



“Applied prospect theory: assessing the β s of M&A-intensive firms”

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Garth Ryan Homan (South Africa), Gary van Vuuren (South Africa)

APPLIED PROSPECT THEORY: ASSESSING THE β_s OF M&A-INTENSIVE FIRMS

Abstract

Behavioral components of Kahneman and Tversky's (1979) prospect theory (PT) were applied to derive an adjusted Capital Asset Pricing Model (CAPM) in the estimation of merger and acquisition-intensive firms' expected returns. The premise was that the CAPM – rooted in expected utility theory – is violated by the behavioral biases identified in prospect theory. Kahneman and Tversky's prospect theory (1979) has demonstrated that weaknesses abound in the viability of classical utility theory predictions. For mergers and acquisitions, firms appear to be isolated from and immune to human error, yet decisions which involve the undertaking of capital-intensive projects are delegated to senior management. These individuals are prone to cognitive biases and personalized risk appetites that may (and often do) compromise attitudes and behavior when it comes to pricing risky ventures. Having established that beta estimates using linear regression are inferior, the CAPM was implemented utilizing beta estimates obtained from the Kalman filter. The results obtained were assessed for their long-term market price predictive accuracy. The authors test the reliability of the CAPM as a predictor of price, observe the rationality of human behavior in capital markets, and attempt to model premiums to adjust CAPM returns to a level that more appropriately accounts for firm specific risk. The researchers show that market participants behave irrationally when assessing M&A firms' specific risk. Logistic regression coupled with the development of a risk premium was implemented to correct the original Kalman filter returns and was tested for improvements in predictive power.

Keywords

prospect theory, mergers and acquisitions, Capital Asset Pricing Model, behavioral finance, Kalman filter

JEL Classification

C55, C58, G1

INTRODUCTION

The CAPM is derived from Markowitz's efficient utility theory (Treyner, 1961) and is the classical method of pricing returns that arise from firm mergers or acquisitions (M&As) (Brunner, 2004). This article showcases the inefficiency of the CAPM as a forecaster of gains to a firm's shareholders, the presence of irrational behavior in M&A pricing and integrates the axioms of Kahneman and Tversky's prospect theory (PT) into a measure of estimating the presence of hidden information privy only to a firm's management.

We postulate that while capital markets are shown to adequately price historical and publicly available ex-ante information, the CAPM's pricing of hidden information reveals exploitable opportunities.

Bernoulli (1954) derived Expected Utility Theory (EUT) to model human behavior based on probability-weighted utility outcomes. Markowitz (1952) observed that fair equilibrium asset prices could be ascertained by assuming that investors are risk-averse utility maximizers and from this rose the CAPM. EUMs such as the CAPM are insufficiently robust to withstand empirical tests of their ability to predict investor behavior and asset returns. Roll and Ross

(1983) asserted that this was because the CAPM only accounted for systematic risk and the market portfolio's risk premium.

Kahneman and Tversky's PT (1979) exposed other weaknesses in classical UT's viability. For M&As, companies appear remote from human error, yet decisions to undertake capital intensive projects are largely left to senior management: individuals open to cognitive biases and personalized risk appetites that compromise their attitudes to pricing risky ventures. This cognitive dissonance between theory and practical application of risk assessment creates exposures to operational agency costs that could lead investors to incorrectly price M&A intensive firms.

While semi-strong market efficiency is empirically supported by cross-sectional tests, such support is not garnered for the strictly strong form of market efficiency (Givoly & Lakonishok, 1979). Such failure of market efficiency is due to the implicit, covert nature of firm operations, the delay in performance indicators, the availability of data, and the control exerted on firms by autocratic structures that deliver capital allocation decisions to senior management, not shareholders.

Bergstresser, Desai, and Rauh (2006), Li and Tang (2010) observed that, despite intensive training in quantitative techniques, financial theory, and emphasis on ethical conduct, senior managers remain heavily inclined towards behavior that erodes shareholder gains value¹. It follows that, as with all situations where there are differentials in the access to information, a prospective investor faces the problems of moral hazard where the incentive to reveal information on risk taking behavior by firm executives does not align with investor preferences (Shavell, 1979); and adverse selection where there is uncertainty in an investor's appraisal of available information on a firm being accurate (Akerlof, 1970).

Investors lending capital to a firm that has undergone an M&A (or announces its intentions to) face a dilemma. With a heavy reliance on rational, utility-maximizing behavior, the CAPM lends itself to a reduced equity appraisal view when faced with evidence that internal operations (as human capital) are not accounted for. A risk premium attached to senior management's risk appetite is investigated. We test the reliability of the CAPM as a predictor of price, observe the rationality of human behavior in capital markets, and attempt to model premiums to adjust CAPM returns to a level that more appropriately accounts for firm specific risk.

The remainder of this article proceeds as follows: Section 1 presents a literature review, section 2 – data and methodology, section 3 – results obtained, and final section concludes.

