Estimating the Market Value of Franking Credits in Australia

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ESTIMATING THE MARKET VALUE OF FRANKING CREDITS: EMPIRICAL EVIDENCE FROM AUSTRALIA

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ESTIMATING THE MARKET VALUE OF FRANKING CREDITS: EMPIRICAL EVIDENCE FROM AUSTRALIA

Abstract

The market value of franking credits, known as theta, is an important input for estimating the weighted average cost of capital in Australian regulatory decisions. There is, however, a lack of consensus on an appropriate estimate of the market value of franking credits. This paper attempts to estimate the market value of franking credits using a dividend drop-off methodology. A list of 2,595 unique tickers was compiled by observing stocks listed on the ASX during the period 1 July 2001 to 1 July 2012. Dividend distribution events from 1 July 2001 to 1 July 2012 were obtained and a dividend sample was constructed using filters identified in literature on the topic. Regression techniques and parametric forms of the dividend drop−off equation were also sourced from relevant literature. Initial estimates of the value of theta were calculated, and then a sensitivity analysis was performed to ascertain the robustness of the estimates. It was found that due to the high multicolinearity between the net dividend and the franking credit, precise estimates of theta could not be readily obtained. . Because of this, it may be more appropriate to use a range for the value of theta rather than a derived point estimate. The appropriate range suggested by this study is between 0.35 and 0.55.

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I Introduction

Personal taxes impact the required rate of return an investor requires on both equity and debt. It is the post-tax (as opposed to pre-tax) rate of return that investors consider when evaluating investment opportunities. As a consequence, it is vital to consider the implication of personal taxation on the WACC estimate. Specifically, given that Australia has an imputation tax system; its impact on the required return to equity must be considered.

The purpose of the imputation tax system is to avoid corporate profits being taxed twice. Previously, company profits were taxed at the corporate level, and taxed again in the form of dividends paid out to shareholders as personal income tax. Under the Australian imputation tax system, a franking credit is distributed to individuals with dividends to offset personal taxation liability. The franking credit represents the amount of personal taxation already paid at the corporate level. Imputation credits in Australia have a face value of one dollar per credit which can be claimed as a rebate to offset personal tax liabilities. Since the 1st July 2000, a refund on any excess credits over personal tax liabilities can be claimed. It is important to note that international investors cannot utilise imputation tax credits. As such, imputation tax credits provide benefits to Australian investors only.

Any value generated by the presence of franking credits in the Australian tax system must be accounted for in the required return to equity, and in turn the weighted average cost of capital. Investors would be willing to accept a relatively lower required rate of return on an investment that has franking credits compared with an investment with similar risk and without a benefit of franking credits. The precise value investors place on franking credits is ambiguous, given that individual investors have differing taxation circumstances and personal franking credit valuations.

II Theoretical Background

(i) Gamma in the Weighted Average Cost of Capital

Franking credits represent a rebate which reduces personal taxation liabilities. As franking credits alter the effective after-tax return on an equity investment; franking credits will alter the required return on equity an investor requires. An early theoretical framework presenting how franking credits alter the after-tax cost of capital was proposed by Officer (1994). The operating income (or Earnings before Interest and Tax, (EBIT) of a company is defined as follows:

$$X_0 = X_G + X_D + X_E \tag{1}$$

where X_0 is the operating income, X_G is the government's share of operating income (i.e. company taxation), X_D is the debt holders' share of operating income and X_E is the equity holder's share of operating income.

The amount $T \times (X_O - X_D)$ is the amount of company taxation collected from the company by the government. However, a proportion of this amount, which is defined as γ (gamma), represents the tax collected from the company which will be rebated against personal income tax. It is convenient to consider gamma as the proportion of personal income tax collected at the company level. As a consequence, the effective company taxation is defined as:

$$
\begin{aligned}
X_G &= T(X_O - X_D) - \gamma T(X_O - X_D) \\
&= T(X_O - X_D)(1 - \gamma)
\end{aligned}
\tag{2}
$$

Therefore, in this representation, gamma is the proportion of tax collected from the company which gives rise to franking credits. Gamma can be considered as the proportion of company tax that is used as prepayment of personal tax liabilities (Hathaway &Officer 2004).

