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Systematic Risk and Accounting Determinants: An Empirical Assessment in the Indian Stock Market

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Abstract. *This study explores the contemporaneous association between market determined risk measures and accounting determined risk measures using the large liquid non-financial stocks in the Indian stock market in the recent 2012-2017 period. Two measures of systematic risk and seven accounting determined risk measures are chosen based on prior research. This study uses three regression techniques, namely Ordinary Least Squares (OLS), stepwise regression and robust regression, to identify the influential accounting variables for the systematic risk measured by market beta. The results evidence that there is a high degree of contemporaneous association between market determined and accounting determined risk measures, with nearly 30% of the cross sectional variance in systematic risk explained by accounting determined risk measures. The results suggest that the accounting variables can be used in the predictive models of future risk, leading to superior decision making at the level of individual decision maker.*

Keywords: *Market determined risk measures, accounting determined risk measures, Indian stock market.*

1. Introduction

Investment decision is the most crucial aspect of financial management. Consequently, financial economists strive to improve the modeling of the financial markets to make better investment decisions. A very important parameter of investment decision is risk. Even though the academic interest in risk goes as far back as the 18^{th} century to the time of Daniel Bernoulli, a numerical and analytical model did not evolve till the 1950s,

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when the work of Markowitz, Sharpe and Lintner culminated in the most influential capital asset pricing model (CAPM). CAPM asserts that the risk-averse investors form portfolios, and the only risk that matters is the systematic risk measured by systematic beta. In the CAPM world, beta is the covariance of a stock's return to the market portfolio standardized by the variance of the market portfolio. However, CAPM does not provide any information regarding the underlying factors that affect beta. The understanding of the underlying economic factors that affect beta have been the focus of many researchers since the advent of CAPM. Since the accounting data is generally considered capturing the underlying economic factors, the relationship between beta and the accounting variables is very important and has also been the focus of the researchers since Beaver et al. (1970). Accounting is defined as the systematic process of measuring the economic activity of the business to provide information to those who make economic decisions, and financial accounting provides information to external users like investors to take informed investment decisions. Lipe (1998) demonstrates the importance of accounting information in evaluating firms by showing that investors prefer accounting determined risk measures in their risk analysis. Beaver et al. (1970) also suggest that investors use accounting determined risk measures as surrogates for risk. Beaver et al. (2005, 2010, 2102b) evidenced that 90% of the explanatory power of the market-based financial risk models can be captured by relatively parsimonious accounting based models.

The identification of the relationship between accounting determined risk measures and market determined equity beta is important for the following reasons. The instability of market betas over time means that they are not a good predictor of future risk, and the identification of the relationship between accounting variables and market beta can improve predictive models of future risk. Secondly, our knowledge of risk determination is incomplete without knowing the exogenous variables or non-price data that are impounded in the stock prices and price changes. Thirdly, if accounting determined risk measures can explain market determined risk measures, investors and managers can rely on accounting based risk measures during periods of instability in the market or absence of market risk measures as in the case of private companies, IPOs and divisional capital budgeting. Even when market risk measures are available, accounting determined risk measures can be used to complement and verify them.

A considerable body of literature has investigated the relationship between market determined risk measures and accounting determined risk measures in the developed and emerging markets (Beaver et al., 2005, 2010, 2012b; Brimble & Hodgson, 2007; Rutkowska & Pyke, 2017). However, in the Indian stock market, researchers have focused on the relationship between the accounting variables and the stock return rather than the systematic risk (Mishra et al., 2011). The studies focusing on systematic risk are few and far between in the Indian stock market. The natural question that arises is 'what is the relationship between market determined risk measures and accounting determined risk measures in the Indian stock market'? The research question is whether there is statistically significant association between market determined risk measures and accounting determined risk measures in the Indian stock market.

The objective of this study is to examine the contemporaneous association between market determined risk measures and accounting determined risk measures using the large liquid non-financial stocks in the Indian stock market in the recent 2012-2017 period. The purpose of the study is only to analyze the predictive power of accounting determined risk measures based on the accounting variables derived from the financial statements of a company and not to search for the real determinants of market risk. This study contributes to the existing research by establishing those accounting determined risk measures that can explain the market risk measure using the recent data in the Indian stock market. The results are compared to important previous research in the developed and other emerging markets.

2. Literature Review

A number of studies have attempted to identify the accounting determined risk measures that can explain the systematic or market risk. The pioneering study in this area by Beaver et al. (1970) examined the seven accounting variables, namely dividend payout, leverage, liquidity, size, growth, earning variability and accounting beta, and found that their best model incorporated only three of the seven examined variables, namely earnings variability, dividend payout ratio and asset growth, which explained nearly 45% of the cross sectional variation in market beta. Subsequently, there are many studies on association between accounting risk variables and systematic risk, namely Pettit and Westerfield (1972), Beaver and Manegold (1975), and Mandelkar and Rhee (1984) that found significant positive relationship between systematic risk and accounting determined risk measures. Some of the studies which did not find significant relationships are Breen and Lerner (1973), Goendes (1973), and St. Pierre and Bahiri (2006). Some researchers like Rosenberg and Mckibben (1973), and Rosenberg and Marathe (1975) have used multiple variables; other researchers have used specific variables, e.g., Lev (1974) used operating leverage, Bildersee (1975) used turnover and coverage ratios. Borde (1998) and Gu (2002) studied the association between systematic risk and accounting variables in the restaurant industry in the USA and found significant association between systematic risk and accounting risk variables.

In the recent period, Gilner and Reverte (2006) analyzed the relevance of the accounting fundamentals on the equity risk in the Madrid stock exchange and found association between accounting variables and systematic risk. Brimble and Hodgson (2007) used five measures of systematic risk and twelve measures of accounting risk in the Australian stock market and evidenced significant association with significant variables such as earnings variability, size and operating leverage. Lee and Jang (2007) examined the association between financial variables and systematic risk in the US airline industry. While profitability and earnings growth were negatively related to beta, leverage and size were positively related to beta. Chiou and Su (2007) used an analytical approach to examine the relation between systematic risk and accounting variables and suggested that the determinants of systematic risk include sales growth, dividend, operating and financial leverage. Nekrasov and Shroff (2009), using ROE based accounting beta, highlighted the usefulness of accounting numbers in estimating systematic risk.

