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AN EMPIRICAL ANALYSIS OF MARKET AND INDUSTRY FACTORS IN STOCK RETURNS OF U.S. AEROSPACE INDUSTRY

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Abstract

This paper applies multi-index CAPMs to explore the relationships of U.S. aerospace company stock returns to selected market and industry variables. This paper finds that the market returns represented by the S&P 500 index and Department of Defense expenditures are significantly positively related to aerospace stock returns. The regression results on other variables are mixed; in particular, aircraft shipments are positively related to aerospace stock returns, but the relations are not significant. Additional regression analysis of employing unanticipated changes in independent variables provides confirmatory evidence. The results of this paper suggest that a multi-index CAPM using selected economic and industry variables provides additional power in explaining the variability of U.S. aerospace stock returns over a single index model using the market index alone.

INTRODUCTION

The U.S. aerospace industry is one of the most unique industries of the American economy. It is one of the few industries that combines heavy manufacturing with high technology research activities. The industry is a large consumer of scientific talent and spends more money on research and development than any other sector of the American economy (Canning (1992)). It is also an industry where customers wield enormous power and influence. On the commercial side the customers are the various airlines, while on the military side the primary customer is the United States government.

The purpose of this study is to develop a multi-index model for U.S. firms operating in the military aerospace industry. The model consists of six predetermined market and industry variables which would seem intuitively to affect stock returns of aerospace firms. The model is tested on five major participants in the aerospace industry to examine if these variables have significant explanatory power in explaining the variability of the selected firms' stock returns.

Surprisingly, little published research is found concerning the testing of multi-index models for the returns of firms in specific industries. The majority of the previous research on this topic has used firms in the utility industry as subjects. Melicher (1974) studied returns of 84 electric utility firms for the period 1967 - 1971. Using factor analysis to determine the significance of 28 variables, he found that seven of these variables affected a firm's stock returns. These seven variables were financial leverage, size, earnings trend and stability, operating efficiency, financing policy, return on investment, and market activity. Bower and Bower (1984) studied a multi-index model developed by Salomon Brothers, which was tested for daily stock returns of 93 electric utilities from 1977 through 1981. Practically no multi-index CAPM studies can be found for industries other than the utility industry. While the U.S. aerospace industry is quasi regulated, it is not one where the end product is produced and then sold, rather it is an industry where the end product is first sold and then produced. This makes the entire industry structure drastically different from utilities and other industries.

This paper attempts to discover which, if any, of the market and industry variables are of use in explaining the variability of aerospace security returns. In particular, the following questions are examined: Is the inclusion of extra variables worth the effort and expense of including them, or is a single index model using only a market

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index adequate to explain variability of aerospace stock returns? If the model is significant for one firm, is it significant for the others? The strength of the relationship of the independent variables with aerospace stock returns will determine whether a useful multi-index CAPM can be developed.

This paper finds that aerospace stock returns have significant positive relationships with Department of Defense expenditures, as well as the S&P 500 index returns. The relationships between aerospace stock returns and the other variables are, however, mixed; in particular, aerospace stock returns are, as hypothesized, positively related to industry aircraft shipments, but the relations are not significant. These findings are robust to a different regression model using unanticipated changes in independent variables. The results of this study tend to support a multi-index CAPM over a single index model in estimating U.S. aerospace stock returns.

Section II reviews related studies, and Section III presents a brief discussion of U.S. aerospace industry. Section IV discusses the data and empirical methodology employed for this study. Section V reports the empirical results, with conclusions in Section VI.

LITERATURE REVIEW

Sharpe (1963) developed a simplified single-index model to predict security returns. The major characteristic, and the primary shortcoming, of the single index model is that the only factor influencing a security's return is its sensitivity to changes in the market portfolio return (Martin and Klemkosky (1976)).

King (1966) published the first important study proving that stock prices for firms in the same industry exhibit a common movement that goes beyond the market effect. Employing monthly closing stock prices for 63 firms in six industries during the June 1927 to December 1960 period, his study documents that while 50% of stock price movements could be explained by movements in the market index, 20% of the residual variance was accounted for by industry affiliation.

Meyers (1973) and Livingston (1977) in similar studies confirmed King's findings. The Meyers study involved 60 of the same companies used by King and 60 additional companies, using data through December 1967. Meyers concluded that although there were strong industry effects, King may have overstated the percent of residual variance explained by industry association. Livingston used 50 companies in 10 industry groups and studied monthly returns from January 1966 through June 1970. He also found strong comovement among stocks in the same industry, and concluded that 18% of residual variance was accounted for by industry effects. The recognition that factors other than movement in the market index affect security returns led to the development of multi-index models.