1. LITERATURE REVIEW

1.1. Expected utility theory

While the research assumes that Kahneman and Tversky (1979) correctly identified violations of EUT, it is important to provide an overview of the axioms from which EUT draws its conclusions. The axioms of cardinal utility are the limiting conditions for rational behavior when they hold. This is of value to the research as violation of these axioms is a qualitative motivation for testing the validity of the CAPM which are discussed later.

The axioms are shown in Table 1 (Von Neumann & Morgenstern, 2007).

Two assumptions are apparent: individuals are rational (using real probabilities in assessing choices), and they always prefer holding more wealth to less. This means individuals will always seek to maximize the expected utility of their wealth – or seek to maximize the function

$$E(U) = p(x_1)U(W_1) + p(x_2)U(W_2) + p(x_3)U(W_3) + \dots + p(x_n)U(W_n),$$

¹ Utilitarian ethics is the ethical conduct that maximizes utility (Bentham & Bowring, 1843; Mill & Warnock, 2003).

Table 1. EUT axioms

Axiom	Description
1. Comparability	The entire set S of risky events, an individual will prefer some gamble x to gamble y , y to gamble x , or they are indifferent between such choices
2. Transitivity	If an individual prefers x to y , and y to z , by implication they prefer x to z , and if they are indifferent between x and y , and y and z , by implication they are indifferent between x and z
3. Strong independence	Indifference between events x and y which both occur at probability a , when faced with mutually exclusive event z , will further be indifferent between events x and z and y and z
4. Measurability	If x is preferred to y and y preferred to z , some gamble with probability a can be arranged that will make an individual indifferent between y with certainty and a combination of x and z
5. Ranking	If y and u lie somewhere in preference between x and z , a gamble can be constructed at probability a_1 that will make the individual indifferent to y and a risky combination between x and z . Likewise, another gamble at probability a_2 can be constructed that will make an individual indifferent to u and a combination of x and z . If $a_1 < a_2$, then y is preferred to u

where $E(U)$ – expected utility of wealth, $p(x)$ – probability of state of wealth occurring and $U(W)$ – utility of a given level of wealth.

1.2. Markowitz UT

Markowitz (1952) asserted that exchange-traded assets are valued based on EUT by investors all of whom are risk-averse. The CAPM preserved Markowitz efficiency: investors are risk-averse (more wealth is preferred to less), but expected utility of wealth shows marginal utility, i.e. $U(W) = \ln(W)$ and $U'(W) < 0$ (Figure 1).

1.3. Relevance of breaches to UT

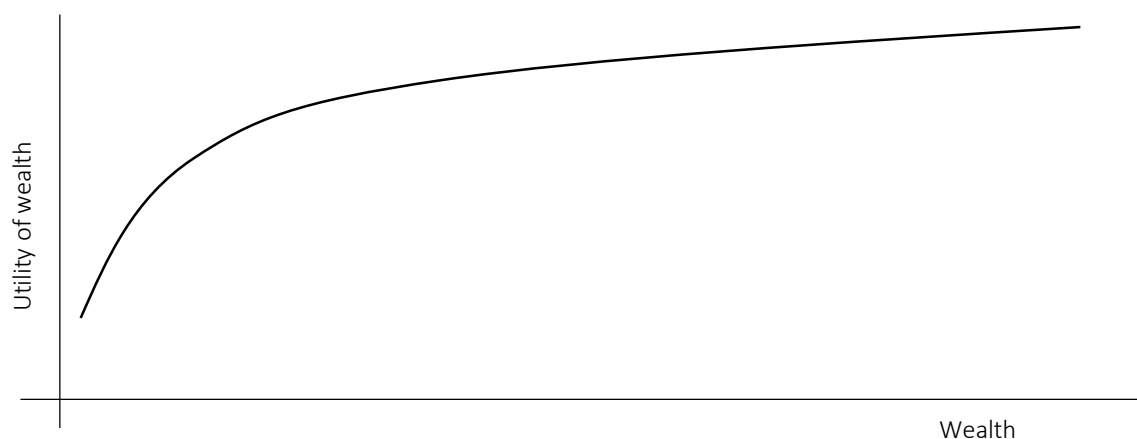
This research aims to show the inefficiency of the CAPM itself derived from Markowitz efficiency. If the axioms of EUT are violated, or if the assumption of rationality and risk aversion in Markowitz efficiency is not true of human behavior, then EUT would not hold.

Kahneman and Tversky (1979) identified the tenets of EUT and tested whether these held when individuals were faced with risky gambles involving changes in wealth. These gambles (or prospects) are contracts with outcome x_i at probability p_i .

The empirical tests used in PT involve randomized unbiased questionnaires under controlled conditions. Kahneman and Tversky (1979) noted that while laboratory experiments provide insight, qualitative results from real-world analysis of consumer behavior suffer severe drawbacks in assessing probability and utility. These drawbacks benefit other approaches (Kahneman & Tversky, 1976).