Voulgaris and Rizonaki (2011) analyzed the effect of leverage, liquidity, dividend, profitability, size and growth on the systematic risk of Greek listed firms and evidenced that the leverage, liquidity, dividend and growth can explain the variations in beta. Papadmov and Tzivinikos (2013) examined the Greek stock market and found evidence for the association between market based risk measures and accounting variables. Schlueter and Sievers (2014) examined the association between systematic risk, accounting variables and macroeconomic variables using data from 1990-1999 in US and evidenced that growth risk explains the cross sectional variations in beta. Sabogal and Sadeghi (2015) attempted to test the accounting betas as a proxy for the systematic beta in the US stock market and found that accounting betas overestimate market betas by 20% to 50%. Rutkowska and Pyke (2017) analyzed the Warsaw stock market during a six year period and found evidence for positive association between accounting variables and systematic risk. The prior literature shows that this important issue has been analyzed using a plethora of market beta estimates and accounting variables and is very much relevant in both the emerging and developed markets. This study intends to add to this body of knowledge by examining the association between market determined risk measures and accounting determined risk measures in the Indian stock market.

In India, Vipul (1998) examined the impact of accounting variables like the size of a company, industry group and liquidity on beta using data in the period 1988-1996 in India. He evidenced that the size had an impact on beta value, whereas industry group and liquidity had no impact on the systematic risk. In India, researchers have generally focused on the effect of accounting variables on stock return rather than systematic risk (Mishra, 2011). The association between accounting determined risk measures and market determined risk measures has not been studied in the recent past in the Indian stock market. This study intends to bridge this gap by analyzing the impact of accounting determined risk measures on the systematic risk, using the latest period data from 2012 to 2017 in India and employing the methodology of Beaver et al. (1970).

This study is very important in India for the following reasons. Firstly, the Indian equity market will be 5th largest in the world by the end of 2018 in terms of both traded value and market capitalization, and India is one of the fastest growing economies in the world. The liberalization and globalization in the 1990s in India have exposed Indian firms to various risks in the global economy, and the success of the firms depends on effective risk management. Risk and return go together, and return maximization is a function of risk. Chiou and Su (2007) contend that understanding of the systematic risk through its determinants is important for successful risk management and investment decision. Investigating the determinants of the market risk of securities will lead to superior decision making at the level of an individual decision maker. Investors also benefit from the knowledge of such determinants as it will enable them to make improved forecasts of the risk associated with investments. The role of accounting information in a country can also be evaluated by examining which accounting determined risk measures can facilitate the forecast of market determined risk measures. Ball (2001) and Kang et al. (2015) contended that the role of financial reporting in the capital markets depends on the strength of the economic and legal infrastructure in the country. Xing and Yan (2019) proved that the accounting information quality is negatively associated with systematic risk. Over the last decade Indian Accounting Standards (Ind-As) have been aligned with International Financial Reporting Standards (IFRS) in pursuit of improving information quality; and with the economic and legal infrastructure being strengthened in India continuously since 1993, India offers a good case to conduct this research at this juncture.

3. Data and Variables Used

3.1 Data

The study is based on a sample drawn from the population of Indian firms which are listed in the Indian stock exchanges, namely National Stock Exchange (NSE) and Bombay Stock Exchange (BSE) during the period from 2012 to 2017. The period of study is chosen as five years starting from 01/04/2012 to 31/03/2017 as Damodaran (2008) argues that, in emerging markets, both the market and the companies change significantly over short periods of time. The NSE is the biggest and the BSE is the oldest exchange in India, and they are the top two exchanges in terms of market capitalization and turnover in India. In order to select the stocks, the following criteria were used: 1. The stocks constituting the BSE 100 and/or NSE 100 indices are only considered. 2. The financial stocks were excluded. 3. The stocks for which either the market data or the accounting data are not available for the 2012-2017 period were excluded. The NSE 100 index had 78 non-financial stocks and BSE 100 index had 80 non-financial stocks as of December 2017. Of the 80 BSE 100 stocks, 66 stocks belonged to the NSE 100 index as well, leading to a total of 92 stocks. Four stocks, namely BhartiInfratel, Avenue Supermart, Crompton Greaves and Interglobe Aviation did not have the complete market date for the 2012–2017 period and were excluded, leading to a total of 88 stocks. Appendix 1 lists the 88 included stocks. The sample may appear modest, but this is the sample consisting of all the large, liquid and blue-chip stocks in the Indian stock market representing approximately 75% of the Free Float Market Capitalization and approximately 60% of the traded value of all stocks on both the NSE and BSE as of March 2017. It was also ensured that other corporate actions like stock split and stock dividend did not vitiate the sample. The market and accounting information is obtained from the Moneycontrol website, Yahoo finance website and the BSE, NSE official websites.

3.2 Market determined risk measures

The market betas are used as surrogates for market risk in this study. The first market beta measure is Ordinary least squares (OLS) beta, β_m is normally calculated using the static market model regression

$$R_{it} = \alpha_i + \beta_i R_{mt} + e \qquad (1)$$

where R_{it} and R_{mt} are the stock return and market return respectively. α_i is the intercept term for stock 'i', and 'e' represents the residual term. The return includes dividend and is calculated as the log return[1]. The five year study period is also due to the fact that according to Gonedes (1973), Kim (1993) and Groenewold and Fraser (2000), betas tend to be stable over five-year estimation periods. The five years[2] represent a tradeoff between adequate sample size for efficient estimation, and the period is short enough so that the underlying variables can be assumed to be stable. Damodaran (2008) argues that, in emerging markets, both the market and the companies change significantly over short periods of time. Using a longer period of data may yield a beta for a market that bears little resemblance to the company as it exists today.

The second market beta is the Bayesian adjustment beta, or the central tendency beta. Bayesian decision theory utilizes the information available prior to sampling together with sampling information to develop optimal estimates. Vascilek (1973) adjustment modified by Beaver and Manegold (1975) is used in this study.

$$\beta_{adj} = k\,\beta_{prior} + (1 - k)\,\beta_{sample} \qquad (2)$$

where $$k = \frac{\sigma^2\ sample}{\sigma^2\ sample + \sigma^2\ prior} \qquad (3)$$

β_{adj} = a bayesian adjusted beta
β_{prior} = the mean of all the sample betas
β_{sample} = historical OLS beta calculated from the sample
σ^2_{sample} = variance of the sample based on the estimate of the stock beta as assessed by OLS regression
σ^2_{prior} = variance of the distribution of all sample betas.