Several subsequent studies attempted to determine factors other than the market index which affect security prices. Sharpe (1982) studied monthly returns for stocks of 2,197 firms from 1931 through 1979. His findings showed that the R^2 for a regression model was significantly improved using dividend yield, company size, and bond beta in addition to a market index. Pari and Chen (1984) conducted a test of an Arbitrage Pricing Theory (APT) model for 2,090 firms for the period 1975 to 1980. Using this model, they found that factors such as the general market index, price volatility of energy, and interest rate risk, influence stock price. Chen, Roll, and Ross (1986) tested an APT model for significance of several factors in explaining security returns. Using monthly data for the period 1953-1983, their results indicate that the following factors are significant in explaining the variability of a security return: spread between long and short interest rates, expected and unexpected inflation, industrial production, and the spread between returns on high- and low-grade bonds.

Chen (1991) provides improved framework for analyzing stock returns and macroeconomic factors. He shows that using the test period 1954-1986, state variables, such as the lagged production growth rate, the default risk premium, the term premium, the short-term interest rates, and the market dividend-price ratio, are important indicators of current economic growth, which is in turn negatively correlated with the market excess return. Chan (1991) examines the cross-sectional differences in Japanese stock returns and finds a significant relationship between expected returns in the Japanese stock market and four variables including earnings yield, size, book to market ratio, and cash flow yield, of which the last two variables have the most significant positive effect on expected stock returns.

In sum, early studies of industry effects on stock returns show that up to 20% of a stock's residual variance, or 10% of total variance, is due to industry association. These early studies mainly documented that stocks in the same industry do tend to move together. Beginning in the early 1980's, researchers began applying multi-index

CAPMs to identify which factors influenced stock returns. These studies tend to cover stocks in various industries, mainly focusing on utility industry, and show that various factors have significant influence on stock returns. In particular, the CAPM approach has been widely used in the utility industry for determining its cost of capital and the utility's rate structure.

INDUSTRY BACKGROUND

The military aerospace industry is one of the most interesting and challenging sectors of the American economy for financial managers to operate in. As noted by Canning (1992), the military aerospace industry has several unique characteristics, which make the aerospace industry distinguished from other industries in the American economy.

1. Historically, the aerospace industry has been the leading exporter among all sectors of the American economy. In 1991, commercial and military aerospace exports totaled $43.8 billion, which resulted in a positive trade balance of $29.8 billion.
2. The health of the military sector of the industry is influenced by government spending for defense.
3. The aerospace industry is concentrated; there are only two American producers of commercial airliners and five major producers of military aircraft.
4. The industry is involved in both heavy manufacturing and high technology research and development. In 1990, this industry spent 24.2% of total U.S. industrial R&D expenditures, with the government funding 72% of the aerospace industry total.
5. The industry is highly capital intensive; the cost to bring a new military aircraft into production can run to several billion dollars.
6. The primary customer of military aerospace companies is the U.S. government, which has its influence over the industry through a maze of procurement regulations, cost accounting standards, and design specifications.

As noted by Butler, Podrasky, and Allen (1977), the aerospace industry is characterized by its reliance on Department of Defense (DOD) expenditures. In 1991, military aircraft sales were $39.2 billion, or 51.9% of the total aircraft sales of $75.6 billion. This percentage has declined somewhat since 1982 (see *Predicasts Basebook*). DOD expenditures are expected to decline further in the future due to the fall of communism in Eastern Europe and the Soviet Union. Government expenditures for defense in fiscal year 1993 are down by 7% in real terms compared to fiscal year 1992. By fiscal year 1997, defense expenditures are expected to be 36.8% lower in real terms than the peak in fiscal year 1985 (Canning (1992)). The pace of technological change is very rapid, and costs are often uncertain, which makes government funding of research and development very important. Despite a declining military market, aerospace contractors have remained profitable in recent years due to cost reduction efforts, mainly in workforce and facility reductions as mentioned above. Future profit opportunities will exist in equipment upgrades and research and development activities.

The industry has also seen much consolidation since World War II. Two examples of this consolidation are Consolidated Vultee being absorbed by General Dynamics in 1954 and Douglas Aircraft merging with McDonnell in 1967. Boeing, McDonnell Douglas, Lockheed, General Dynamics, Grumman, Northrop, and Rockwell are the only major firms remaining in the aerospace industry.

