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## The incorporation of risk into the clean-surplus valuation model: evidence from UK stocks

### Abstract

Prior studies on equity valuation, use Ohlson's (1995) valuation model which assumes risk neutrality. This paper examines the issue of how one can generalize and modify the analysis in order to incorporate risk. To do so we replace the risk free rate with a risk-adjusted interest rate that can be used as a firm's cost of equity capital. More specifically, we test the empirical validity of the standard clean-surplus valuation model against that of the clean surplus approach within a risk-adjusted framework for two sectors of the British equity market using panel data techniques. To anticipate the results, these models appear to be equally reliable empirical share valuation models, for the two sectors examined by this paper.

**Keywords:** equity valuation, clean surplus accounting, book value, abnormal earnings, risk-adjusted, risk-free, panel data.

**JEL Classification:** G1.

### Introduction

Traditional equity valuation models discount expected future dividends in order to arrive at a theoretically correct intrinsic value, which will be then compared to the current market price (Gordon, 1959). However, in their studies Peasnell (1982), Ohlson (1995) and Feltham and Ohlson (1995) suggest that security prices should be determined by book value and discounted future abnormal earnings.

Risk plays a fundamental but not yet well-understood role in the clean-surplus valuation model. Feltham and Ohlson (1999) emphasize the role of risk in this model and point out that the capital markets should price non-diversifiable (systematic) variability inherent in expected future abnormal earnings. However, it is not clear exactly how one should incorporate risk into empirical tests or practical applications of the clean-surplus valuation framework. Consequently, empirical researchers have used different procedures for examining the impact of risk in empirical applications of the clean-surplus valuation model.

There is, however a lack of studies testing the validity of clean-surplus valuation model correcting the interest rate for risk directly. This is precisely the motivation of this paper. The aim of the study is to test the empirical validity of the standard clean-surplus valuation model adjusting the risk-free interest rate for risk. To do so, we follow the suggestion by Ohlson (1995 p.680) who argues that a straightforward way to incorporate risk into the analysis would be to infer a risk-adjusted interest rate from a firm's estimated beta and the market's average risk premium for stocks. Ohlson (1995) therefore suggests replacing the risk-free with a risk-adjusted interest rate that can be used as a

firm's cost-of-equity capital in order to calculate the charge for the use of capital. This is exactly the route we take in this paper. More specifically, we compare the empirical performance of the standard clean-surplus valuation model against that of the clean-surplus approach within a risk adjusted framework using data for two sectors (food & beverages and pharmaceuticals) from the London Stock Exchange for the period of 1996-2002 and panel data techniques overcoming a number of frequently encountered estimation problems. In particular, we examine whether changes in observed share prices are better explained by changes in book value and abnormal earnings when risk is incorporated into the model. If this were to be the case, we would infer that Ohlson's model in its traditional version would yield biased inferences due to the omission of a significant explanatory variable (i.e. risk) from the analysis.

To anticipate our empirical findings, the clean-surplus valuation model in its standard form performs very well for one of the two examined sectors and reasonably well for the second. The models adjusting for risk produce empirical findings consistent with the predictions of the standard model without increasing significantly the model's explanatory power. This provides evidence in favour of the robustness of standard Ohlson's model when risk is incorporated into the analysis. The remainder of the paper is organized as follows. Section 1 discusses previous literature. Section 2 presents research design and data. Section 3 presents methodology and the construction of variables. Section 4 presents our empirical findings. Finally, the last section concludes the paper.