3.3 Accounting determined risk measures

The dependent variable for this study is the market, or the systematic beta, estimated for each company using the market model and the Bayesian adjusted, or the central tendency beta. The independent variables are accounting determined risk measures.

1 Capital gain return (not adjusted for dividends) was also considered, and similar results were evidenced.
2 Data availability is another reason for the period of study as the size is greatly reduced once the period of study is increased. Neither market data or accounting data are available.

Unlike market determined risk measures, the problem of choosing accounting determined risk measures is more acute. In this study, the choice of accounting determined risk measures is based on the methodology of Beaver et al. (1970) and other previous empirical research. The accounting beta is not considered due to data availability, and to restrict the research to the chosen 5 years. ROE was considered in place of accounting beta. Accounting determined risk measures are classified into operating risk, financial risk and growth risk variables as in Brimble and Hodgson (2007). The operating risk variables are 1) Variability of earnings, 2) Return on Equity (ROE), 3) Dividend payout ratio and 4) Liquidity. The financial risk variable is 5) the debt equity ratio, and the growth risk variables are 6) growth and 7) size.

1. Earning Variability (EV): The measurement is the standard deviation of the ratio of earnings available to equity holders divided by the market value of equity as in Beaver et al. (1970). This measure is similar to many other studies like Bildersee (1975), Castagna et al. (1978) and Brimble et al. (2007), which evidenced significant association with market determined risk measures. This is logical because in finance theory, risk is defined as the variability due to market conditions. This study expects significant association between variability in earnings and systematic risk.
2. Dividend Payout (Div) is the cash dividends divided by the earning available for equity stock holders as in Beaver et al. (1970). This risk variable is used in Borde (1998), Rosenberg et al. (1973), and Brimble and Hodgson (2007). Unlike Brimble and Hodgson (2007), Beaver et al. (1970) and Rosenberg (1973) found significant association with the market determined risk measures. The firms with low payout ratio are expected to be risky as firms with great variability in earnings will tend to have lower payout ratio because of dividend smoothing. But even otherwise, Beaver et al. (1970) assert that firms with low payout ratio are more risky.
3. Liquidity (QR). The current ratio and the quick ratio are normally used as the risk measures of liquidity, and quick ratio is used in this study as in Moyer and Chatfield (1998), Gu and Kim (2002). Quick ratio is equal to cash, marketable securities and account receivable divided by the current liabilities. Beaver et al. (1970) contended that the liquid assets must have less volatile return compared to fixed assets and did not evidence significant association with market determined risk measures. However, the higher the ratio, the stronger is the financial position of the firm and the lower the risk. However, prior studies provided mixed results: Beaver et al. (1970) showed significant negative association with systematic risk, while Borde (1998) and Rosenberg et al. (1973) evidenced positive association with systematic risk; Gu and Kim (1998) and Logue and Merville (1972) failed to evidence significant association. This study posits liquidity will have significant association with market determined risk measures.
4. Return on Equity (ROE) is a profitability measure indicating the health of the firm from the point of view of the equity investors. In finance theory, risk and return go together, and hence firms with high ROE are expected to be risky. However, a

low ROE persisting for some time can also increase the risk of the firm. Melicher (1974) and Rowe and Kim (2010) evidenced positive relationship between ROE and systematic risk**.** This study expects ROE will have significant association with systematic risk.

5. Financial Leverage (DE). Debt to equity ratio is used in this study as in Moyer and Chatfield (1998), Gu and Kim (2002) and Chiou and Su (2007). Mendelkar and Rhee (1984), Lee and Jang (2007) and Voulgaris and Rizonaki (2011) found significant positive association, but Beaver et al. (1970) and Brimble and Hodgson (2007) did not find significant association between systematic risk and financial leverage. In finance theory, financial leverage is expected to increase the variability of earnings because of the fixed interest payments in spite of the variable earnings, and this study posits significant relationship with market determined risk measures.
6. Size (S) in this study is the natural logarithm of total assets as in Beaver et al. (1970). Some other studies which have used size as an accounting risk measure are Logue and Merville (1972), Breen and Lerner (1973) and Gu and Kim (2002). The larger companies tend to be less risky than smaller companies. According to Beaver et al. (1970), larger firms will have a lower variance of rate of return compared to smaller firms. Logue and Merville (1972) and Breen and Lerner (1973) found significant negative association between size and systematic risk.
7. Growth (G) in this study is the growth in total assets as in Beaver et al. (1970). The growth variable is calculated as the natural logarithm of terminal total asset size divided by the initial asset size and divided by the number of years between the initial and terminal dates. The newer assets are generally considered to be riskier than the existing assets. According to Logue and Merville (1972), firms growing fast might have higher systematic risk. In finance theory, 'growth' of an unlevered firm is equal to the ROE times the dividend retention ratio. If by design, for a healthy company with satisfactory ROE, dividend is not retained, then low growth is not a risk factor. But, if the persistence of low growth is not due to the dividend decision, then low growth can also be a risk factor. This study expects significant association between growth and market determined risk measures.

The research model capturing all the independent variables is

$$\beta_{ji} = C + b_1 EV_i + b_2 Div_{i\,+}\, b_3 S_i + b_4\, G_i + b_5\, QR_i\; + b_6\, ROE_i\; + b_7 DE_i + e_i \text{ -} \qquad (4)$$

where 'j' is β_m and β_{adj} , and 'i' = firm i.

3.4 Research hypotheses

The research hypotheses of this study are:

Hypothesis 1: Earning variability has statistically significant association with systematic risk in the Indian stock market.

Hypothesis 2: Dividend payout has statistically significant association with systematic risk in the Indian stock market.

Hypothesis 3: Liquidity has statistically significant association with systematic risk in the Indian stock market.

Hypothesis 4: ROE has statistically significant association with systematic risk in the Indian stock market.

Hypothesis 5: Financial leverage has statistically significant association with systematic risk in the Indian stock market.

Hypothesis 6: Firm size has statistically significant association with systematic risk in the Indian stock market.

Hypothesis 7: Asset growth has statistically significant association with systematic risk in the Indian stock market.