1.4. Tenets of EUT

- expectation: overall utility of any prospect is the expected utility of its outcomes;
- asset integration: integrating a new asset in a portfolio is worthwhile to an individual if its

**Figure 1.** Wealth utility for a risk-averse utility maximizer

expected utility from addition exceeds the expected utility gained from not adding it;

- risk aversion: individuals show concave utility functions and are risk-averse.

1.5. Violations of EUT in PT

Certainty effect: individuals overweigh the probability of more certain events compared with those which are only probable. This is a violation of the substitution axiom: individuals prefer outcomes that are not expected utility maximizing.

Reflection effect: risk aversion in the domain of already certain wealth is reciprocated by risk seeking in the negative domain of certain loss. This violates the tenet of expectation – even though the expected utility of some risky prospect positive net wealth prospect is higher than the expected utility of a riskless one, investors will choose the less risky prospect. Conversely, even though the expected utility of some negative prospect is lower than that of a riskless prospect, individuals choose it over the certain outcome.

Isolation effect: individuals disregard similarities between prospects and focus on their distinguishing features. This is demonstrated when individuals are given the wealth to purchase either a risky prospect or a certain one with outcomes that end in identical final states of wealth. Individuals continue upholding the reflection effect, risk aversion in the gain domain, and risk seeking in the loss domain. EUT predicts individuals to be indifferent between choices resulting in the same expected wealth. The isolation effect again violates this.

These results are consistent and repeatable (Coombs & Huang, 1970; Björkman, 1984). PT identifies violations to EUT and further rational, risk-averse behavior is inconsistent with decision making frameworks used when individuals are faced with risky outcomes.

1.6. Value and weighting functions in a M&A framework

PT finds that individuals assess the value of a prospect on changes in wealth relative to some

reference point as opposed to final states of wealth as purported by EUT, and further, these changes in wealth are evaluated in terms of individually assessed decision weights and not on empirical probabilities.

The value function is defined for a regular [neither strictly positive nor negative gamble] prospect as:

$$V(x, p; y, q) = \pi(p)v(x) + \pi(q)v(y),$$

where V – prospect value, π – decision weight, v – outcome value, p – empirical outcome probability and $q = 1 - p$.

The weighting function is $\pi(p(x)) + \pi(1 - p(x)) \leq 1$, where π – individually assessed decision weight and $p(x)$ – empirical outcome probability. Investors thus skew their perception of probabilities based on individual assessments of the outcome of any prospect compared with the individuals biased reference point (Kahneman & Tversky, 1979). Tversky and Kahneman (1992) developed cumulative PT and confirmed that individuals disregard extremely low probability outcomes as impossible a $p(x) = 0.10\%$ weighted $\pi(p) = 0$ and extremely high probabilities as certain $p(x) = 99.999\ldots\%$ weighted $\pi(p) = 1$.

The value function's shape leads to behavior generalizations, which show that individuals are risk-averse when faced with positive outcomes, risk-seeking when faced with negative outcomes, and that the probability of a loss weighs more than its positive counterpart. The reflective risk preferences of individuals are important to M&As, because managerial behavior may be modelled which embrace implicit dependence on the PT framework.

Value and weighting functions behave such that limits on information access about individual preferences make it impossible to assess each person's unique value and weighting functions. However, generalizations can be drawn from PT that allow the information privy only to a firm's management to be assessed. Kahneman and Tversky (1979) identified that managers tended to be more willing to undertake risky gambles

for which they were considered experts. Our further research involves assessing more accurate probabilities of success or loss for a firm's investment decision making and adjusting expected returns of M&A majority firms to assess future share prices of the major party to the transaction².

1.7. The CAPM

The CAPM model assumes that investors are rational, risk-averse, utility maximizers who assess expected asset returns on the same one period time horizon using homogenous expectations with regards to the probability distribution of risky outcomes. It also assumes that investors have access to the completely diversified market portfolio and some risk-free asset, which compresses all preferences into a decision to weight between the fully diversified market portfolio and the risk-free asset. The CAPM function is $r_e - r_f = \alpha + \beta(r_m - r_f)$, where r_e – expected return on equity $E(r)$, β – equity beta, r_m – market return, r_f – risk free rate and α – excess return generated above compensation for systematic risk. The CAPM assumes investors would expect no more compensation than that for non-diversifiable risk.

Research shows that rational, risk-averse, utility maximizing behavior is inconsistent with human behavior under risky gambles. PT identifies a set of framing effects that contradict the CAPM's assumptions. These findings motivate our hypothesis that the CAPM inadequately predicts future asset prices.

1.8. The CAPM in M&As

Bruner (2004) notes the prevalence of the CAPM as the industry standard model used to assess returns due from a merger or acquisition transaction. Such preferences are unfounded and neglect inherent cognitive biases displayed in investor behavior discussed above. Managers are prone to framing effects identified in PT, and their assessment of returns to equity using the CAPM should be expected to inaccurately represent the true risk of a given transaction.