### 1. Literature review

In their studies Ohlson (1990, 1991, 1995) and Feltham and Ohlson (1995) suggest that, as long as forecasts of earnings, book values and divi-

dends follow clean surplus accounting ( $B_t = B_{t-1} + X_t - d_t$ ), security prices should be determined by book value and discounted future abnormal earnings:

$$P_t = B_t + \sum_{\tau=1}^{\infty} \frac{E_t(X_{t+\tau} - r_f B_{t+\tau-1})}{(1 + r_f)^\tau}, \quad (1)$$

where,  $d_t$  denotes the dividend per share at time  $t$ ,  $P_t$  denotes the price per share at time  $t$ ,  $B_t$  denotes the book value per share at time  $t$ ,  $E_t$  represents the expectations operator at time  $t$ ,  $X_{t+\tau}$  represents earnings per share in period  $t + \tau$  and  $r_f$  denotes the risk-free discount rate. This specification has three advantages. Firstly, special emphasis is given to book value, thus avoiding any economic hypotheses about future cash flows. Secondly, the treatment of investments is such that investments are a balance sheet factor and not a factor that reduces cash flows (for a more detailed discussion, see, Penman and Sougiannis (1998)). Thirdly, as Bernard (1995) has shown for shorter horizons the Ohlson approach is more suitable than the dividend valuation model as the latter underestimates share value. Previous empirical studies find that book value and discounted future abnormal earnings play an important role in the determination of equity prices. Indeed, a number of papers have found that the clean-surplus valuation model, not correcting for risk, has a superior empirical performance relative to dividend model of equity valuation (see, for example, Bernard, 1995; Lundholm, 1995; Collins et al., 1997; Lee et al., 1998; Penman and Sougiannis, 1998; Dechow et al., 1999; Myers, 1999; Francis et al., 2000; Swartz and Negash, 2006; Spilioti and Karathanassis, 2010)<sup>1</sup>.

Building on their initial model, Feltham and Ohlson (1999) emphasize the role of risk in the clean-surplus valuation model and point out that equity values should price as fundamental risk the non-diversifiable (systematic) variability inherent in expected future abnormal earnings. They demonstrate analytically that one can incorporate risk in clean-surplus valuation model by reducing expected future abnormal earnings to certainty equivalents based on investors' risk aversion across all possible events and dates. In this demonstration, Feltham and Ohlson (1999) measure abnormal earnings as earnings less a charge for the cost of equity capital, basing the charge on the book value of equity and the

term structure of risk-free interest rates at the time of valuation. The pricing of risk therefore depends on the appropriate set of event-date-contingent prices for future abnormal earnings measured as certainty equivalents.

The clean-surplus valuation model is the basis for a large empirical literature that aims to estimate the cost of capital from data on observed prices and the variables included in the right-hand-side in the clean-surplus valuation formula. The empirical findings of this literature (mostly based on U.S. data for the period of 1979-1998) are rather mixed with studies suggesting varying degrees of risk premia embodied in the derived cost of capital in excess of the risk-free interest rate (see, for example, O' Hanlon and Steele (2000); Claus and Thomas (2001); Gebhardt et al. (2001); Easton et al. (2000); Botosan and Plumlee (2002); Baginski and Wahlen (2003)).

Despite the important contribution of the literature quoted above to establishing the significance of risk in equity price valuation, there is not a widely accepted methodology for determining the intrinsic value of equities based on the clean-surplus valuation model within a risky framework. Indeed, the question for incorporating risk in the clean-surplus valuation model has not been addressed by the literature, with the exception of a recent study by Nerkašov and Shroff (2009). This paper presents a methodology that incorporates risk measures based on economic fundamentals directly in the clean-surplus valuation model. More specifically, this study suggests a measure that is an adjustment for risk in the numerator of the valuation formula which is a function of the covariance between a firm's excess returns on equity (ROE) and market-wide risk factors. The empirical results (based on U.S. firms for the period of 1982-2005) indicate that the valuation errors obtained from value estimates based on fundamentals risk adjustment are significantly lower than those based on standard risk adjustment procedures such as the CAPM and the Fama-French three factor model.