TABLE 1. **The descriptive statistics for market determined and accounting determined risk variables.**

Variable	Obs	Mean	Median	Std. Dev.	Skew.	Kurt.	Jarque-Bera	Prob
β_m	88	0.930	0.891	0.523	0.193	2.697	0.882	0.643
β_{adj}	88	0.929	0.892	0.516	0.188	2.692	0.864	0.649
EV	88	0.021	0.013	0.030	4.722	29.987	3031.496	0.000
Div	88	0.367	0.314	0.220	1.087	4.017	21.354	0.000
S	88	9.951	9.715	1.437	0.145	2.266	2.312	0.315
G	88	0.089	0.090	0.070	1.187	7.956	111.997	0.000
QR	88	1.640	1.130	1.690	2.834	11.511	387.740	0.000
ROE	88	0.199	0.170	0.164	2.240	10.610	289.199	0.000
DE	88	0.348	0.148	0.644	5.124	36.376	4520.409	0.000
The table presents the descriptive statistics of the large, liquid non-financial stocks in the India stock market for the complete period 2012–2017 dataset. The variables are described in sections 3.2 and 3.3.								

Source: Compiled by the author.

The descriptive statistics for the chosen market determined and accounting determined market risk measures are given in Table 1. It is seen that both market betas are a little less than one, the reason for that is the fact that the excluded financial stocks generally have betas between 1.3 and 1.6 in the Indian stock market[3]. So the mean of the

[3] The NSE and BSE bank index betas for the 2012-2017 period are approximately 1.4.

market betas suggests that the sample represents the overall economy. Both the market betas and the size accounting variable follow a normal distribution. All the other variables have non-normal distributions. The distributions of EV, QR, ROE and DE are heavily skewed. The descriptive statistics reveals that the sample includes a wide range of firms from different industries including high dividend payout and low dividend payout firms, high and negative growth firms, firms that are relatively highly and lowly leveraged, and firms with different liquidity positions. Hence, the results are reflective of the overall economy with a wide range of firms in a variety of business and financial situations.

4. Statistical Association Techniques

The statistical association means the extent to which accounting determined risk measures reflect the same underlying economic phenomena that appear to be relevant in the stock market. According to Joos and Ooghe (1994), the central issue is this statistical association. This study uses regression analysis to identify the important explaining variables for the equity beta or the market beta. The research design used in this study is listed below:

1. Preliminary analysis: Descriptive statistics and correlation analysis
2. Regression Analysis: Ordinary least squares (OLS) and stepwise regression
3. Robustness analysis
4. Model stability analysis.

4.1 Preliminary analysis

The regression techniques used in the study are parametric regressions where certain assumptions about the underlying data are a must for proper application. The preliminary analysis is needed to analyze whether the variable meets the assumptions. Descriptive statistics like the mean, median, standard deviation, skewness and kurtosis are analyzed. Independence between variables is also an important assumption, and correlation analysis includes the analysis between market determined risk measures and accounting determined risk measures.

4.2 Multiple Regression Analysis

In this study, two types of multiple regressions, namely ordinary least squares (OLS) and stepwise regression are employed. The first regression includes all the independent variables which may lead to multicollinearity issues. The stepwise regression is then conducted to get a non-redundant equation with significant coefficients. This study employs various statistical tests to examine the data sets and the assumption required for regression modeling. The important assumptions under which the OLS estimators are efficient for the sample parameters are absence of multicollinearity, serial correlation and heteroskedasticity. This study employs Normality plots, and serial correlation LM tests to examine the serial correlation in the residuals. The presence of multi collinearity between the independent variables might bias the regression results. This study, apart from stepwise regressions, employs variance inflation factors (VIF) and visual inspection through confidence ellipse plots to assess multicollinearity. Finally, the White heteroskedasticity test is used to examine the issue of heteroskedasticity.

4.3 Robustness analysis

In multiple regressions, sometimes, extreme observations might influence the results leading to faulty models. In order to check whether extreme observations have influenced the results, robust regression is used on the final reduced model. The sign, magnitude and statistical significance of important parameters obtained in the robust regression are compared with that of the OLS regression.

4.4 Tests for model stability

One of the most important conditions for the validity of the models is the stability of relationship between accounting determined risks and market risk. A model should be able to forecast better than a naïve model. Firstly, the total sample period 4/2012 to 3/2017 is divided into sub periods, namely, 4/2012 to 3/2015 and 4/2014 to 3/2017, with one overlapping year[4] in both the periods. The model estimated in the first period is used to forecast the market betas in the second period similar to Beaver et al. (1970). The first method is to compare the R^2 of both the estimated and predicted model and check whether the difference is large.

Secondly, the complete period market beta is regressed with both Period one (4/2012 to 3/2015) and Period two (4/2014 to 3/2017) accounting determined risk variables separately, and the R^2 of both the regressions are compared.

The third and last method is to test the predictive ability of the accounting determined risk models as in Hochman (1983). This study develops two predictions for the 4/2014 to 3/2017 period based on market betas and bayesian adjusted betas of 4/2012 to 3/2015 period. Then the actual 4/2014 to 3/2017 market betas are regressed with the predicted betas.

$$\text{Actual market beta}_{4/2014 \text{ to } 3/2017} = a_0 + B_1 \times P_i + e \quad (5)$$

If the predictor is good, the intercept a_0 should be close to zero, and slope B_1 should be closer to one.

[4] The reason for the sub periods with the overlapping period is that dividing the sample into two years will give less data points for regression analysis. However, the model stability tests were repeated with the sample period divided into two sub periods of two years each, namely, 4/2012 to 3/2014 and 4/2015 to 3/2017, without overlap. The model stability tests were again repeated with the sample period divided into sub periods, namely, 4/2012 to 3/2016 and 4/2013 to 3/2017, with two overlapping years in both the periods. The model stability test results in both the cases were similar to the evidenced results reported in Table 5.

This study examines only the large and liquid stocks constituting the NSE and BSE 100 indices and generalizes the results to the entire Indian stock market. This study has assumed that the recent five years of data is enough to examine the relationship between market determined and accounting determined risk measures. Future research can use a larger sample size and an extended period of data. This research only uses multiple regression and capital asset pricing model (CAPM). The linear regression model though statistically worthwhile, in reality the independent and dependent variables might have non-linear relationships. There are also limitations to the CAPM model. These limitations open up new avenues for future research.