1.9. Management incentives and shareholder value

Classical Capital Budgeting Theory and Modern Portfolio Theory proposit that the goal of a firm is to maximize shareholder value (Lazonick & O'Sullivan, 2000) and that management behavior is aligned consistent with a risk-averse, utility maximizing shareholder. Agency theory asserts that value maximising management is a case-by-case dependent occurrence (Main, 1995). CEOs who do not hold large amounts of their employer's stock exhibit higher risk-taking behavior in capital budgeting decisions. Incentives to maximize short-term share price fluctuations would be strong in a low stock ownership management model, as management compensation is directly correlated with share price performance when managers do not hold their firm's stock (Fama & Jensen, 1983). A corollary is that a high stock ownership management model must induce a more risk-averse manager, regardless of potential earnings from short-term share price increases, since more current wealth is at risk.

These considerations are consistent with PT's certainty effect – the surety of maintaining wealth to a manager who holds their firm's stock is more valuable than the increases in their earnings should they act to increase share prices in the short term. The converse also holds: managers holding insufficient wealth in stock increase their short-term compensation despite a large likelihood of the total loss in future wealth (by becoming unemployed). Studies of share prices following M&A activity show significant price moves in either direction (MacKinlay, 1997). Whether M&A activity is indicative of managers who deviate from rational, risk-averse, shareholder value maximizing behavior³ is of interest.

1.10. Market efficiency and the access to information

Both the weak and semi-strong form of the efficient market hypothesis are supported by cross-sectional and time series regression tests of price movement and share returns. The strong form, howev-

² The firm with the greatest market capitalization in a merger, or the firm attempting to buy-out another in an acquisition.

³ If investors are utility maximizers, they prefer more wealth to less regardless of risk appetite. An increase in the value of a financial security held is tantamount to increased wealth (Markowitz, 1952).

er, does not enjoy such support when the ability to generate superior risk adjusted returns from anomalous trading strategies are tested for significance against market returns. We conclude that there must be present hidden information inaccessible to market participants that causes firm asset mispricing. Parties to M&As undergo lengthy analytical processes before announcement and conclusion of transactions: insiders may have access to information that external participants do not.

The CAPM is an equilibrium model of asset returns, reliant on a market that is informationally efficient. M&As violate this assumption. Skews in information availability should lead to invalid perceptions of stock price returns and risk, and we later test the presence of such inefficiency by comparing investors' perception of M&A acquirer firm risk compared to the market overall. Inefficient markets further justify an approach to an adjusted CAPM that incorporates behavioral biases.

2. DATA AND METHODOLOGY

2.1. Empirical test of CAPM

Strong support has been gleaned for rejection of the CAPM and implementation of PT. Niu and Zeng (2017) observed discrepancies between shareholder beliefs and those of management when considering capital allocation decisions and prospective undertaking of risky projects.

We assess whether the CAPM predicts prices that correlate with long-term real stock prices during M&A intensive periods. Should the CAPM not be a strong price predictor, there will be enough reason to continue with a confirmation of a deviation in investor attitudes to risk that should prevail when observing a M&A intensive firms under normal Markowitz efficient conditions.

2.2. Model market

We constrain our analysis to markets, which have been historically heavy in M&As, for which there are many data on several disparate companies, on US-listed exchanges (NYSE, NASDAQ and the S&P500). The US presents an extremely developed capital market, which has undergone multiple

waves of M&A and as such data from this market presents opportunity for analytics that are applicable to the global economy (Bousquin, 2017).

We aim to test the CAPM for accuracy, so we choose firms that underwent M&As in a chosen period and observe if their long-term share prices deviated significantly from the expected value according to the CAPM. We focus on 29 firms that were active majority participants (majority meaning the firm that is either the greatest in market capitalization or the firm that is the buying party to the transaction) in M&A transactions spanning a 30-year period from 1980 to 2010.

2.3. Kalman filter β

Most estimates of the CAPM β rely on linear regression, but its robustness has been questioned (Thomson & van Vuuren, 2018).

The Kalman filter is a recursive procedure for computing the optimal estimator of the state vector at time $t+1$, based on information available at time t (Kalman, 1960), which provides a linear estimation method for equations represented in a state space form. Output is generated from measurement and transition equations, which depend on the form of stochastic process that the time-varying α s and β s are assumed to follow. The random walk model provides robust characterization of time-varying β s (Faff, D. Hillier, & J. Hillier, 2000) implying that market exposure is a normally-distributed random variable with mean equal to the exposure of the previous period, i.e. at $t-1$. Uncorrelated system noises are also normally distributed. The state variables $x_t \in \mathbb{R}^2$ are time-varying coefficients:

$$x_t = \begin{bmatrix} \alpha_t \\ \beta_t \end{bmatrix}$$

at each time t . The state equation is:

$$\begin{bmatrix} \alpha_{t+1} \\ \beta_{t+1} \end{bmatrix} = \begin{bmatrix} \alpha(t+1) & 1 & 0 \\ \beta(t+1) & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \alpha_t \\ \beta_t \end{bmatrix} + \begin{bmatrix} \alpha(t) \\ \beta(t) \end{bmatrix} \begin{bmatrix} \gamma \\ \delta \end{bmatrix},$$

where

$$\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{bmatrix} \sigma_\gamma^2 & 0 \\ 0 & \sigma_\delta^2 \end{bmatrix} \right] \gamma \sim N \left(\left[\begin{pmatrix} \sigma_\gamma^2 & 0 \\ 0 & \sigma_\delta^2 \end{pmatrix} 0 \right], \begin{bmatrix} \sigma_\gamma^2 & 0 \\ 0 & \sigma_\delta^2 \end{bmatrix} \right).$$