## 2. Research design and data

Drawing on the suggestion made by Ohlson (1995) there is a need to compare the explanatory power of the clean-surplus valuation model with that of the clean surplus approach when risk is incorporated. The main objective of our empirical analysis is to establish whether incorporating risk in the standard clean-surplus valuation model explains better changes in share prices. If that were to be the case, and assuming market rationality, empirical valuation models constructed to include a proxy for risk would have superior explanatory power relative to a

<sup>1</sup> Frankel and Lee (1998), Ang and Liu (1998), Penman (1998), Garrod and Rees (1998), Collins et al. (1999), Barth et al. (1999), Karathanassis and Spilioti (2003).

model based on the risk-free interest rate included in the standard clean-surplus valuation model. To test our competing hypotheses, we estimate two clean-surplus valuation models. The first one was constructed assuming investors are risk-neutral, while in the second the standard assumption of risk-aversion was incorporated into the calculation of the abnormal earnings. The main hypothesis we aim to test is whether changes in share prices are explained better by changes in book value and risk-adjusted abnormal earnings than by changes in book value and abnormal earnings that are based on risk-free interest rate. If the former is true, the implication would be that adjusting for risk would reveal a superior empirical valuation model. If the alternative hypothesis is true we would infer that accounting for risk measured in the way suggested by Ohlson is not improving our understanding of pricing behavior.

Our empirical analysis is based on combined time-series and cross-sectional data from the London Stock Exchange, available from Datastream, covering the period between 1996 and 2002. The data is expressed in nominal values and annual frequency and is a balanced panel data set. The implications of them are considered to be that our estimates are more efficient than an unbalanced panel data set since there are not missing observations. Our sample includes companies from the British food & beverages and pharmaceuticals sectors (28 and 20 companies, respectively). We choose these specific sectors for the following three reasons. Firstly, these sectors are typical examples of “defensive” industries as far as investment strategies are concerned. This is so because they include firms for whose products demand remains relatively stable both in good as well as in bad market conditions. Therefore, their share prices are likely to be less volatile than those of other industries during periods of high market volatility such as the one covered by our sample (1996-2002). From that point of view, defensive industries are useful to investors as hedging instruments limiting their overall portfolio risk. Secondly, the majority of the firms that are included in these two sectors have large market capitalization and consequently show low liquidity conversion risk making them consistent with the implicit assumption of the Ohlson model according to which all shares are equally liquid. Thirdly, these sectors have high invested capital on R&D expenses (pharmaceuticals) and in fixed assets (food & beverages). Capital expenditure is a key factor in valuations based on the Ohlson model because the earnings used in the Ohlson formula include capital and technology investments which operate as a key indicator of future profits (Penman and Sougiannis, 1998). As these sectors are those that displaying a high volume of

capital and technology expenditure, they are suitable for empirical estimations of the Ohlson model.

### 3. Methodology and construction of variables

**3.1. Methodology.** Previous research on equity valuation has typically used either time-series or cross-section methods. In this paper we use a combination of time-series and cross-section data (panel data analysis) which has a number of advantages. For example, a panel data approach not only provides efficient and unbiased estimators but also a larger number of degrees of freedom allowing researchers to overcome small sample problems associated with the estimation of the linear regression model, especially due to the time-dimension of the data (see, for example, Baltagi and Raj, 1992; and Maddala, 1987). Additionally, the panel data models allow researcher to analyze a number of important economic questions that cannot be addressed using cross-sectional or time-series data sets alone. Our econometric model can be represented as follows:

$$Y_{it} = \alpha + \mu_i + \lambda_t + \sum_{K=1}^K \beta_K X_{Kit} + \varepsilon_{it}, \quad (2)$$

$$i = 1, \dots, N,$$

$$t = 1, \dots, T,$$

where  $Y_{it}$  is the price per share for the cross section  $i$  at time  $t$ ,  $X_{Kit}$  is the value of the  $K_{it}$  explanatory variable for the cross section  $i$  at time  $t$ ,  $\mu_i$  is an unobserved cross-section, individual effect,  $\lambda_t$  is an unobserved time effect and  $\varepsilon_{it}$  is the unobserved overall remainder. Equation (2) can be estimated either under the assumption that  $\mu_i$  and  $\lambda_t$  are fixed so that

$$\sum_{i=1}^N \mu_i = 0 \text{ and } \sum_{t=1}^T \lambda_t = 0, \text{ or under the assumption}$$

that  $\mu_i$  and  $\lambda_t$  are random variables. The first case describes the well known least square dummy variable model or the covariance model, while the second case describes the error components model (see, among others, Kmenta (1971), Griffiths et al. (1993), Hsiao (1986), Greene (2000)).