RESEARCH METHODOLOGY AND DATA

The Empirical Model

The model to be tested consists of six independent variables for the ten year period from January 1982 through December 1991. These independent variables, potentially related to aerospace stock returns, are described in some detail below. Also given are the expected directions of influence in a multivariate regression context. These independent variables are selected as descriptive of the market and economy conditions and of the industry characteristics. The multi-index model takes the form:

Equation 1

$$k_{it} = b_0 + b_1 S\&P_t + b_2 CPI_t + b_3 TB_t + b_4 IPI_t + b_5 SHIPLN_t + b_6 DODLN_t + e_t$$

where the dependent variable, k_{it}, is the monthly stock return of an aerospace firm i in month t, and b_i values measure the sensitivity of aerospace stock returns to each independent variable.

Four macroeconomic variables are employed in Equation (1) as representing the market conditions: *S&P*, *CPI*, *TB*, and *IPI*. First, the *S&P* variable represents the monthly relative change in the S&P 500 index to be used as a measure of market return. The estimated regression coefficient, b_1, will measure the return volatility of aerospace stocks associated with the stock market movement. The dependent variable (k) is expected to have a positive relationship with the market index.

Second, the *CPI* variable represents a measure of inflation. This variable is measured as the monthly relative changes in the Consumer Price Index (*CPI*) as published by the U.S. Department of Labor. *CPI* calculates price changes on consumer transactions in the retail market. Large changes in *CPI* would indicate a high rate of inflation, which would cause adverse impacts on a firm’s earnings. Thus, the *CPI* variable is expected to have a negative relationship with a firm’s stock returns.

Third, the *TB* variable measures the relative changes in risk-free rates of return as depicted by the three-month Treasury bill yields. The change in return on the risk-free investment would have a positive relationship with a firm’s stock returns since investors will demand higher risk-adjusted returns on risky investments as the return on the risk-free investment increases.

Finally, the *IPI* variable is the monthly relative change in the Industrial Production Index. This index is a measure of overall economic activity and is chosen over GNP since figures on GNP are only available on a quarterly basis. The *IPI* variable is expected to have a positive relationship with a firm’s stock returns.

Two variables unique to aerospace industry are used as representing the industry conditions: *SHIPLN* and *DODLN*. First, the *SHIPLN* variable is measured as the natural logarithm of monthly aircraft shipments. A firm’s stock returns are expected to be positively related with the *SHIPLN* variable since higher levels of aircraft shipments should lead to higher profitability of an aerospace company.

Second, the *DODLN* variable is measured as the natural logarithm of purchases of military aircraft by *DOD*. As stated previously, military aerospace firms rely heavily on government sales. Increased government sales would be expected to lead to higher profitability. Hence, the aerospace stock returns are expected to be positively related to the *DOD* variable.

The first attempt to create a useful multi-index model uses a basic multiple regression technique to determine which of the independent variables have a significant relationship with the dependent variable. After the multiple regression equation is created, stepwise regression techniques using both the MaxR and the Backward procedures. Finally, the unanticipated changes in the independent variables other than *SP* are estimated and used to create a multi-index model. In an efficient market, a security price is determined only by the unanticipated levels of economic variables. Therefore, inclusion of the unanticipated changes may be more useful in estimating stock returns.

Each regression procedure is run six times, using each of the five firms’ stock returns, in addition to the portfolio return, as the dependent variable. A determination is made as to whether a multi-index model better than a single index model using the market index as a sole independent variable, can be developed, and whether the independent variables have the same degrees of influence on the stock returns of firms examined.

Data

The five firms selected for this study are General Dynamics, McDonnell Douglas, Lockheed, Northrop, and Grumman. These five companies are all in the top ten largest military contractors, with 1991 sales to the government in excess of $24 billion. Boeing is not included in the study because the majority of its sales are from commercial aircraft, while Rockwell is not included because it has many diversified non-aerospace interests, such as automotive and electronics. Table 1 presents summary statistics for these five companies for the year of 1991.

The sales of aerospace companies range from $ 4 billion for Grumman to more than $18 billion for McDonnell Douglas, with an average of $9.4 billion. The average P/E for the five companies is 6.53, and, as one would expect, the aerospace firms are highly debt-financed, as evidenced by an average debt ratio of 65%.