The measurement equation is

$$r_t^P - r_t^f = \begin{bmatrix} 1 & r_t^M - r_t^f \end{bmatrix} \begin{bmatrix} \alpha_t \\ \beta_t \end{bmatrix} + \varepsilon_t$$

(Jain, Yongvanich, & Zhou, 2011).

2.4. CAPM regression analysis

Utilising the Kalman β , the expected value of any stock according to the CAPM is $E(S_t) = S_0(1 + r_e)^n$, where S_t – expected end of period price, S_0 – start period price, n – number of compounding periods and $r_e - r_f = \alpha + \beta(r_m - r_f)$.

If the CAPM is an accurate price predictor, then a strong linear relationship between the CAPM $E(S_t)$ and the real price of a stock at the end of a period should be observed (denoted S_p). A hypothesis test of the correlation between S_t and S_p should lead to a strong positive linear relationship.

Our method follows Thomson and van Vuuren (2018) who used rolling β and α values calculated from the Kalman filter β estimation method to test the correlation between the historical CAPM model and the Kalman filter model. The Kalman filter was shown to be a superior predictor of returns compared with linear regression. We calculated the market risk premium and estimated future prices on a rolling daily basis across 29 firms listed contained in the S&P500 index, presenting the expected share price as the compounded value of the share price a month prior using the r_e calculated at the date of the old share price, and tested this against the observed prices of those firms on each day.

The test parameters are (Underhill & Bradfield, 1996): the null hypothesis $H_0: p = 0$, alternative hypothesis: $H_a: p \neq 0$. Level of significance: $\alpha = 5\%$, degrees of freedom: $n = 200$ and critical values: $(-13.81\%; +13.81\%)$.

UT assumes investors are rational, risk-averse, and can access all public and private information on any traded security (Kahneman & Tversky, 1979). Empirical evidence shows this is false (Fama, Fisher, Jensen, & Roll, 1969). PT asserts that when faced with decisions under risk, individuals' frame'

the probability of events to underweight empirical probability of extreme losses and underweight the probability of further gains. This results risk-seeking behavior in the loss domain, and risk-averse in the gain domain. The risk attitudes attained in PT are inconsistent with UT's assumption of risk-averse investors. We aim to show that firms who regularly undergo M&A transactions are not efficiently assessed by investors when UT and the CAPM are used as governing asset pricing models.

2.5. Implied volatility as a test for irrational markets

The VIX is an indicator of investor sentiment of stock price volatility. An 11-share portfolio of mid to large cap S&P-listed firms who underwent M&As in the period from March 1, 1994 to December 28, 2017 was constructed creating an aggregated implied volatility portfolio of equal weighting. An F -test was used for significance, a pairwise t -test, and a χ^2 goodness of fit test, all with significance of 5%.

2.6. Modelling financial distress using logistic regression

Logit models that use accounting ratios are strong predictive models for future operations of firms that undergo M&As (Castagna & Matolcsy, 1985) and are ideal candidates for approximating financial distress to firm value based on M&A activity.

2.7. Appropriate inputs to the logit model

M&As result in the consolidation of two different firms' revenue streams (Bruner, 2004). We posit that accounting revenue should, when a firm is undertaking successful M&A projects, show an increasing trend over time. Revenue is the operational income of a business, and consistent, stable increases to revenue are value-accretive. We define the binary event as a decrease in a firm's revenue compared with its mean revenue of all prior reported years.

The events $E(\text{Loss in Revenue}) = 1$ and its antithesis $E(\text{Loss in Revenue}) = 0$ are defined.

We assert this is an unbiased loss indicator to firm value. Managers with low stakes in their firm

seeking to maximize short-term share prices to elicit higher compensation have no incentive to report losses in accounting earnings and vice versa. These facts neutralise the certainty effect of PT. A bias free indicator makes the associated probability of loss to shareholder value more reliable.

PT proports that individuals assess multiple stage prospects that have dependent outcomes with disregard to prior information or the results of choices already made (the isolation effect (Kahneman & Tversky, 1979)). We hypothesize an explanatory variable that indicates the activity of managers who disregard results of past transactions, i.e.

$$\frac{\text{Cumulative number of transactions}}{\text{Cumulative number of years between transactions}}.$$

Our goal is to identify the probability of risk to shareholder value for which PT theoretically indicates is presently under or over represented by firms that undergo M&As and incorporate it into a premium that adjusts the CAPM expected return to account for such risk. We apply our method to 19 of the original CAPM test firms across the period from 1980 to 2018.