Substituting (2) into (1) yields:

$$X_0 = T(X_0 - X_D)(1-\gamma) + X_D + X_E \tag{3}$$

Solving for X_0:

$$X_0 = \frac{X_E}{(1-T(1-\gamma))} + X_D \tag{4}$$

The weighted average cost of capital can be derived from (4) via the perpetuity definitions of value. Let

$$E = \frac{X_E}{r_e}, \ D = \frac{X_D}{r_D} \text{ and } V = \frac{X_O}{r_O}$$

where E is the value of equity, r_e is the required rate of return to equity holders after-company tax but before-personal tax, D is the value of debt, V is the sum of debt and equity, r_D is the required return to debt holders after tax, r_O is the required return before taxes or the before-tax weighted average cost of capital (WACC).

Substituting these definitions into (4) yields the before-tax cost of capital:

$$r_o = \frac{r_e}{(1-T(1-\gamma))} \cdot \frac{E}{V} + r_d \cdot \frac{D}{V} \tag{5}$$

The impact of franking credits on the WACC is therefore through the value of gamma.

The WACC is considered as the firm's weighted average cost of capital that represents the average return the firm must pay to its investors (both debt and equity) to fund its assets. Given that equity holders consider the value of franking credits when evaluating investment opportunities, their value must be accounted for when calculating the required return of equity an investor requires.

(ii) Interpretation of Gamma

Gamma has the interpretation of being the proportion of the company tax collected that will be rebated against personal tax. Gamma is the product of two components (Monkhouse 2008):

- the fraction of imputation credits created that are assumed to be distributed to shareholders (F); and-

- the market value of imputation credits distributed as a proportion of their face value (θ).

$$\gamma = F \times \theta \tag{6}$$

Officer (1994) argued that F is equal to one when considering the cash flows from equity in perpetuity. In perpetuity, all dividends and thus the corresponding franking credits must eventually be paid out in each period.

An alternative approach outlined by Monkhouse (1996) incorporates the time value discount associated with the retention of imputation credits into the definition of gamma:

$$\gamma = F \times \theta + (1 - F) \times \psi \qquad (7)$$

Where: $\psi < \theta$ due to the time value loss associated with the retained franking credits.

This specification recognises the fact that not all dividends and imputation credits will be paid out in each period and as such, in perpetuity, the loss associated with time value must be accounted for. Given the extreme difficulty in estimating the time value discount of retained franking credits, equation (6) is used to calculate the value of gamma for the purposes of estimating the WACC.

Empirical evidence suggests the annual payout ratio of a company in Australia is 0.71 (Hathaway & Officer 2004). As a consequence, 71% of the return of equity is assumed to be in the form of dividends with corresponding franking credits attached. Therefore, it is assumed that 71% of all imputation credits are distributed to shareholders in the same year they are created. This is the main evidence cited in choosing the value of the payout ratio for the calculation of gamma.

The market value of franking credits, θ, can be defined as how much an investor would be willing to pay for obtaining franking credits, as a proportion of their face value. It is the reduction in investor's personal taxes that determines the value investors place on franking credits. Investors who fully value franking credits have a personal theta of 1; whilst investors who place no value on franking credits have a theta of 0. As a consequence, the value of theta has a theoretical interval of $0 \leq \theta \leq 1$. For the purposes of calculating a firm's WACC, the appropriate value of theta must represent a weighted average of all investor's individual valuations of franking credits. Investors would be willing to accept relatively lower required rates of return on equity investments if it comes attached with franking credits. Each investor would accept different required rates of return, based on their own personal franking credit valuation. As a consequence, this average required rate of return depends on the weighted average of each investor's personal franking credit valuation.