TABLE 1
Summary Statistics Of Five Sample Companies For The Year Of 1991

Company	Number Of Employees	Sales	Net Income	EPS	P/E Ratio	Return On Equity	Return On Assets	Current Ratio	Debt Ratio
General Dynamics	80,600	$ 8,751	$505	$12.06	4.45 x	25.51%	8.14%	1.39 x	68.10%
McDonnell Douglas	109,100	18,448	423	11.03	6.64 x	10.85%	2.85%	1.70 x	73.74%
Lockheed	72,300	9,809	308	4.86	9.26 x	12.31%	4.65%	1.23 x	62.17%
Northrop	36,200	5,694	535	4.28	6.13 x	45.07%	17.10%	1.51 x	62.18%
Grumman	23,600	4,038	99	2.84	6.16 x	10.06%	4.19%	3.88 x	59.71%
Average	64,360	9,348	374	7.01	6.53 x	20.76	7.39	1.94	65.18

Notes: Sales and net income are stated in millions of dollars. Sources are 1991 annual reports and Standard and Poor's *Corporate Record*.

The data for each firm's stock prices and the S&P 500 index values were collected from the Standard and Poor's *Daily Stock Price Record* for the ten year period from January 1982 through December 1991. The portfolio return is calculated as an equally weighted average of the returns of the five companies. These stock prices and index values were converted to returns by including dividends and adjusting for stock dividends and stock splits. The data for the Consumer Price Index and Industrial Production Index were taken from monthly data published by the U.S. Department of Labor and by *Survey of Current Business*, respectively. The yields on the three month Treasury bills were obtained from the various issues of *Federal Reserve Bulletin*. Data for the monthly aircraft shipments and *DOD* expenditures were obtained from various issues of *Survey of Current Business*. Data for monthly aircraft shipments are on a monthly basis through August 1990. After August 1990, the data are on a yearly basis only; hence, monthly changes in aircraft shipments after August 1990 were necessary to be converted from the yearly data. *DOD* expenditures are on a quarterly basis through December 1983, and then on a yearly basis thereafter; accordingly, monthly relative changes were calculated from these figures.

EMPIRICAL RESULTS

Multivariate Regression

Prior to constructing the cross-sectional regression models, the pairwise correlation coefficients for the independent variables were examined. The correlation coefficient analysis shows the strength of the linear relationship between two variables. It can be used to detect the presence of multicollinearity, which may affect the true relationship of a independent variable with the dependent variable. The results from this analysis, which for brevity's sake are not reported here, show that correlation among the independent variables is not a problem, with *S&P - CPI*, *TB - IPI*, and *TB - DOD* being the only pairs having statistically significant linear relationships at the 0.05 level.

Table 2 presents the results from time-series, cross-sectional regression analysis. Overall, the inclusion of all six independent variables does not produce significant models. The adjusted R^2 values range from a high of 0.391 for the portfolio of five stocks to a low of 0.149 for Grumman. The F-values for all five companies and the portfolio show that the model is significant at the 0.05 level. The Durbin-Watson statistics range from 1.912 for McDonnell

Douglas to 2.463 for Northrop. These values indicate that the models are largely free from serial correlation, except for the Northrop model that exhibits significant negative, serial correlation.

TABLE 2
Multivariate Regression Analysis

Model: $K_{it} = b_0 + b_1 S\&P_t + b_2 CPI_t + b_3 TB_t + b_4 IPI_t + b_5 SHIPLN_t + b_6 DODLN_t + e_t$

Company	b_0	b_1	b_2	b_3	b_4	b_5	b_6	Adjusted R^2	F-value	D-W Statistic
General Dynamics	0.780*** (2.450)	0.968*** (6.474)	-3.299** (-1.995)	-0.051 (-0.343)	0.534 (0.565)	0.013 (0.735)	0.101** (2.353)	0.355	10.374	2.187
McDonnell Douglas	0.607* (1.816)	0.636*** (4.049)	-2.183 (-1.256)	0.014 (0.092)	1.497 (1.508)	0.019 (1.050)	0.086* (1.904)	0.184	4.258	1.981
Lockheed	0.819*** (2.633)	0.969*** (6.629)	-0.017 (-0.010)	0.123 (0.849)	-0.529 (-0.573)	0.004 (0.209)	0.098** (2.346)	0.331	9.315	2.179
Northrop	0.403 (0.956)	0.922*** (4.660)	0.547 (0.250)	-0.262 (-1.336)	-0.083 (-0.066)	0.008 (0.350)	0.054 (0.949)	0.191	4.455	2.493
Grumman	0.635* (1.649)	0.787*** (4.354)	1.518 (0.760)	-0.119 (-0.664)	1.518 (1.329)	0.018 (0.862)	0.090* (1.729)	0.163	3.657	2.285
Portfolio	0.649*** (2.926)	0.857*** (8.221)	-0.687 (-0.596)	-0.059 (-0.570)	0.587 (0.893)	0.012 (1.018)	0.086*** (2.869)	0.424	13.881	2.172

Notes: The results are based on 120 monthly observations for the period from January 1982 through December 1991; S&P = the monthly returns in the S&P 500 index; CPI = monthly changes in Consumer Price Index; TB = monthly changes in 3-month Treasury Bill; IPI = monthly changes in Industrial Production Index; SHIPLN and DODLN are natural logarithms of aircraft shipments and Department of Defense expenditures, respectively; D-W statistic denotes Durbin-Watson statistic; t-statistics are in parentheses.