5. Results and Discussion

5.1 Correlation Analysis

Correlation analysis helps in understanding the linear relationship between the variables. Table 2 Panel A reports the degree of association between market determined risk measures and accounting determined risk measures. The correlation is statistically significant for all the variables except dividend payout. The degree of association is strongest for ROE followed by earnings variability, growth, size and DE. The interesting part is the sign, or the direction of the relationships. The sign, or direction, is on expected lines for earning variability (+), QR (-) and DE (+). The positive association between systematic risk and size is interesting as it means bigger stocks are more risky. However,

TABLE 2. **The results of the correlation analysis.**

Panel A: Contemporaneous association between market determined and accounting determined risk variables.				**Panel B: Association between accounting determined risk measures in Period one (2012–2015) and Period two (2014–2017)**		
Variable	Obs	β_m	β_{adj}	Variable	Obs	Correlation coefficient
EV	88	0.268	0.267	EV	88	0.344
Div	88	-0.091	-0.091	Div	88	0.626
S	88	0.225	0.225	S	88	0.994
G	88	-0.244	-0.244	G	88	0.048
QR	88	-0.170	-0.171	QR	88	0.694
ROE	88	-0.331	-0.331	ROE	88	0.910
DE	88	0.216	0.216	DE	88	0.961
The variables are described in sections 3.2 and 3.3.						

Source: Compiled by the author

the reason could be that only the large and liquid stocks are considered in this study. The negative association between market determined risk measures and both ROE and Growth is also in a way different. Generally, high growth firms are supposed to be risky. However, consistent low growth and low ROE can also be risky for investors especially when they are not a function of the dividend decision.

Table 2 Panel B reports the association between accounting determined risk measures in Period one (2012–2015) and Period two (2014–2017). The complete period (2012–2017) data was split into two periods for model stability analysis. All the accounting variables in both the periods are highly correlated except growth variable. The association is relatively lesser for earning variability.

5.2 Regression Analysis

A multivariate regression is used to model (Equation 4) the relationship between accounting determined and market determined risk measures. There are two models, each analyzing the association between accounting determined risk measures and the two market beta risk measures for the complete period from 2012 to 2017. Table 3

TABLE 3. **The association between market risk measures and accounting determined risk measures – cross-sectional OLS regression results.**

Obs - 88	**OLS Beta**		**Adjusted Beta**	
Variable	Coefficients	t-stat	Coefficients	t-stat
Constant	1.410	3.200***	1.404	3.224***
EV	5.454	2.843***	5.360	2.827***
Div	-0.078	-0.332	-0.079	-0.340
S	-0.007	-0.174	-0.007	-0.172
G	-2.854	-3.719***	-2.815	-3.712***
QR	-0.065	-2.158**	-0.064	-2.155**
ROE	-0.713	-2.009**	-0.705	-2.012**
DE	0.029	0.197	0.028	0.196
Corr. Coeff R		0.540		0.538
R -Sq		0.292		0.291
F - stat		4.693***		4.679***

The table reports the regression coefficients for the five-year period between 2012 and 2017 using the model: $\beta_{ji} = C + b_1EV_i + b_2Div_i + b_3S_i + b_4G_i + b_5QR_i + b_6ROE_i + b_7DE_i + e_i$, where j is β_m and β_{adj}. 'i' = Firm i. The variables are described in sections 3.2 and 3.3. Section 5.2 describes the results reported in this table. *** represents significance at 1% level. ** represents significance at 5% level.

Source: Compiled by the author.

reports the results of the cross sectional OLS regression results between market risk measures and accounting determined risk measures. The coefficients of determination R–Square and F - statistic indicate that the accounting determined risk variable measure possesses significant risk-related information explaining nearly 30% of the variation in the two measures of market or systematic risk in the Indian stock market.

The association between accounting determined risk measures and market determined risk measures as measured by correlation coefficient 'R' is 54% and 53.8% for OLS beta and adjusted beta respectively. The R–Sq is 29.2% and 29.1% for OLS beta and adjusted beta respectively. The F-Stat is statistically significant at a 1% level of significance for both the measures of market beta rejecting the null hypothesis that all the slope coefficients are zero.

As in Beaver et al. (1970), all the seven accounting determined risk variables are included in the regression equation initially. The coefficients of earning variability and growth are statistically significant at a 1 % level. The results show that the earning variability and growth have statistically significant association with systematic risk and support Hypothesis 1 and Hypothesis 7. The coefficients of quick ratio and ROE are statistically significant at a 5 % level. The results show that the liquidity and ROE also have statistically significant association with systematic risk and support hypotheses 3 and 4**.** Earnings variability, as expected, is positively related to systematic risk measured by beta. All the other three significant variables are negatively correlated to beta. The direction of QR is as expected, but persistent low growth and ROE appear to be risk factors. The final instrumental equation has only four variables, namely, earnings variability, growth, liquidity and ROE. The constant 'c' also has a large t-value, but according to Beaver et al. (1970), it will be impossible to specify the value of the constant when all the values of the independent variables are zero.

Overall, the results support the notion of strong association between earning variability and growth, which is in line with prior literature (Beaver et al. (1970), Lev (1974), and Brimble and Hodgson (2007). However, the direction of the association for the growth variable is negative contrary to earlier evidence (Beaver et al., 1970, Voulgaris & Rizonaki, 2011). Further, the lack of association in the case of dividend payout is also contrary to prior literature (Beaver et al. (1970), Rosenberg et al. (1973), but similar to Brimble and Hodgson (2007). As companies tend to retain more earnings after the internet era, low dividend payout may not be a significant risk factor anymore. Another reason may be due to dividend smoothing or the lower reliance on internally generated funds. However, this might suggest that growth and ROE may be capturing the same risk, and one of them may be redundant in the equation as Growth = ROE × (1-Div payout) in finance theory. This view was not substantiated due to lack of correlation between growth and ROE. The negative association between ROE and systematic risk is in contrast to the positive relationship evidenced by Melicher (1974) and Rowe and Kim (2010). It appears that persistent low ROE is a significant risk factor. The lack of association between the leverage and systematic risk is similar to Beaver et al. (1970)

and Brimble et al. (2007) but contrary to the findings of Mandelkar and Rhee (1984), Gu and Kim (2002), Lee and Jang (2007), Chiou and Su (2007), and Voulgaris and Rizonaki (2011). The reason may be due to the fact that nearly 15% of the sample is populated by public sector companies which have the government as the major stockholder. In these companies, the capital structure is based on the amount of money the government is ready to infuse, and not on the market forces. Further, 10% of the sample is populated by group companies, where, according to Damodaran (2008), the capital structure will depend on the extra debt capacity of the group companies rather than the industry related effects**.** The significant negative association between liquidity and systematic risk is in line with expectations. This result is similar to Voulgaris and Rizonaki (2011), but in contrast to the findings of Beaver et al. (1970). The lack of association between size and systematic risk is similar to the findings of Beaver et al. (1970), but in contrast to the findings of Brimble et al. (2007) and Lee and Jang (2007). This may be due to the fact that this study has considered only the large stocks. The overall results clearly prove that there is significant, strong contemporaneous association between market determined risk measures and accounting determined risk measures in the Indian stock market.