Investor's will value franking credits less than their face value. In order to qualify for franking credits, investors must take on risk by purchasing and/or holding stocks. In addition, domestic investors forgo the benefits of international diversification and incur transaction costs by qualifying for franking credits. International investors, who cannot utilise franking credits to reduce their personal taxation liability, place no value on franking credits. As a consequence, investors will on average value franking credits at less than their face value. Unfortunately, franking credits are not tradable, and prices are not directly observable. However, the market value of franking credits can be inferred by observing how the market price of stocks reacts upon the distribution of dividends and franking credits. In this situation, the stock price will be reduced by the market value of both the cash dividend and franking credit paid. Econometrics can then be employed to distinguish the component of the price drop off due solely to the value of the franking credits. By performing this analysis over a long period of time and across a large number of dividend events, an average market valuation of franking credits can be obtained.

(iii) Dividend Drop Off Studies

Dividend drop-off (DDO) studies involve examining how much a firms stock price changes after going ex-dividend. DDO studies are based on the assumption of perfect capital markets in which there are no transaction costs, no differential taxation between dividends and capital gains, and that share prices are not subject to any other influence other then the distribution of dividends and franking credits. The theory of arbitrage predicts that in this situation, the expected reduction of the share price from cum-dividend day to the ex-dividend day (the price drop off) should equal to the gross dividend

which includes the value of the cash dividend and the value of the franking credit. However, the assumption of perfect capital markets is unlikely to hold in reality. In addition, given that investors will not fully value the combined package of the gross dividend, the expected price drop-off should be less than that of the face value.

Formally, this assertion can be expressed as:

$$E \mid P_{c,i} - P_{x,i} \mid = \gamma_1 D_i + \gamma_2 FC_i \tag{8}$$

Where $E \mid P_{c,i} - P_{x,i} \mid$ is the expected price drop-off from the cum-dividend day price $P_{c,i}$, to the ex-dividend day price $P_{x,i}$. γ_1 is the value investors place on the cash dividend (also referred to as the net dividend) D_i, as a proportion of its face value. γ_2 is the value investors place on the franking credit FC_i, as a proportion of its face value.

To estimate the values of γ_1 and γ_2, regression procedures are employed by collecting data on historical dividend events. The regression equation to be estimated is:

$$P_{c,i} - P_{x,i} = \gamma_1 D_i + \gamma_2 FC_i + \varepsilon_i \tag{9}$$

Where ε_i is an error term designed to capture all other factors that influence the DDO outside of the cash dividend and franking credit. It is assumed that ε_i is a normally distributed random variable with $E[\varepsilon_i] = 0$.[1]

Equation (9) and its variations are used to estimate the values of γ_1 and γ_2 using regression analysis. The impact that the net dividend and franking credit has on the price drop-off, γ_1 and γ_2 can be interpreted as the market value of each respectively.

It has been noted that DDO studies are vulnerable to heteroscedasticity (Beggs & Skeels 2006), multicolinearity (Mckenzie & Partington 2010), and the presence of outliers (Beggs & Skeels 2006). Heteroscedasticity refers to the non-constant variance of the error term. In particular, the variance of the error term is conditional on another variable related to the observation. Formally, heteroscedasticity can be expressed as:

$$\mathrm{Var}[\varepsilon_i \mid x_i] = \sigma_i^2 \tag{10}$$

where x_i is a variable related to observation i.

In the context of DDO studies, the variance of the error term is assumed to be related to the size of the cum-dividend price or the size of the dividend. In order to perform Ordinary Least Squares (OLS) analysis, a constant variance term (or homoskedasticity) is required. Performing OLS in the presence

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[1] *The combined value of the net dividend (D_i) and franking credit (FC_i) is referred to as the gross dividend, (G_i).*

of heteroscedasticity will result in an estimator with a large variance, and incorrect standard error (Hill, Griffiths and Lim 2008).