***significantly different from zero at the 0.01 level.
**significantly different from zero at the 0.05 level.
*significantly different from zero at the 0.10 level.

When the independent variables are examined on an individual basis, the only variable significant at the 0.01 level in all six models is S&P, the return on the S&P 500 index. In fact, the only other independent variables significant at the 0.10 level in any models are *CPI* in the General Dynamics model and *DODLN* in all models except for Northrop. S&P is, as hypothesized, significantly positively related with the returns of the individual stock and the portfolio. These results confirm the logic behind the single index model as developed by Sharpe (1963). The average regression coefficient of S&P for the portfolio, which represents the market beta in the single index model, is 0.814, ranking from 0.626 for McDonnell Douglas to 0.916 for General Dynamics. Hence, the stock returns of aerospace companies are slightly less sensitive than the average stock to changes in the market return.

CPI is significant only in the General Dynamics model. *CPI* has a negative relationship with the monthly stock returns of General Dynamics, McDonnell Douglas, Lockheed, and the portfolio, as hypothesized, but is insignificantly positively related with Northrop and Grumman returns. Substituting the Producer Price Index as a measure of inflation does not alter the results; *PPI* is not statistically significant in any of the six models, although slight R^2 improvements are found in the Lockheed, Northrop, and Grumman models.

The lack of a significant relationship between the aerospace stock returns and the inflation changes is surprising given the long horizon and the heavy expenditures required to develop new aircraft. A mitigating factor is that many government contracts are on a cost-plus basis, thereby assuring that all of the contractor's costs are covered. This type of contract is still prevalent, although the number has declined in recent years. Another plausible reason for the lack of the significant relationship is that aerospace companies utilize mainly real assets, which are not supposedly affected by inflation to the extent that financial assets are; hence, a significant link between CPI and stock returns of manufacturing firms would not be present (see Bae (1990)). It is also possible that in an efficient market, stock returns would only be affected by unanticipated changes in inflation. If changes in the rate of inflation are expected, they should have already been incorporated into the stock returns.

As hypothesized, *TB*, the relative changes in the returns of the three month Treasury bill, is positively related with stock returns of General Dynamics, McDonnell Douglas, Lockheed, and the portfolio, and the relationship is significant at the 0.10 level only in the Lockheed model. The relation of *TB* with Northrop and Grumman stock returns, however, is negative, though insignificant. The lack of a significant relationship between the stock returns and the level of interest rates can again be explained by the types of assets employed by aerospace companies. As stated above, aerospace companies utilize mainly real assets. Also, if investors correctly anticipate changes in the risk-free rate of return, this information would already be included in the stock returns.

The estimated coefficients of *IPI* have mixed signs. While the stock returns of General Dynamics, McDonnell Douglas, Grumman, and the portfolio are positively related to *IPI*, as expected, those of Lockheed and Northrop are negatively related to *IPI*. The lack of a significant positive relationship between aerospace stock returns and the health of the economy (measured by the changes in *IPI*) would be explained by the fact that revenues for an aerospace firm are based on defense needs. Revenues and profits for a military aerospace contractor are likely to increase during periods of heavy defense expenditures, as was the case during Reagan's presidency. The findings on IPI suggest that aerospace companies are not dependent on the economy as other manufacturing firms are.

The estimated coefficients of two aerospace industry specific variables, *SHIPLN* and *DODLN*, are in general consistent with the expected relationships of these variables. Both *SHIPLN* and *DODLN* are positively related to aerospace stock returns, suggesting that the higher levels of military aircraft shipments and *DOD* expenditures in a given month positively affect aerospace stock returns. However, none of the estimated coefficients for *SHIPLN* is statistically significant at the 0.10 level. On the contrary, the effect of *DODLN* on aerospace stock returns is more pronounced; *DODLN* is significant at the 0.05 level in the General Dynamics and Lockheed models and significant at the 0.10 level in the McDonnell Douglas and Grumman models. In the portfolio model, *DODLN* is shown to be significant at the 0.01 level, indicating that a dollar increase in *DOD* expenditures will generate approximately an increase of $0.086 in aerospace stock returns. The regression model was also run using the monthly relative changes of aircraft shipments and *DOD* expenditures in replacement of *SHIPLN* and *DODLN*, respectively. The results from this analysis were almost identical to those reported in Table 2, but with lower adjusted R^2s.