Researchers are often faced with the problem of choosing among the above two approaches as it cannot be known beforehand whether the  $\mu_i$  and  $\lambda_t$  terms are random or fixed variables. It has been suggested that the distinction between fixed and random effects models is an erroneous interpretation. Mundlak (1978) argues that we should always treat the individual effects as random. In our model, these effects may reveal for instance the quality or faith in management or the efficiency of management. The fixed effects model is simply analyzed conditionally on the effects present in the observed sample. One can argue that certain institutional fac-



tors or characteristics of the data argue for one or the other, but unfortunately, this approach does not always provide much guidance. From a purely practical standpoint, the fixed effects model is costly in terms of degrees of freedom lost, and in a wide panel data set, the random effects has some intuitive appeal. On the other hand, the fixed effects approach has one considerable virtue. There is no justification for treating the individual effects as uncorrelated with the other regressors, as is assumed in the random effects model. The random effects treatment, therefore, may suffer from the inconsistency due to omitted variables.

In order to overcome the above mentioned problem of choosing between the two approaches, one could possibly test for the orthogonality assumption of random effects and the regressors (i.e. the explanatory variables are uncorrelated with the cross-section and time-series effects), Greene (2000). This assumption is based on the idea that under the hypothesis of no correlation between the error term and the explanatory variables, both the ordinary least squares (OLS) estimator in the least square dummy variables model and the generalized least squares (GLS) estimator in the error component model are consistent but the OLS estimator is inefficient. On the other hand, under the alternative hypothesis, the OLS estimator is consistent but GLS is not (see, for details, Madalla, 1971; and Mundlack, 1978).

To examine whether the explanatory variables are uncorrelated with the cross-section and time-series effects one can apply the specification test developed by Hausman (1978), where the null hypothesis is that the error component model is correctly specified, i.e. that  $\mu_i$  and  $\lambda_t$  are uncorrelated with the explanatory variables,  $X_{Kit}$ . The test statistic,  $m$ , is defined as equation (3) below:

$$m = (\hat{\beta}_{FE} - \hat{\beta}_{GLS})(\hat{M}_1 - \hat{M}_0)^{-1}(\hat{\beta}_{FE} - \hat{\beta}_{GLS}), \quad (3)$$

where  $\beta_{GLS}$  is the generalized-least square error component model estimator,  $\beta_{FE}$  is the ordinary least square dummy variable model estimator,  $M_1$  is the covariance matrix of  $\beta_{FE}$ , and  $M_0$  is the covariance matrix of  $\beta_{GLS}$ . This  $m$ -statistic has an asymptotic  $\chi_k^2$  distribution. Accepting the null hypothesis suggests the use of the generalized least square estimator. Rejecting the null hypothesis indicates the use of the ordinary least square estimator.

Therefore drawing on equation (2) the hypotheses stated in the data and research design section could now be formally described as follows in both sectors.

Concerning the standard clean-surplus valuation model we test:

$$H_0 : \beta_{\kappa} = 0$$

against

$$H_1 : \beta_{\kappa} \neq 0,$$

where  $\kappa = 1, 2$ .

According to the standard clean-surplus valuation model, we expect the coefficients of both explanatory variables i.e. book value per share and abnormal earnings per share to be positive and statistically significant (i.e.  $\beta_1, \beta_2 > 0$ ). Similarly the same formal description and coefficients restrictions of the explanatory variables (book value per share and risk-adjusted abnormal earnings per share) apply to the hypotheses regarding the estimation of the risk-adjusted valuation model.