Multicolinearity is often cited as another issue in the DDO studies. Multicolinearity refers to the situation where a linear relationship exists between the explanatory variables. Specifically, the explanatory variables are correlated and tend to move together. Multicolinearity is a problem in that the data set does not contain enough information in order to estimate the individual effects of the variables in the model precisely. Multicolinearity causes an increase in the standard errors of the estimated regression coefficients, which implies less precision in the resulting estimate. The consequences of multicolinearity arise if the purpose of regression is explanation; that is to explain the individual effect each dependent variable has on the independent variable. If the purpose of regression is prediction, multicolinearity is not an issue as there is no need to separate out the independent effects of the correlated variables. It is well documented that in situations where extreme multicolinearity arises, it is nearly impossible to separate the impact that the independent variables have individually on the dependent variable (Berry & Feldman 1985). Multicolinearity can cause the estimated model to be extremely sensitive to changes in the underlying sample, regression technique used or the parametric form[2] applied to the data (Berry & Feldman 1985).

In dividend-drop off studies, multicolinearity arises from the fact that the franking credit is calculated from the size of the net dividend as follows:

$$FC_i = \frac{t_c}{1-t_c} D_i \times f_i \qquad (11)$$

where t_c is the corporate tax rate, f_i is the franking proportion[3] and D_i is the net dividend.

In the situation where all dividends are fully franked, $f_i = 1, \forall i$ perfect multicolinearity exists and it is impossible to estimate the value of franking credits. In practice, as some dividends are either partially franked or have no franking, it is possible to estimate the value of franking credits. However, because most dividends are fully franked, there exists an extremely high degree of correlation between the cash dividend and the franking credits. As a consequence, it becomes difficult to differentiate the influence on the price drop off separately.

The presence of outliers is cited as another weakness of DDO studies (McKenzie & Partington 2010). Outliers can have a large disproportionate influence on the regression coefficients, masking the underlying trend of the rest of the data. Outliers are distinct from heteroscedasticity in that they are not simply the result of a large variance, but rather indicate the inadequacy of the current model in explaining the data. Excluding outliers based on their influence on the regression coefficient can be seen as a form of data mining, which may exclude important information from the analysis. An alternative introduced by Truong and Partington (2006) is to utilise various forms of robust regression; regression techniques that are not heavily influenced by the presence of outliers.

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[2] *The parametric form of a regression model refers to the particular form of the regression equation to be estimated. For example, multiplying equation (9) by the inverse of the cum-dividend price for each event results in a new parametric form of the model.*

[3] *The franking proportion represents the fraction of dividends that have franking credits attached to them. A franking proportion of 1 indicates that the dividends are fully franked; a 0 franking proportion indicates no franking credits are attached to dividends.*

III Previous Australian Dividend Drop-Off Studies

(i) Hathaway and Officer (2004)

Hathaway and Officer (2004) explore a slightly different parametric form of the DDO equation. Theoretically, if both the cash dividend and franking credit are fully valued, this leads to a price drop-off equal to the value of both the cash dividend and the face value of the franking credit. This situation can be represented as:

$$\Delta P_i = D_i + F_i + \varepsilon_i \tag{12}$$

Where ΔP_i is the change in stock price from the cum-dividend day to the ex- dividend day, D_i is the net dividend, F_i is the franking credit and ε_i is an error term designed to capture all other factors that influence the DDO outside of the cash dividend and franking credit.

The face value of the franking credit can be expressed as follows:

$$F_i = D_i \times (\frac{t_c}{1-t_c}) \times f_i \tag{13}$$

Where f_i is the franking proportion of the imputation tax credit, t_c is the corporate tax rate for observation i.

Substituting (13) into (12) produces:

$$\Delta P_i = D_i + D_i \times (\frac{t_c}{1-t_c}) \times f_i + \varepsilon_i \tag{14}$$

Dividing this equation by the cash dividend produces the following:

$$\frac{\Delta P_i}{D_i} = 1 + (\frac{t_c}{1-t_c}) \times f_i + \varepsilon_i^{'} \tag{15}$$

It is noted that this is the theoretical case where the value of the cash dividend and franking credit is fully valued. In the situation where cash dividends and franking credits are not fully valued, the model becomes:

$$\frac{\Delta P_i}{D_i} = a + b.f_i + \varepsilon_i^{'} \tag{16}$$

The interpretation of a is the drop-off proportion that is due to the cash component of the dividend, and b is the drop-off proportion due to the franking credit.