The lack of a significant relationship between *SHIPLN* and aerospace stock returns could be explained by the factor that in many cases, military aircraft are built using cost plus contracts; costs plus profits are billed as they occur, and not when the aircraft are actually delivered. It is also plausible that aerospace contracts specify known deliveries far in advance of shipment. Therefore, the actual shipment does not contain any unexpected information that would affect stock returns. It is also worth noting that *DOD* expenditures for military aircraft were reported on a quarterly basis through December 1983, after which the data were reported on a yearly basis. Hence, the manner in which the statistics of *DOD* expenditures are reported may have obscured the true variability of *DOD* expenditures.

Stepwise Regression

Two stepwise regression procedures are used in an attempt to build more useful models than those incorporating all six independent variables. The first stepwise procedure is the MaxR procedure. MaxR begins with an independent variable that results in the highest R^2, and successively adds variables at each iteration in order to maximize R^2. The second stepwise procedure is the Backward method. The Backward procedure begins with all independent variables in the model, and then in succession eliminates a variable that does not meet a specified level of significance. For this study, a significance level of 0.05 is specified. In addition to R^2, mean squared error (*MSE*) is used as a criteria in selecting the best model for each company involved (Schmidt and Wand (1983)); the best-fit model is deemed to be the one that results in the lowest *MSE*.

Table 3 presents the results from the stepwise procedures. The number of variables included in each aerospace stock ranges from two to four, while three variables of *S&P*, *CPI*, and *DODLN* are included in the portfolio model. *S&P* is the only independent variable that appears in all six models and is the first variable added in each of the models. *DODLN* is the second most prevalent variable, appearing in four company models, in addition to the portfolio model; *SHIPLN* appears only in the Northrop model. These results indicate that the monthly stock returns of the five aerospace companies are affected to different degrees by changes in the industry and macroeconomic variables. The results also indicate that variables such as *CPI*, *TB*, *IPI*, and *SHIPLN* do not add much explanatory power when the returns of aerospace stocks are estimated.

TABLE 3
Stepwise Regression Results

Company	Model With Lowest MSE	Adjusted R^2	MSE
General Dynamics	0.006 + 0.911 *S&P* + 0.581 *DODLN* - 3.885 *CPI*	0.330	0.0055
McDonnell Douglas	0.010 + 0.616 *S&P* + 0.527 *DODLN* - 2.459 *CPI*	0.158	0.0061
Lockheed	-0.002 + 0.918 *S&P* + 0.248 *TB* - 0.986 IPI + 0.994 *DODLN*	0.317	0.0052
Northrop	0.002 + 0.899 *S&P* - 2.584 *TB* + 0.024 *SHIPLN*	0.193	0.0093
Grumman	-0.001 + 0.682 *S&P* + 0.763 *DODLN*	0.141	0.0079
Portfolio	0.003 + 0.805 *S&P* + 0.483 *DOD* - 1.206 *CPI*	0.389	0.0027

Notes: The results are based on 120 monthly observations for the period from January 1982 through December 1991; *S&P* = the monthly returns in the S&P 500 index; *CPI* = monthly changes in Consumer Price Index; *TB* = monthly changes in 3-month Treasury Bill; *IPI* = monthly changes in Industrial Production Index; *SHIPLN* and *DODLN* are natural logarithms of aircraft shipments and Department of Defense expenditures, respectively; *MSE* denotes mean square errors.

In sum, the regression analysis shows that *S&P* exhibits, as expected, a strong positive relationship for all aerospace companies. *SHIPLN* is also positive for all companies, but the relationship is not significant. *DODLN* has a significant positive relationship with stock returns of most aerospace companies. The other three variables, *CPI*, *TB* and *IPI*, are shown to be consistently positive or negative among the models. The overall results indicate that the estimated multi-index models are all significant at the 0.01 level and add significant improvement in explaining the data over a single-index CAPM.

The Effect Of Unanticipated Changes Of Independent Variables

One of the reasons cited previously for the lack of significant relationships between some of the independent variables and the aerospace stock returns is that a stock's return should only be affected by unanticipated changes in the independent variables. In an efficient market, information regarding factors that affect stock returns is assessed and incorporated into stock prices. In this process, only when surprises occur in these variables, there will be an impact on stock prices. Hence, a more useful CAPM could be developed by segregating the unanticipated changes from the observed, realized changes in each variable and incorporating them into the model.

