1.455	12.129	52.338
4	1.148	9.567	61.905	1.148	9.567	61.905
5	0.979	8.159	70.064			
6	0.941	7.843	77.907			
7	0.804	6.697	84.604			
8	0.792	6.603	91.207			
9	0.613	5.106	96.313			
10	0.257	2.143	98.456			
11	0.178	1.487	99.942			
12	0.007	0.058	100.000			

Table 7: Component Matrix for the delta economic factors

	Component			
	1	2	3	4
CPI	0.270	0.000	-0.261	0.574
Currency and Demand Deposit M1	0.423	0.751	0.252	0.041
Discount Rate	0.321	-0.675	0.434	0.164
Fed Funds	0.496	-0.503	0.530	0.115
M1	0.347	0.800	0.246	0.104
M2	-0.046	0.310	0.054	-0.400
Money Base	0.303	0.499	0.377	0.115
AAA Bond Yield	0.459	-0.156	0.144	-0.116
Disposable Income	-0.016	-0.003	0.030	-0.644
Unemployment Rate	-0.096	0.204	-0.490	0.321
SP500	-0.846	0.101	0.452	0.173
NYSE	-0.856	0.105	0.427	0.176

no other economic indicators follow both the direction and the magnitude of these two.

Economic Indicators and Components of the Dow

The objective of this section is to identify the relationship between the economic indicators and the components of the Dow. The correlation analysis is conducted to determine whether the factors extracted from economic indicators help explain the behavior of 30 components of the Dow. If the correlation between the Dow factors and the nominal economic factors is significant, then it follows that the nominal economic factors will be able to explain the movements of the components of the Dow. The condition also holds for the correlation between the Dow factors and the delta economic factors.

As shown in Table 8, the correlation between the nominal economic factors and the Dow factors is not statistically significant. While there is correlation at some level, it is largely meaningless: the highest correlation level is at 0.149, between the sixth Dow factor and the first nominal economic factor. Therefore, the correlation analysis indicates that the nominal

Table 8: Correlation Analysis between The Dow Factors and The Nominal Economic Factors

	The Nominal Economic Factors	
The Dow Factors	1	2
1	0.055	0.040
Sig. (2-tailed)	0.489	0.618
2	0.040	-0.130
Sig. (2-tailed)	0.614	0.102
3	-0.028	-0.012
Sig. (2-tailed)	0.728	0.878
4	-0.095	0.017
Sig. (2-tailed)	0.232	0.835
5	0.117	-0.030
Sig. (2-tailed)	0.141	0.710
6	-0.149	0.115
Sig. (2-tailed)	0.059	0.148

Table 9: Correlation Analysis between The Dow Factors and The Delta Economic Factors

	The Delta Economic Factors			
The Dow Factors	1	2	3	4
1	-0.803**	0.134	0.413**	0.196*
Sig. (2-tailed)	0.000	0.900	0.000	0.013
2	0.470	-0.074	-0.074	0.090
Sig. (2-tailed)	0.555	0.354	0.351	0.258
3	-0.004	-0.008	-0.021	0.030
Sig. (2-tailed)	0.963	0.923	0.791	0.704
4	0.022	-0.027	-0.028	0.191
Sig. (2-tailed)	0.779	0.730	0.727	0.015
5	-0.077	0.129	0.144	-0.066
Sig. (2-tailed)	0.333	0.104	0.070	0.405
6	-0.024	-0.083	-0.045	0.003
Sig. (2-tailed)	0.763	0.295	0.575	0.973

economic factors are not useful instruments to explain the Dow factors.

Table 9 illustrates the correlation between the delta economic factors and the Dow factors. The results indicate that the delta economic factors explain only the change in the first Dow factor. The first, third and fourth delta economic factors correlate to the first Dow factor at 0.803, 0.413, and 0.196 (chronologically). In addition, the first delta economic factor has a negative relationship with the first Dow factor.

DISCUSSIONS AND CONCLUSIONS

This study utilized the APT as a guideline model, augmented by factor analysis to provide useful sets of uncorrelated factors. The sets of uncorrelated factors extracted from the nominal and the first derivative of economic indicators have been used to find a relationship between the 30 components of the Dow and the economic indicators. We found a significant relationship between the first factor of the Dow components and the delta economic factors. However, the first factor of the Dow components explains only 38% of the original return rates, meaning that there is another 62% left unexplained.

This study supports the idea that the returns on securities are not only influenced by the market, but by economic conditions. The market can force one stock to behave differently than another, but the economic conditions affect the market as a whole.

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