Hathaway and Officer noted that the error term was inversely proportional to the dividend yield. To account for this form of heteroscedasticity, equation (16) was re-weighted by the dividend yields of each dividend event to produce the following equation:

$$\frac{\Delta P_i}{P_i} = a.Div/P_i + b.Div.f/P_i + \varepsilon_i^{''} \tag{17}$$

The dividend sample was constructed by compiling a list of all dividend events for stocks listed within the ASX/S&P 500 index between August 1986 and August 2004. OLS was applied to equation (16) and (17) in order to produce an estimate of the value of franking credits over this period.

Hathaway and Officer concluded that net dividends are valued between 80 and 81 cents while franking credits are valued between 49 and 52 cents for large capitalised companies. Hathaway and Officer noted that they did not believe that their estimate of the value of franking credits was precise; however they noted that attributing a zero value to franking credits is incorrect. 4

(ii) Beggs and Skeels (2006)

Beggs and Skeels (2006) utilise the DDO methodology in order to estimate the value of cash-dividends and franking credits. Beggs and Skeels define the Gross Drop-Off Ratio (GDOR) as follows:

$$GDOR = \frac{P_C - P_X}{G} \qquad (18)$$

Where P_C is the cum-dividend price, P_X is the ex-dividend day price, G is the gross dividend. Based on the previous literature explored by Beggs and Skeels, it is expected that the GDOR<1. This implies that investors are valuing the combined package of the net dividend and franking credits at less than their face value.

The DDO methodology in their study assumes that:

$$P_{c,i} - P_{x,i} = \beta_0 + \beta_1 G_i + \varepsilon_i \qquad (19)$$

Where β_1 is the value that investors place on the gross dividend.

Separating the gross dividend of equation (19) into its components yields:

$$P_{c,i} - P^*_{x,i} = \gamma_1 D_i + \gamma_2 FC_i + \varepsilon_i \qquad (20)$$

where: $P_{c,i}$ is the cum-dividend price of dividend event i, $P^*_{x,i}$ is the market adjusted ex-dividend day price of dividend event i, γ_1 is the cash drop-off ratio, γ_2 is the franking credit drop-off ratio, D_i is the net dividend and FC_i is the face value of franking credits.

It is noted by Beggs and Skeels that DDO models suffer from heteroscedasticity. As such, OLS regression is not appropriate. Beggs and Skeels use the Feasible Generalised Least Squares (FGLS) estimator approach by modelling the variance as follows:

$$\ln \hat{\varepsilon}_i^2 = \lambda_0 + \lambda_1 W_i + \lambda_2 G_i + \lambda_3 P_{c,i} + u_i \qquad (21)$$

Where $\hat{\varepsilon}_i$ are the OLS residuals from (20), W_i is the company size of dividend event i measured by market capitalisation as a proportion of the All ordinaries Index, G_i is the gross dividend of dividend event i and $P_{c,i}$ is the cum-dividend price of dividend event i.

With this model of variance, the fitted values of the variance are calculated for each individual dividend observation:

$$\ln \widehat{\sigma}_i^2 = \widehat{\lambda}_0 + \widehat{\lambda}_1 W_i + \widehat{\lambda}_2 G_i + \widehat{\lambda}_3 P_{c,i}$$

(22)

The estimated standard deviation of each dividend event is then calculated using the estimated regression coefficients of (22). The inverse of this estimate is then used as weights in the original DDO equation (20) and OLS is then applied to the following:

$$\frac{P_{c,i} - P_{x,i}^*}{\widehat{\sigma}_i} = \gamma_1 \frac{D_i}{\widehat{\sigma}_i} + \gamma_2 \frac{FC_i}{\widehat{\sigma}_i} + \frac{\varepsilon_i}{\widehat{\sigma}_i}$$

(23)

The Beggs and Skeels study was based on the Commsec Share Portfolio data. They showed that the GDOR was significantly less than 1 with the implication that net dividends and/or franking credits are not fully valued by the average investor. Between 2001 and 2004, their estimated value was 80 cents for net dividends and 57 cents for franking credits.