In order to estimate the unanticipated changes of each relevant variable, a time-series regression model was first run for monthly percentage changes of *CPI*, *TB*, *IPI*, *SHIP*, and *DOD*, with the lag value specified at six. The residual value of each regression model was then used to represent the unanticipated changes of each variable. A regression model for each company was chosen by examining the partial correlations and autocorrelations of residual terms of each time-series model to be consistent with white noise process (Flannery and James (1984)). Table 4 presents the results from the regression analysis using the unanticipated changes in *CPI*, *TB*, *IPI*, *SHIP*, and *DOD*, in addition to S&P, as the independent variables.

The results reported in Table 4 are not significantly different from those presented in Table 2. The adjusted R^2 values range from 0.164 for the McDonnell Douglas model to 0.392 for the portfolio model, which are approximately the same range of values as presented in Table 2. For the industry, as measured by the portfolio, the market beta increases slightly from 0.814 to 0.863. The Durbin-Watson statistics suggest that the residuals are free from first-order serial correlation.

TABLE 4
Regression Analysis Of Aerospace Stock Returns Using Unanticipated Changes Of Independent Variables

Model: $K_{it} = b_0 + b_1S\&P_t + b_2UCCPI_t + b_3UCTB_t + b_4UCIPI_t + b_5UCSHIP_t + b_6UCDOD_t + e_t$

Company	b_0	b_1	b_2	b_3	b_4	b_5	b_6	Adjusted R^2	F-value	D-W Statistic
General Dynamics	0.001 (0.135)	0.989*** (6.551)	-2.645 (-1.387)	0.067 (0.375)	0.521 (0.487)	0.005 (0.228)	2.398*** (3.731)	0.327	9.144	1.995
McDonnell Douglas	0.007 (1.011)	0.612*** (3.894)	-3.256 (-1.640)	0.023 (0.123)	1.384 (1.244)	-0.004 (-0.187)	1.397** (2.472)	0.164	3.700	2.001
Lockheed	0.001 (0.211)	0.962*** (6.508)	-0.076 (-0.041)	0.239 (1.363)	0.164 (0.157)	0.001 (0.057)	1.857*** (3.084)	0.300	8.052	1.994
Northrop	0.001 (0.146)	0.968*** (4.988)	1.932 (0.788)	-0.367 (-1.594)	0.171 (0.124)	0.028 (1.049)	0.507 (1.054)	0.202	4.769	2.031
Grumman	0.003 (0.372)	0.785*** (4.418)	1.834 (0.817)	0.048 (0.229)	1.879 (1.493)	-0.034 (-1.390)	1.962*** (3.012)	0.171	3.875	2.017
Portfolio	0.002 (0.577)	0.863*** (8.164)	-0.442 (-0.331)	0.002 (0.016)	0.824 (1.100)	0.003 (0.218)	1.734*** (3.298)	0.392	12.161	1.994

Notes: The results are based on 120 monthly observations for the period from January 1982 through December 1991; S&P = the monthly returns in the S&P 500 index; CPI = monthly changes in Consumer Price Index; TB = monthly changes in 3-month Treasury Bill; IPI = monthly changes in Industrial Production Index; SHIPLN and DODLN are natural logarithms of aircraft shipments and Department of Defense expenditures, respectively; D-W statistic denotes Durbin-Watson statistic; t-statistics are in parentheses.

***significantly different from zero at the 0.01 level.
**significantly different from zero at the 0.05 level.
*significantly different from zero at the 0.10 level.

The estimated coefficients of S&P are all positive and significant at the 0.01 level in all six models. The unanticipated changes in *DOD* expenditures (*UCDOD*) have a positive relationship with aerospace stock returns, and the relationships are significant at the 0.10 level in five models. A notable difference is the estimated coefficients for *UCSHIP*, the unanticipated changes in aircraft shipments in that *UCSHIP* is negatively related to returns of three aerospace stocks, though none of them is statistically significant. These results reaffirm the previous findings in Table 2 that aircraft shipments are known well in advance and are already incorporated into aerospace stock returns. The other three variables (*UCCPI*, *UCTB*, and *UCIPI*) have, as in Table 2, mixed signs and are insignificantly related to aerospace stock returns.

SUMMARY AND CONCLUSIONS

This paper attempts to develop a multi-index CAPM for five U.S. military aerospace companies. The monthly returns of these companies for the period from January 1982 through December 1991 were regressed against six market and industry variables including S&P 500 index, Consumer Price Index, three-month Treasury bill yields, Industrial Production Index, aircraft shipments, and Department of Defense expenditures.