Provided that in both versions of the model, the coefficient of the explanatory variables (book value per share and abnormal earnings per share) are positive and statistically significant, we can compare the explanatory power of two models to determine which of the two fits the data best. In case the model incorporating risk has higher explanatory power we would infer that our hypothesis outlined in section 2 (i.e. adjusting for risk would reveal a superior empirical valuation model) is upheld by the data.

**3.2. Construction of variables.** *3.2.1. The dependent variable: share price (P).*  $P$  is the arithmetic average<sup>1</sup> of monthly average closing equity prices. Some authors may prefer to use share prices prevailing on the day immediately following the cross-section year. It could, however, be argued that share prices prevailing at any one day may contain random or temporary disturbances (Marris and Singh, 1966). On the other hand, an average of monthly prices may be relatively free of temporary disturbances.

*3.2.2. The Independent variables.* According to the standard clean-surplus valuation model there are four variables:

**Book value per share (BV).** BV is the owners' equity over the number of shares in circulation. According to the theory (Ohlson, 1995), we expect a positive relationship between share prices and book value.

**Abnormal earnings per share (AE).** AE is the difference between current earnings and the opportunity cost of capital. The opportunity cost for the use of capital is defined as the previous period's BV times the cost of capital (that is, the 3-month treas-

<sup>1</sup> The average price of each month is obtained by division of the sum of closing prices during the month by the number of working days for each month.

ury bill). According to Ohlson (1995), we should obtain a positive relationship between share prices and abnormal earnings.

The estimated model takes the following form:

$$P_{it} = \alpha + \mu_i + \lambda_t + \beta_1 BV_{it} + \beta_2 AE_{it} + \varepsilon_{it}. \quad (4)$$

According to the clean-surplus valuation model within a risk adjusted framework:

**Book value per share (BV).** BV is the owners' equity over the number of shares in circulation. Theoretically, we expect (Ohlson, 1995), a positive relationship between share prices and book value.

**Abnormal earnings per share adjusted for risk (AER).** AER is the difference between current earnings and the opportunity cost of capital. In this case we have employed a risk-adjusted interest rate in order to calculate the opportunity cost of capital. We would expect a positive relationship between share prices and risk-adjusted abnormal earnings.

The estimated model takes the following form:

$$P_{it} = \alpha + \mu_i + \lambda_t + \beta_1 BV_{it} + \beta_2 AER_{it} + \varepsilon_{it}. \quad (5)$$

In order to calculate the risk-adjusted interest rate, we use the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965) that determines the expected market return of a security by the equation below:

$$E(R_i) = R_f + \beta_i [E(R_m) - R_f], \quad (6)$$

where,  $E(R_i)$  denotes the expected rate of return of a security  $i$ ,  $E(R_m)$  denotes the expected return of the market index,  $R_f$  denotes the risk-free interest rate,  $\beta_i$  denotes the systematic risk of a security  $i$ . According to Ohlson's (1995) proposal,  $E(R_i)$  is a measure of the risk-adjusted interest rate which we adopt in our analysis. The market model (that uses ex-post data) can be used to calculate empirically the above relationship. This involves estimating equation (7) below:

$$R_{it} = \alpha_i + \beta_i R_{mt} + u_{it}, \quad (7)$$

where,  $R_{it}$  represents the return of the security  $i$  at the time period  $t-1, t$ ,  $R_{mt}$  represents the return of the market-index at the time period  $t-1, t$ ,  $\alpha_i$  represents the return of the security  $i$  when the market-index return is zero,  $\beta_i$  represents the systematic risk of a security  $i$ ,  $u_{it}$  represents the disturbance term. The market beta of each firm was estimated by OLS, using 24 to 60 months of past return data ending in December of year  $t$  and using the FTSE 100 stock index of

the LSE, which is a value-weighted index. Firms that had less than 24 continuous monthly return observations were omitted for this estimation period. The procedure was repeated for each calendar year from 1996 to 2002, giving a time-series of market beta for each firm.