2.8. Adjusting the CAPM for PT using the results of Logistic Regression

Clere and Marande (2018) adjusted CAPM returns for financial risk using⁴ $\hat{r} = E(r) + \Pi_d$, where \hat{r} is the adjusted return, $E(r)$ is the CAPM return, and Π_d is the default risk premium (PT premium).

The default risk premium is

$$\Pi_d = (1+r) \left(\left(\frac{1}{r\sqrt{S_e}} \right) - 1 \right).$$

With $S_e = 1 - d \cdot (1 - R)$ and Loss Given Default (LGD) $= d \cdot (1 - R)$, d is the probability of loss $p(x)$, and R is the recovery rate.

This model corrects an under or overstated CAPM return by the financial risk premium and is useful if the premium identified by logit regression

yields a closer linear approximator of share prices than the Kalman filter. If differences are not significantly different, this would not mean that PT is not a viable alternative to the CAPM. Instead, we assert that the Kalman method will have incorporated the premium for value loss risk attained from the logit regression of our loss events.

We modify S_e to $S_e = 1 - p(x) \cdot E(r)$ for $E(r) > 0$, and $S_e = 1$ for $E(r) \leq 0$. $\Pi_d = \Pi_{PT}$ is the risk premium. Then, the true return is $\hat{r}_{PT} = E(r) + \Pi_{PT}$.

There is a considerable drawback in our testing method. The LGD is calculated from information on firm assets, credit scores, and the laws of the countries in which a firm's credit contracts are governed. When considering the expected LGD to stock prices on a short-term basis, we note that stock prices tend to follow a random walk over short periods (Hull, 2010). We argue that because all firms were not bankrupt (i.e. shares not delisted), expected losses present two states, for $E(r) > 0$, shareholders expect to retrieve capital gains on their firm holdings proportional to $E(r)$. We simplify the loss in this instance to be to the expected return, for $E(r) \leq 0$, shareholders expect to lose capital value. Here, no premium need be accounted for because incorporating a negative expected return into the variable S_e results in values > 1 , intuitively impossible, because they are constrained to a maximum of 1 (Clere & Marande, 2018).

3. RESULTS

3.1. Results of the CAPM test

The correlation between the CAPM expected price and the actual price for all firms was 13.85% ($> 13.81\%$), statistically significant at 5%. These data imply a weak positive linear relationship between predicted and actual prices of M&A intensive firms. The poor predictive power of the CAPM indicates that PT is potentially explanatory of deviations from EUT and the CAPM when assessing M&A transactions (see Figure 2).

4 This is a simplified model that ignores three other risk premiums.

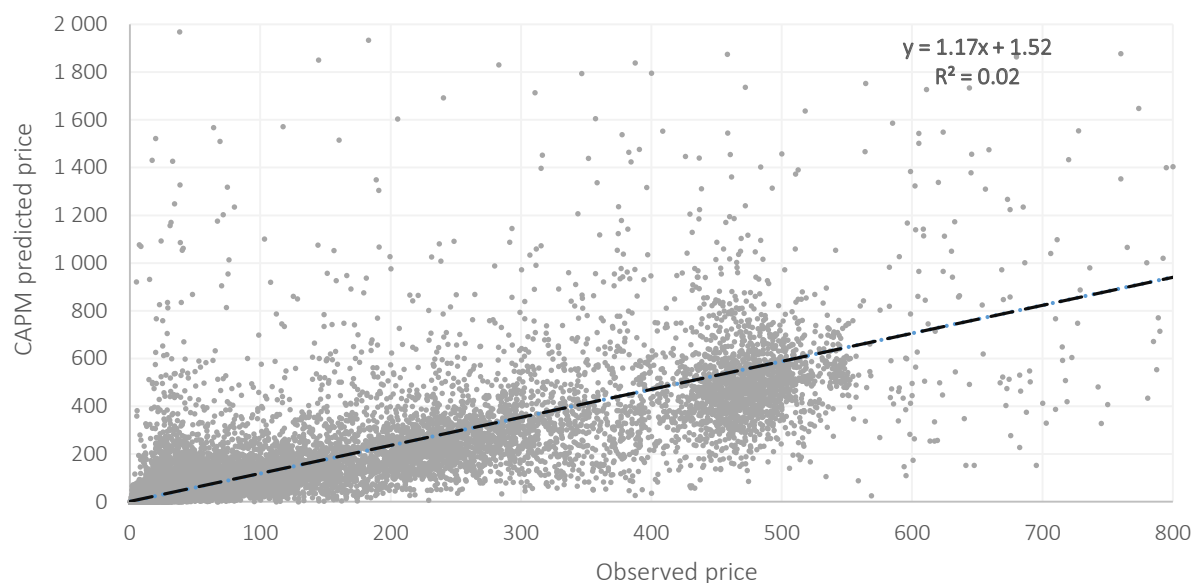


Figure 2. CAPM predicted asset prices vs actual observed price

4. RESULTS OF IMPLIED VOLATILITY TEST

Figure 3 illustrates the observed relationship between implied portfolio volatilities and the market.