The results might be due to multicollinearity, therefore a stepwise regression procedure is conducted with different entry restrictions. The stepwise regression results reported in Appendix 2 support the results of the OLS regression and suggest multicollinearity might not be the reason for the findings. The variance inflation factors (VIF) are used to measure multicollinearity between regressors and were found to be less than 1.5 for all the variables (Appendix 2). A VIF greater than 9 suggests the presence of multicollinearity. The visual inspection through confidence ellipse plots (not shown) also supports the above result. Of the seven confidence ellipse plots, six were near circles suggesting coefficient estimates are independent. This shows that the results reported in Table 3 are not due to multicollinearity.

The LM test and normality plots were employed to test for serial correlation in the residuals. The results of the tests (Appendix 3) showed that the null of no serial correlation was not rejected even at a 10% level of significance in the LM test. The JarqueBera statistic was not statistically significant suggesting the residuals are normally distributed. White's heteroskedasticity test is a test of 'no heteroskedasticity' against heteroskeasditicity of the general form. A significant statistic in any of the three statistics, namely F-statistic, Obs* R-sq and LM statistic, might suggest the presence of heteroskedasticity. The results reported in Appendix 4 show that none of the three statistic is significant at any level of significance, which suggests homoskedasticity. The validation of the assumptions shows that the model parameters obtained by OLS regression are estimated efficiently.

5.3 Robustness sensitivity analysis

According to Joos and Ooghe (1994), an important way to analyze multivariate distribution properties is to detect multivariate outliers. Regression outliers might vitiate OLS regression analysis. Robust regression was used to attenuate the effects of influential observations that might influence OLS regression. In this study, robust regression is employed on the limited model with four variables not on the full model. Table 4 reports the results of both the OLS regression and robust regression on the limited model with four explaining variables.

TABLE 4. **The association between market risk measures and accounting determined risk measures – OLS and robust regression on the reduced model.**

Panel 1 – OLS beta β_m				
Obs - 88	OLS Regression		Robust Regression	
Variable	Coefficients	t-stat	Coefficients	t-stat
Constant	1.324	11.275***	1.339	10.835***
EV	5.383	2.984***	5.396	2.849***
G	-2.796	-3.846***	-2.855	-3.742***
QR	-0.067	-2.318**	-0.081	-2.592**
ROE	-0.746	-2.403**	-0.740	-2.190**
Corr. Coeff R		0.538		0.507
R -Sq		0.290		0.257
Panel 2 – Adjusted beta β_{adj}				
Obs - 88	OLS Regression		Robust Regression	
Variable	Coefficients	t-stat	Coefficients	t-stat
Constant	1.320	11.369***	1.331	10.924***
EV	5.290	2.967***	5.299	2.832***
G	-2.757	-3.839***	-2.816	-3.735***
QR	-0.067	-2.316**	-0.078	-2.583***
ROE	-0.740	-2.410**	-0.708	-2.198**
Corr. Coeff R		0.537		0.506
R -Sq		0.288		0.256

The table reports the regression coefficients of OLS and robust for the five-year period between 2012 and 2017 using the reduced model: $\beta_{ij} = c + b_1 EV_i + b_2 G_i + b_3 QR_i + b_4 ROE_i + e_{it}$, where j is β_m and β_{adj}. 'i' = Firm i.
The variables are described in sections 3.2 and 3.3. Section 5.3 describes the results reported in this table. *** and ** represents significance at a 1% and 5% level respectively.

Source: Compiled by the author.

The R-sq of the OLS and robust regressions are 29% and 25.7% respectively for OLS beta. For the adjusted market beta, the R-sq of the OLS and robust regressions are 28.8% and 25.6% respectively. The signs of all the coefficients remain the same as in the OLS models. The signs, relative magnitudes and significance are all similar to that of the OLS model. These results clearly show that the results in Table 3 are not due to a few outliers.

5.4 Model stability analysis

The stability of the model is tested by comparing the R-sq between the 2012–2015 and 2014–2017 periods. The model identified based on the 2012–2015 data is used to estimate the market betas for the 2014–2017 period, and the R-sq of the observed 2012–2015 model is compared to the predicted 2014–2017 model based on Beaver et al. (1970) methodology. Table 5 Panel A reports the results of this model stability analysis. The R-sq for the observed regression with OLS market beta of the 2012–2015 period as the dependent variable and accounting variables of the 2012–2015 period as independent variables are 27.2% and 23.6% for OLS regression and robust regression respectively. The identified model is used to predict the market beta of 2014–2017, and R-sq of the predicted model are 33.4% and 25.6% for OLS regression and robust regression respectively. Similarly, for the adjusted beta, the R-sq of the observed regression are 27.1% and 23.6% for OLS regression and robust regression respectively. The R-sq of the predicted model is 33.2% and 25.5% for OLS regression and robust regression respectively. The changes are positive, contrary to expectation, as this means that the first period accounting variables predict the second period market beta better than the first period beta. The R-sq for the observed and predicted model is not too different, which suggests stable relationship between market determined and accounting determined risk measures.

The second method to examine the model stability is as follows: The association between the complete period 2012–2017 market beta and the accounting variables of the first period 2012–2014 is modeled. Then, the association between the complete period 2012–2017 market beta and the accounting variables of the second period 2014–2017 is modeled. The R-sq of this model is compared with the R-sq of the regression between the complete period market beta with the accounting variables from the 2014–2017 period for model stability. Table 5 Panel B reports the results of this model stability analysis. The change is 20.8% and 0.4% for OLS and robust regression respectively for OLS market beta. In the case of adjusted market beta, the changes are 20.9% and 0.4% for OLS and robust regression respectively. The changes appear reasonable especially when the literature has not suggested any particular limits. The results of the model stability tests clearly show stable relationship between accounting determined risk measures and market determined risk measures.