This paper finds that the S&P market index returns and Department of Defense expenditures are both significantly positively related to aerospace stock returns, but the other variables have insignificant influence on aerospace stock returns. This evidence is further confirmed by the results from additional regression analysis. Of particular interest is the finding that the monthly volume of aircraft shipments is, as expected, positively related to stock returns, but the relationship is not statistically significant in any aerospace company model. This lack of a significant relationship appears to be, at least in part, attributable to the fact that military aircraft are built using cost plus contracts; thus, costs plus profits are billed as they occur, and not when the aircraft are actually delivered. It is also plausible that aerospace contracts specify known deliveries far in advance of shipment. Therefore, the actual shipment does not contain any unexpected information that might affect stock returns.

In an efficient market, only the unanticipated changes in macroeconomic variables would affect securities prices. To address this issue, unanticipated changes of each variable were estimated using a time-series regression model, and the residual values of each model were used as unanticipated changes in the corresponding independent variable. The segregation of the unanticipated changes in the independent variables yields qualitatively the same results as those documented earlier, providing confirmatory evidence supporting the significance of the market returns and Department of Defense expenditures in explaining aerospace stock returns.

REFERENCES

[1] Bae, Sung C., "Interest Rate Changes and Common Stock Returns of Financial Institutions: Revisited," ***Journal of Financial Research*** 8, No. 1, Spring 1990, pp. 71-79.

[2] Bower, Richard S. and Dorothy H. Bower, "The Salomon Brothers Electric Utility Model: Another Challenge to Market Efficiency," ***Financial Analysts Journal*** 13, No. 5, October/November 1984, pp. 57-67.

[3] Butler, Hartman L. Jr., George J. Podrasky, and J. Devon Allen, "The Aerospace Industry Revisited," ***Financial Analysts Journal*** 33, No. 4, August/September 1977, pp. 22-35.

[4] Canning, Thomas, "Aerospace & Air Transport," ***Standard and Poor's Industry Surveys***, June 25 1992, pp. A15-A33.

[5] Chan, Louis K.C., "Fundamentals and Stock Returns in Japan," ***Journal of Finance*** 46, No. 5, December 1991, pp. 1739-1764.

[6] Chen, Nai-Fu, "Financial Investment Opportunities and the Macroeconomy," ***Journal of Finance*** 46, No. 2, June 1991, pp. 529-554.

[7] Chen, Nai-Fu, Richard Roll, and Stephen A. Ross, "Economic Forces and the Stock Market," ***Journal of Business*** 59, No. 3, July 1986, pp. 383-403.

[8] Cohen, Kalman J. and Jerry A. Pogue, "An Empirical Evaluation of Alternative Portfolio Selection Models," ***Journal of Business*** 40, No. 2, April 1967, pp. 166-193.

[9] Flannery, Mark J. and Christopher M. James, "The Effect of Interest Rate Changes on the Common Stock Returns of Financial Institutions," ***Journal of Finance*** 39, 1984, pp. 1141-1153.

[10] King, Benjamin F., "Market and Industry Factors in Stock Price Behavior," ***Journal of Business*** 39, No. 1, January 1966, pp. 139-190.

[11] Livingston, Miles, "Industry Movements of Common Stocks," ***Journal of Finance*** 32, No. 3, June 1977, pp. 861-874.

[12] Martin, John D. and Robert C. Klemkosky, "The Effect of Homogeneous Stock Groupings on Portfolio Risk," ***Journal of Business*** 49, No. 3, July 1976, pp. 339-349.

[13] Melicher, Ronald W., "Financial Factors Which Influence Beta Variations Within a Homogeneous Industry," ***Journal of Financial and Quantitative Analysis*** 9, No. 2, March 1974, pp. 231-241.

[14] Meyers, Stephen L., "A Re-examination of Market and Industry Factors in Stock Price Behavior," ***Journal of Finance*** 28, No. 3, June 1973, pp. 695-705.

[15] Pari, Robert A. and Son-Nan Chen, "An Empirical Test of the Arbitrage Pricing Theory," ***Journal of Financial Research*** 7, No. 2, Summer 1984, pp. 121-130.

[16] Sharpe, William F., "A Simplified Model for Portfolio Analysis," ***Management Science*** 9, No.1, January 1963, pp. 277-293.

[17] Sharpe, William F., "Factors in New York Stock Exchange Security Returns, 1931-1979," ***Journal of Portfolio Management*** 8, No. 4, Summer 1982, pp. 5-19.

[18] Schmidt, Peter and Robert N. Waud, "The Almon Lag Technique and the Monetary versus Fiscal Policy Debate," ***Journal of the American Statistical Association*** 68, 1983, pp. 11-19.