#### 4. Empirical findings

Tables 1, 2 present the descriptive statistics of the variables involved in our study for the two examined sectors. As we can see from these tables, the average  $P$  is similar for both sectors (3.47 and 3.94) with a standard deviation of 7.68 and 6.11 respectively. However, the average  $BV$  for the food & beverages sector (138.34) is much higher than for the pharmaceuticals sector (69.32) and the  $AE$  for the food & beverages sector is positive (12.08) while for the pharmaceuticals sector is negative (-5.49). Finally, the average  $AER$  for the food & beverages sector is 13.79, much higher than the  $AER$  (0.77) of the pharmaceuticals firms.

Table 1. Food & beverages sector  
descriptive statistics of variables

	$P$	$BV$	$AE$	$AER$
Mean	3.47	138.34	12.08	13.79
Median	2.02	104.64	9.64	8.79
Maximum	94.46	968.23	172.84	239.39
Minimum	0.10	0.49	-94.59	-60.73
Std. dev.	7.68	138.43	27.62	32.08

Notes:  $P$  (price per share) is the arithmetic average of monthly average closing equity prices.  $BV$  (book value per share) is the owners' equity over the number of shares in circulation.  $AE$  (abnormal earnings per share) is the difference between current earnings and the opportunity cost of capital. The opportunity cost for the use of capital is defined as the previous period's  $BV$  times the cost of capital (that is, the 3-month treasury bill).  $AER$  (abnormal earnings adjusted for risk per share) is the difference between current earnings and the opportunity cost of capital. In this case we have employed a risk-adjusted interest rate in order to calculate the opportunity cost of capital.

Table 2. Pharmaceuticals sector  
descriptive statistics of variables

	$P$	$BV$	$AE$	$AER$
Mean	3.94	69.32	-5.49	0.77
Median	1.64	36.19	-6.05	-3.79
Maximum	32.25	704.47	103.42	149.61
Minimum	0.11	-29.24	-168.07	-97.54
Std. Dev.	6.11	107.19	33.96	32.63

Notes:  $P$  (price per share) is the arithmetic average of monthly average closing equity prices.  $BV$  (book value per share) is the owners' equity over the number of shares in circulation.  $AE$  (abnormal earnings per share) is the difference between current earnings and the opportunity cost of capital. The opportunity cost for the use of capital is defined as the previous period's  $BV$  times the cost of capital (that is, the 3-month treasury bill).  $AER$  (abnormal earnings adjusted for risk per share) is the difference between current earnings and the opportunity cost of capital. In this case we have employed a risk-adjusted interest rate in order to calculate the opportunity cost of capital.

As a first step in the analysis we examine which model (fixed effects or random effects) is appropriate for the estimation of equation (2). To this end we apply the Hausman (1978) criterion discussed above. The results are presented in Table 3 and suggest that for both sectors the cross-section

and time-series effects can be considered as random variables. In other words,  $\mu_i$  and  $\lambda_t$  are uncorrelated with the explanatory variables,  $X_{Kit}$ , in which case the error components model is correctly specified and thus, we proceed with its estimation.

Table 3. Are  $\mu_i$  and  $\lambda_t$  uncorrelated with the explanatory variables?

$$m = (\hat{\beta}_{FE} - \hat{\beta}_{GLS})(\hat{M}_1 - \hat{M}_0)^{-1}(\hat{\beta}_{FE} - \hat{\beta}_{GLS})$$

Foods & beverages	m-statistic	p-value	df
Risk-free model	0.64	0.73	2
Risk-adjusted model	0.86	0.65	2
Pharmaceuticals	m-statistic	p-value	df
Risk-free model	1.40	0.24	2
Risk-adjusted model	1.11	0.57	2