TABLE 5. **The results of the model stability analysis.**

	Panel A: Comparison between the actual 2012–2015 model with the estimated 2014–2017 model with accounting variables of the 2012–2015 period.				**Panel B: Comparison between R^2 of the regressions between the five-year complete beta with accounting determined risk measures of 2012–2014 and 2014–2017 periods respectively.**			
Obs - 88	$\boldsymbol{\beta_m}$		$\boldsymbol{\beta_{adj}}$		$\boldsymbol{\beta_m}$		$\boldsymbol{\beta_{adj}}$	
R^2	OLS	Robust	OLS	Robust	OLS	Robust	OLS	Robust
$R^2_{2012\text{-}2015}$	0.272	0.236	0.271	0.235	0.283	0.247	0.282	0.246
$R^2_{2014\text{-}2017}$	0.334	0.256	0.332	0.255	0.224	0.248	0.223	0.247
Change	22.79%	8.47%	22.51%	8.05%	-20.80%	0.4%	-20.9%	0.4%

Panel A: The reduced model of the following regression:
$\boldsymbol{\beta}_{2012\text{-}2015} = c + b_1\, EV_1 + b_2\, Div_1 + b_3\, S_1 + b_4\, G_1 + b_5\, QR_1 + b_6\, ROE_1 + b_7\, DE_1 + e_i$ is used to estimate $\boldsymbol{\beta}_{2014\text{-}2017}$. R^2 of the reduced model and the R^2 of the estimated model are compared.
Panel B : The R^2 of the following regression models are compared.
$\boldsymbol{\beta}_{\mathbf{2012\text{-}2014}} = c + b_1\, EV_1 + b_2\, Div_1 + b_3\, S_1 + b_4\, G_1 + b_5\, QR_1 + b_6\, ROE_1 + b_7\, DE_1 + e_i$
$\boldsymbol{\beta}_{\mathbf{2015\text{-}2017}} = c + b_1\, EV_2 + b_2\, Div_2 + b_3\, S_2 + b_4\, G_2 + b_5\, QR_2 + b_6\, ROE_2 + b_7\, DE_2 + e_i$
Section 5.4 describes the results reported in this table.

Source: Compiled by the author.

Lastly, as in Brimble and Hodgson (2007), this study extends the association between the accounting based risk models to examine the predictive ability of the accounting measures of risk for market risk. Table 7 reports the results of the final stability test based on Hochman (1983). Three predictions are developed for the OLS market beta for the second period 2014 – 2017:

a) OLS market beta 2012 -2015
b) Adjusted market beta 2012 -2015
c) Accounting model: OLS regression reduced model.

TABLE 6. **Prediction of market beta 2014–2017.**

Prediction of market beta 2014–2017			
Predictors P_i	$\mathbf{a_0}$	$\mathbf{B_1}$	**F - Stat**
1. OLS market beta 2012 - 2015	0.445	0.576	105.96***
2. Adjusted market beta 2012 - 2015	0.449	0.571	106.63***
3. Accounting model: OLS regression model	0.261	0.768	34.36***

The three predictions of the $\boldsymbol{\beta}_{2012\text{-}2015}$ are developed, and the real estimated OLS $\boldsymbol{\beta}_{2012\text{-}2015}$ is the predictions P_i from (1) to (3). The table reports the regression.
Market beta $\boldsymbol{\beta}_{2012\text{-}2015} = \mathbf{a_0 + B_1 P_i + e.}$
Section 5.4 describes the results reported in this table.

Source: Compiled by the author.

A good predictor will result in slope B_1 nearer to one and intercept a_0 nearer to zero. It is seen that the accounting model (3) generates slopes and intercepts closer to one and zero respectively in comparison with the naïve prediction models based on market beta. The results are in line with the findings of the earlier studies and underline the importance of accounting information in the predictive context for market betas.

Conclusion

The relationship between the systematic risk and its underlying factors has been the focus of many researchers since the advent of the CAPM. A considerable body of knowledge has focused on accounting information as a proxy for the underlying factors. This study adds to this body of knowledge by examining the association between market determined risk measures and accounting determined risk measures for the large, liquid non-financial stocks in the Indian stock market in the recent 2012 - 2017 period. In order to achieve this objective, two measures of systematic risk and seven accounting determined risk measures were chosen based on prior research. This study used three regression techniques, namely OLS, stepwise and robust regression, to identify the influential accounting variables for the systematic risk measured by market beta. The results evidence that there is a high degree of contemporaneous association between market determined and accounting determined risk measures, with nearly 30% of the cross sectional variance in systematic risk explained by accounting determined risk measures. The evidence supports the contention that accounting determined risk measures are impounded in the market determined risk measures in the Indian stock market. The four accounting variables retained in the final model are earnings variability, growth, liquidity and ROE. The negative association of systematic risk with growth and ROE is different from previous research. The other three variables (dividend payout, size and leverage) evidence weaker associations, which is also different from previous research. The various statistical tests used to examine the data sets evidence that the assumptions required for regression modeling are satisfied. Finally, three methods are used to test the reliability of the final models. All the methods show that the final models are reliable, which suggests that the accounting information conveys useful information to the Indian investor.

The market determined risk variables and the accounting determined risk variables included in this study were based on past research. There might be other variables that were overlooked, which can be avenues for future research. Also, the impact of industry classification, which was not part of this study, can be another issue for future research.

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APPENDIX 1. **The list of stocks included in this study**