The null hypothesis for the F -test (that variances of the M&A portfolio and the VIX were equal), the t -test (that there was no significant difference between the M&A portfolio and the VIX), and the χ^2 test (that the M&A portfolio was dependent upon the VIX) were all rejected. The M&A portfolio was neither clearly related to nor modelled by the VIX.

No single trading day resulted in the VIX displaying a higher implied volatility than the model portfolio. This indicated that investor sentiment not only always viewed the M&A portfolio as more volatile than the market on average, but if investors were rational (assumed in efficient models), then this result contravenes the notion that a well-diversified portfolio should only be representative of its market risk (Sharpe, 1964), and indicates either that investors identify a risk-taking behavior by an M&A engaging firm's management relative to the normal market risk. Conversely, if a firm's management acts in accordance with risk-averse shareholder preference, volatility perceptions priced into M&A engaging firms share prices are irrational. A third case is that both instances are true. Since one of these must be true, either the

axiom of investor rationality in UT, or the assumption of managerial focus on shareholder value creation consistent with risk-averse attitudes, is violated.

We find that capital market participant behavior and asset price movements are consistent with the results of Kahneman and Tversky's (1979) PT. Markets are Markowitz irrational, and asset pricing models that assume rationality are flawed when assessing M&A participant expected share prices. The implied volatility portfolio showed that despite the individual nature of industries and firm operations, market participants assessed M&A projects as more volatile, consistent with the tenet of PT that the probability of loss weighs more than the probability of gain. Individuals are averse to share price losses that could result from M&As and show bias when pricing in this perceived risk.

The CAPM β , despite its use as a benchmark measurement of firm risk by both internal managers and shareholders, has been shown to be a poor predictor of firm share price movements (Thomson & van Vuuren, 2018). Managers and shareholders indicate biased assessments of the risks a firm faces when undergoing M&As. PT is therefore a viable candidate, which could adjust the CAPM $E(r)$ to account for firm-specific risk when market prices are a function of investor sentiment and managerial decision making (as is the case of firms that undergo M&As).

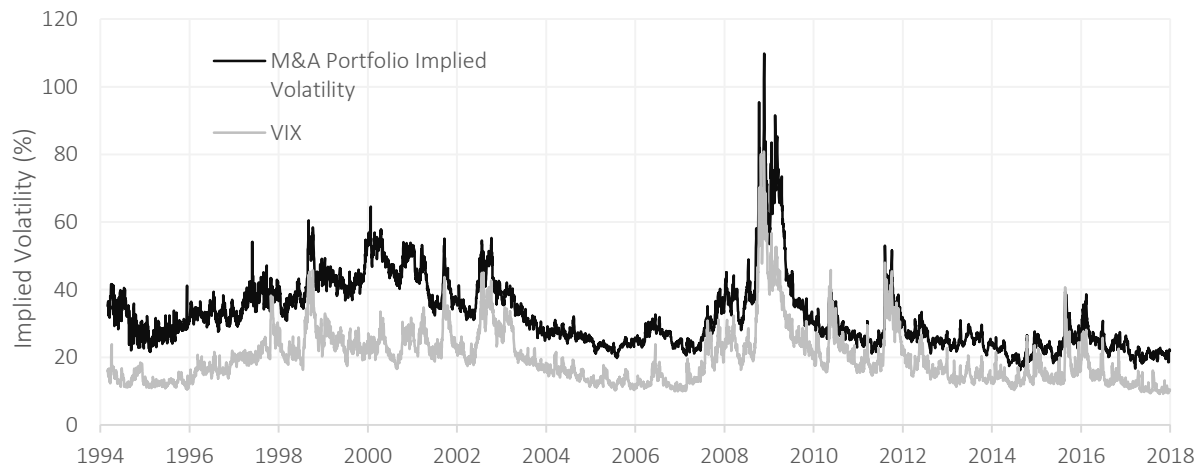


Figure 3. M&A portfolio implied volatility and VIX index

4.1. Logit regression

Table 2 summarizes our results.

Table 2. Results of logit curve regression of loss to revenue and IE

Results	β_0	β_1
β	-2.490	0.096
Standard error (SE_{β})	0.255	0.023
T-score	-9.75	4.15
p-value	0.000%	0.003%
Pseudo R^2 /#iter	0.069	6
LR-test/p-value	16.4	0.00
$\ln(L)/\ln(L_0)$	-110.4	-118.6

The logit curve is shown in Figure 4.

Our explanatory variable is significant at the level $p = 0.5\%$.

4.2. Adjusted CAPM test

We find corrections occur when the CAPM predicts positive returns, and while it does not encompass negative expectations, it should correct returns in the positive domain. Table 3 presents the regression analysis results.