Notes: According to the null hypothesis the error components model is correctly specified, i.e. that  $\mu_i$  and  $\lambda_t$  (cross-section and time effects respectively) are uncorrelated with the explanatory variables  $X_{Kit}$ ,  $m$ -statistic. Hausman's (1978) test statistic is defined as the equation above, where  $\beta_{GLS}$  is the generalized-least square error component model estimator,  $\beta_{FE}$  is the ordinary least square dummy variable model estimator,  $M_1$  is the covariance matrix of  $\beta_{FE}$ , and  $M_0$  is the covariance matrix of  $\beta_{GLS}$ . This  $m$ -statistic has an asymptotic  $\chi_k^2$  distribution. Accepting the null hypothesis suggests the use of the generalized least square estimator. Rejecting the null hypothesis indicates the use of the ordinary least square estimator df (degrees of freedom), p-value at 95% confidence level.

According to the theoretical relationships predicted by the Ohlson valuation model we expect both book value and abnormal earnings to be positively related to share prices. Our empirical findings are in accordance with the theoretical predictions. Furthermore, the empirical results suggest that abnormal earnings adjusted for risk are statistically significant and have the expected positive sign.

As far as the food & beverages sector is concerned, (Table 4) the two independent variables ( $BV$ ,  $AE$ ) are statistically significant with each variable having the expected sign. The standard specification explains 18% of the variability of the dependent variable. The model adjusted for risk also explains a similar portion of the variability of the dependent variable (17%), with both explanatory variables ( $BV$ ,  $AER$ ) being statistically significant and having the expected sign. Similar results are obtained for the pharmaceuticals sector in table 5, with variables in both specifications having the correct sign and being statistically significant. The explanatory power of both models is high, with the first specification explaining 89% of the variability of the dependent variable and the second 90%<sup>1</sup>.

<sup>1</sup> The difference between the  $R^2$ -value of the two sectors can be largely explained by the existence of an extreme residual value for a company operating in the food & beverages sector for year 1996. If we exclude this firm from our sample the value of  $R^2$  increases to 45%. The remaining difference can be explained by the higher volatility of prices in the foods & beverages sector relative to pharmaceuticals. The coefficient of variation of the pooled price series is 2.21 for foods & beverages and 1.55 for pharmaceuticals. As prices for pharmaceuticals exhibits lower volatility around their mean it is not surprising to obtain a higher  $R^2$  for the Ohlson model in the case of pharmaceuticals.

Table 4. Food & beverages sector

$$P_{it} = \alpha + \mu_i + \lambda_t + \sum_{K=1}^K \beta_K X_{Kit} + \varepsilon_{it}$$

Independent variables	Risk-free model	Risk-adjusted model
CONSTANT	1.06 (1.45)	0.86 (1.13)
$BV$	0.01 (1.99) **	0.01 (2.65) ***
$AE$	0.08 (3.03) ***	
$AER$		0.04 (1.87) **
$R^2$	0.18	0.17
$RSS$	9279.20	9455.52

Notes: \*\*\*, \*\* and \* denote statistical significance at the 1, 5 and 10% levels, respectively.  $P$  (price per share) is the arithmetic average of monthly average closing equity prices.  $BV$  (book value per share) is the owners' equity over the number of shares in circulation.  $AE$  (abnormal earnings per share) is the difference between current earnings and the opportunity cost of capital. The opportunity cost for the use of capital is defined as the previous period's  $BV$  times the cost of capital (that is, the 3-month treasury bill).  $AER$  (abnormal earnings adjusted for risk per share) is the difference between current earnings and the opportunity cost of capital. In this case we have employed a risk-adjusted interest rate in order to calculate the opportunity cost of capital.  $\mu_i$  and  $\lambda_t$ , cross-section and time effects respectively (in the above models, these effects are uncorrelated with the explanatory variables  $X_{Kit}$ ). t-statistics appear in parentheses.  $RSS$  denotes the residuals sum of squares.