Company Name	Industry classification	NSE Code
ABB India Ltd.	INDUSTRIAL MANU.	ABB
ACC Ltd.	CEMENT	ACC
Adani Ports and Special Ec. Zone Ltd.	SERVICES	ADANIPORTS
Ambuja Cements Ltd.	CEMENT	AMBUJACEM
Apollo Hospitals Enterprises Ltd.	HEALTHCARE	APOLLOHOSP
Ashok Leyland Ltd.	AUTOMOBILE	ASHOKLEY
Asian Paints Ltd.	CONSUMER GOODS	ASIANPAINT
AurobindoPharma Ltd.	PHARMA	AUROPHARMA
Bajaj Auto Ltd.	AUTOMOBILE	BAJAJ-AUTO
Bharat Electronics Ltd.	INDUSTRIAL MANU.	BEL
Bharat Forge Ltd.	INDUSTRIAL MANU.	BHARATFORG
Bharat Heavy Electricals Ltd.	INDUSTRIAL MANU.	BHEL
Bharat Petroleum Corporation Ltd.	ENERGY	BPCL
BhartiAirtel Ltd.	TELECOM	BHARTIARTL
Biocon Ltd.	PHARMA	BIOCON
Bosch Ltd.	AUTOMOBILE	BOSCHLTD
Britannia Industries Ltd.	CONSUMER GOODS	BRITANNIA
Cadila Healthcare Ltd.	PHARMA	CADILAHC
Cipla Ltd.	PHARMA	CIPLA
Coal India Ltd.	METALS	COALINDIA
Colgate Palmolive (India) Ltd.	CONSUMER GOODS	COLPAL
Container Corporation of India Ltd.	SERVICES	CONCOR
Cummins India Ltd.	INDUSTRIAL MANU.	CUMMINSIND
Dabur India Ltd.	CONSUMER GOODS	DABUR
Divi's Laboratories Ltd.	PHARMA	DIVISLAB
DLF Ltd.	CONSTRUCTION	DLF
Dr. Reddy's Laboratories Ltd.	PHARMA	DRREDDY
Eicher Motors Ltd.	AUTOMOBILE	EICHERMOT
Emami Ltd.	CONSUMER GOODS	EMAMILTD
Exide Industries Ltd.	AUTOMOBILE	EXIDEIND
GAIL (India) Ltd.	ENERGY	GAIL

Company Name	Industry classification	NSE Code
Glenmark Pharmaceuticals Ltd.	PHARMA	GLENMARK
Godrej Consumer Products Ltd.	CONSUMER GOODS	GODREJCP
Grasim Industries Ltd.	CEMENT	GRASIM
Havells India Ltd.	CONSUMER GOODS	HAVELLS
HCL Technologies Ltd.	IT	HCLTECH
Hero MotoCorp Ltd.	AUTOMOBILE	HEROMOTOCO
Hindalco Industries Ltd.	METALS	HINDALCO
Hindustan Petroleum Corporation Ltd.	ENERGY	HINDPETRO
Hindustan Unilever Ltd.	CONSUMER GOODS	HINDUNILVR
Hindustan Zinc Ltd.	METALS	HINDZINC
I T C Ltd.	CONSUMER GOODS	ITC
Idea Cellular Ltd.	TELECOM	IDEA
Indian Oil Corporation Ltd.	ENERGY	IOC
Infosys Ltd.	IT	INFY
JSW Steel Ltd.	METALS	JSWSTEEL
Larsen & Toubro Ltd.	CONSTRUCTION	LT
Lupin Ltd.	PHARMA	LUPIN
Mahindra & Mahindra Ltd.	AUTOMOBILE	M&M
Marico Ltd.	CONSUMER GOODS	MARICO
Maruti Suzuki India Ltd.	AUTOMOBILE	MARUTI
MothersonSumi Systems Ltd.	AUTOMOBILE	MOTHERSUMI
MRF Ltd.	AUTOMOBILE	MRF
Nestle ltd.	CONSUMER GOODS	Nestle
NHPC Ltd.	ENERGY	NHPC
NMDC Ltd.	METALS	NMDC
NTPC Ltd.	ENERGY	NTPC
Oil & Natural Gas Corporation Ltd.	ENERGY	ONGC
Oil India Ltd.	ENERGY	OIL
Oracle Financial Services Software Ltd.	IT	OFSS
Page Industries Ltd.	TEXTILES	PAGEIND
Petronet LNG Ltd.	ENERGY	PETRONET
Pidilite Industries Ltd.	CHEMICALS	PIDILITIND
Piramal Enterprises Ltd.	PHARMA	PEL
Power Grid Corporation of India Ltd.	ENERGY	POWERGRID
Procter & Gamble Ltd.	CONSUMER GOODS	PGHH
Reliance Industries Ltd.	ENERGY	RELIANCE
Shree Cement Ltd.	CEMENT	SHREECEM
Siemens Ltd.	INDUSTRIAL MANU.	SIEMENS
Steel Authority of India Ltd.	METALS	SAIL
Sun Pharmaceutical Industries Ltd.	PHARMA	SUNPHARMA
Sun TV Network Ltd.	MEDIA & ENT.	SUNTV
Tata Chemicals Ltd.	CHEMICALS	TATACHEM
Tata Consultancy Services Ltd.	IT	TCS
Tata Global Beverages Ltd.	CONSUMER GOODS	TATAGLOBAL

Company Name	Industry classification	NSE Code
Tata Motors Ltd.	AUTOMOBILE	TATAMOTORS
Tata Power Co. Ltd.	ENERGY	TATAPOWER
Tata Steel Ltd.	METALS	TATASTEEL
Tech Mahindra Ltd.	IT	TECHM
Titan Company Ltd.	CONSUMER GOODS	TITAN
TVS Motor Company Ltd.	AUTOMOBILE	TVSMOTOR
UltraTech Cement Ltd.	CEMENT	ULTRACEMCO
United Spirits Ltd.	CONSUMER GOODS	MCDOWELL-N
UPL Ltd.	FERTILISERS	UPL
Vakrangee Ltd.	IT	VAKRANGEE
Vedanta Ltd.	METALS	VEDL
Wipro Ltd.	IT	WIPRO
Zee Entertainment Enterprises Ltd.	MEDIA & ENT.	ZEEL

Source: www.nseindia.com

APPENDIX 2. **Tests for multicollinearity: Variance Inflation Factors**

Variance Inflation Factors		
Variable	**Coefficient variance**	**Centred VIF**
Constant	0.194231	NA
EV	3.682532	1.332762
Div	0.055682	1.17244
S	0.001695	1.425026
G	0.589052	1.222066
QR	0.000914	1.087425
ROE	0.125765	1.408631
DE	0.021577	1.365311
Section 5.2 describes the results reported in this table.		

APPENDIX 3. **Tests for serial correlation**

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.202766	Prob. F(2,78)	0.8169
Obs*R-squared	0.455157	Prob. Chi-Square(2)	0.7965
Section 5.2 describes the results reported in this table.			

Source: Compiled by the author.

APPENDIX 4. **Tests for heteroskedasticity**

Heteroskedasticity Test: White			
F-statistic	0.981112	Prob. F(35,52)	0.5164
Obs*R-squared	34.99957	Prob. Chi-Square(35)	0.4682
Scaled explained SS	24.03451	Prob. Chi-Square(35)	0.9189
Section 5.2 describes the results reported in this table.			

Source: Compiled by the author.