Table 3. Correlation of adjusted CAPM returns to actual share prices

Parameters	Kalman filter CAPM (no adjustment)	PT adjusted CAPM
ρ	13.8450%	13.8452%
R^2	1.9168%	1.9169%

The Kalman filter is a robust predictor without needing the prescribed Π_{PT} adjustment. It should not be concluded that PT has been debunked as a

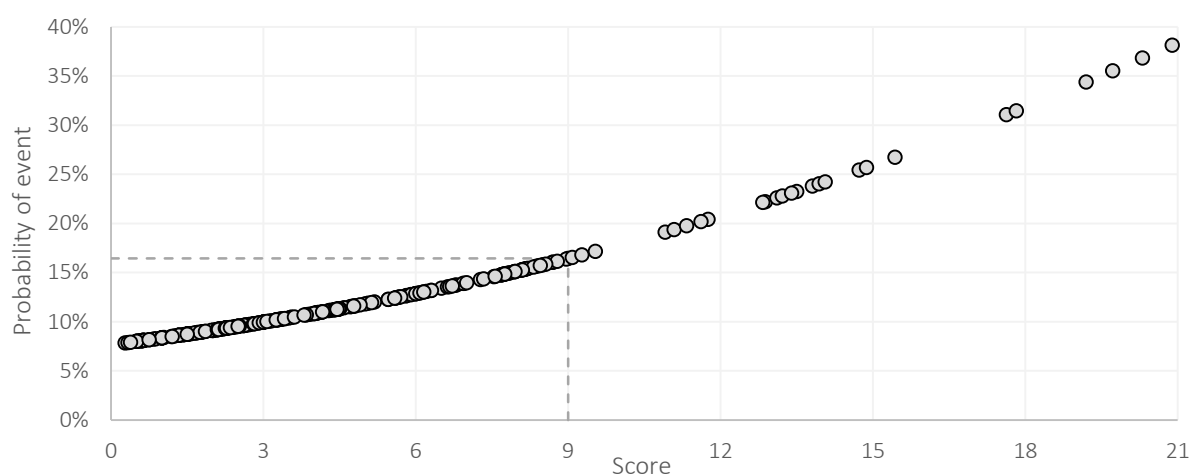


Figure 4. Logit curve regression for the probability of loss in revenue

means of pricing firm specific risk of M&A intensive firms. The logit model is a significant estimator for the probability of loss, and both our theoretical arguments from the literature review and analysis indicate that PT's framing effects should be an important consideration in the assessment of M&A firm risk. An important deduction is that

the Kalman filter, which was justified as a superior estimate of time-varying β (Thompson & van Vuuren, 2018), already incorporates the risks that PT would identify, but from a top-down assessment of share price behavior against the market proxy as opposed to the bottom-up approach used in this research.

CONCLUSION

The Kalman filter provides a robust tool for β estimation. Corporate finance, risk and portfolio management, trading strategies are far more reliant on β when calculating asset returns. Our findings justify that the Kalman filter is useful to such practitioners, as it requires information that is easily accessible, cheap, and incorporates human behavioral risks (identified by PT).

The logit model assesses a firm's exposure to the risk inherent in the cognitive biases of a firm's employees. This has applications for both external investors wishing to limit exposure to certain probabilities of loss, and to internal firm employees involved in the compliance and risk management of their firm operations.

The efficiency of the Kalman filter is under the light of our research undeniable and expected from the research done by Thompson (2018) – yet we prescribe that further testing into an explanation into the low correlation of the CAPM β 's prediction of share prices to actual long-term share prices is warranted. This work focused on a single variable indicative of losses to shareholder value, but several other values affecting indicators may be identified in public accounting data that would be identified by the framing effects of PT.

We sought a practical application of Kahneman and Tsversky's (1979) PT for use in the estimation of expected returns to firms that are the acquiring or majority party to a merger or acquisitions transaction. It was shown that EUT was not an accurate account of human behavior when individuals are faced with risky outcomes, and we argued that both executive managers and investors behaved in a way that was contradictory to the tenets of UT and the CAPM. Baker (2012) highlights the importance of considering prospect theory reference points in the pricing of M&A transactions.

We developed a method for using publicly available accounting data, which identified idiosyncratic probabilities of loss faced by firms involved in M&As. Despite our results showing clear indicators of firm specific risk based on the M&A activity of its managers, our results did not significantly outperform the results of the Kalman filter β estimation method.

Further research in applied prospect theory alongside the methodology we present for developing risk factor loads could aid professional investors when making strategic portfolio allocation decisions, allowing for more accurate expectations of risk and return. Leveraged finance providers to M&A can also benefit from more accurate assessments of firm specific risk, with Basel IV coming into effect, and the shift of international accounting standards to IFRS 9's forward looking provisioning for loss with a client centric behavioral view (Bernhardt, 2014), quantitative methods that incorporate behavioral economics will confer more robust risk governance strategies to banks.

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