Table 5. Pharmaceuticals sector

$$P_{it} = \alpha + \mu_i + \lambda_t + \sum_{K=1}^K \beta_K X_{Kit} + \varepsilon_{it}$$

Independent variables	Risk-free model	Risk-adjusted model
Constant	2.59 (3.64)***	3.04 (3.56)***

Table 5 (cont.). Pharmaceuticals sector

Independent variables	Risk-free model	Risk-adjusted model
<i>BV</i>	0.02 (8.30)***	0.02 (4.82)***
<i>AE</i>	0.04 (3.99)***	
<i>AER</i>		0.05 (4.08)***
<i>R</i> <sup>2</sup>	0.89	0.90
<i>RSS</i>	580.57	498.83

Notes: \*\*\*, \*\* and \* denote statistical significance at the 1, 5 and 10% levels, respectively. *P* (price per share) is the arithmetic average of monthly average closing equity prices. *BV* (book value per share) is the owners' equity over the number of shares in circulation. *AE* (abnormal earnings per share) is the difference between current earnings and the opportunity cost of capital. The opportunity cost for the use of capital is defined as the previous period's *BV* times the cost of capital (that is, the 3-month treasury bill). *AER* (abnormal earnings adjusted for risk per share) is the difference between current earnings and the opportunity cost of capital. In this case we have employed a risk-adjusted interest rate in order to calculate the opportunity cost of capital.  $\mu_i$  and  $\lambda_t$ , cross-section and time effects, respectively (in the above models, these effects are uncorrelated with the explanatory variables  $X_{Kit}$ ). t-statistics appear in parentheses. *RSS* denotes the residuals sum of squares.

Our empirical results suggest that the clean-surplus valuation model in its standard form performs very well for the pharmaceuticals sector and reasonably well for the food & beverages sector. The findings of the standard clean-surplus valuation model appear to be robust to our correction for risk. Although in the econometric model incorporating risk, book value per share and abnormal earnings per share are positively related to share prices with statistical significance, the results show equal explanatory power of both models (risk-free and risk-adjusted) in each of the sectors that are tested. The main hypothesis of our analysis that the incorporation of risk in Ohlson's approach results in a superior empirical valuation model is not upheld by the data. This indicates that the risk-adjusted model does not produce any further insight into the estimation of share prices. The question following this conclusion is to determine the cause of the failure of the incorporation of risk to improve the data fit of standard clean-surplus valuation model. One possible explanation is that markets are risk-neutral, as suggested by Ohlson's original model. An alternative explanation is that the risk measurement is a very complicated process that cannot be captured

by methods based on traditional models of risk identification (see, for example, Nerkasov and Shroff, 2009).

## Conclusion

Previous studies suggest that changes in security prices are explained by book value and discounted future abnormal earnings (Ohlson, 1995; and Feltham and Ohlson, 1995). Feltham and Ohlson (1999) emphasize the role of risk in the clean-surplus valuation model and point out that the capital markets should price non-diversifiable (systematic) variability inherent in expected future abnormal earnings. The objective of this paper is to examine whether changes in share prices are explained better by changes in book value and abnormal earnings when risk is incorporated in the analysis. To that end, we examine the behavior of equity prices in two important sectors of the London Stock Exchange (food & beverages and pharmaceuticals) for the period of 1996-2002 and apply panel data analysis. To incorporate risk into the analysis, we follow the suggestion by Ohlson (1995) to infer a risk-adjusted interest rate from a firm's estimated beta and the market's average risk premium for stocks replacing the risk-free with a risk-adjusted interest rate that can be used as a firm's cost-of-equity capital.

Regarding the food & beverages sector both models explain approximately 17-18% of the variability in prices, while in the pharmaceuticals sector both models explain approximately 89-90% of the variability in prices. The models adjusting for risk produce empirical findings consistent with the predictions of the standard clean-surplus valuation model without increasing significantly the model's explanatory power. This provides evidence in favour of the robustness of standard Ohlson's model when risk is incorporated into the analysis. Our empirical findings support that markets are characterised by risk neutrality, as assumed by Ohlson's original model.

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