(iii) Strategic Finance Group Consulting (2011)

Strategic Finance Group (**SFG**) conducted a DDO study using the Morningstar DatAnalysis database (SFG 2011). Dividend events that had data missing or a market capitalisation of less than 0.03% of the All Ordinaries Index were excluded from the analysis. Company announcements that occurred within 5 days of the ex-dividend date that were considered to be price sensitive resulted in the dividend event being removed from the sample.

SFG applied various scalings to the DDO equation in order to correct for heteroscedasticity. SFG concluded from its survey of the DDO methodology that the heteroscedasticity was directly proportional to the cum dividend price, the size of the dividend paid and the historical volatility of excess returns of the stock.[5] To control for heteroscedasticity, SFG scaled the original DDO equation $P_{c,i} - P_{x,i} = \gamma_1 D_i + \gamma_2 FC_i + \varepsilon_i$, as follows:

<div align="center">

Table 1

Parametric form of DDO equation used by SFG.

</div>

Model	Parametric Form	Scaling Factor
1	$\dfrac{P_{c,i} - P_{x,i}}{D_i} = \delta + \theta \dfrac{FC_i}{D_i} + \varepsilon_i$	D_i
2	$\dfrac{P_{c,i} - P_{e,i}}{P_{c,i}} = \delta \dfrac{D_i}{P_{c,i}} + \theta \dfrac{FC_i}{P_{c,i}} + \varepsilon_i^{''}$	$P_{c,i}$
3	$\dfrac{P_{c,i} - P_{x,i}}{D_{ii}\sigma_i} = \delta^{''} \dfrac{1}{\sigma_i} + \theta^{'} \dfrac{FC_i}{D_i\sigma_i} + \varepsilon_i^{''}$	$D_{ii}\sigma_i$
4	$\dfrac{P_{c,i} - P_{x,i}}{P_{c,i}\sigma_i} = \delta^{'} \dfrac{D_i}{P_{c,i}\sigma_i} + \theta^{'} \dfrac{FC_i}{P_{c,i}\sigma_i} + \varepsilon_i^{'}$	$P_{c,i}\sigma_i$

Where $\sigma_{i,t} := \sqrt{\dfrac{1}{N}\sum_{j=1}^{N}(er_{i,t-5-j} - \overline{er}_{i,t})}$ is the estimated standard deviation of excess returns of stock i

over N trading days, $\overline{er}_{i,t} := \dfrac{1}{N}\sum_{j=1}^{N}\overline{er}_{i,t}$ is the estimated mean of excess return of stock i over N

trading days, $er_{i,t} := r_{i,t} - r_{m,t}$ is the excess return of stock i over the market at time t and $r_{i,t}$ is the

return of stock i at time t; $r_{m,t}$ is the return of the All Ordinaries Index at time t.

Robust regressions were applied to these dividend drops off models using the MM regression estimator. SFG believed that model 4 showed the most consistent results across the robustness checks they performed. As a result, model 4 was assigned the most weight. An average estimate of theta using model 4 was produced using the various robustness checks to produce an estimate for theta of 0.35.

(iv) Summary of Australian Dividend Drop Off Studies

A more extensive summary of Australian DDO studies can be found below:

Table 2

Table 2

Summary of Australian Dividend Drop Off studies.

Author	Year	Data	Techniques	Theta
Brown & Clarke	1993	Statex, Melbourne and Australian Stock Exchange publications, 1973 - 1991	OLS Regression	0.72
Walker & Partington	1999	Securities Industry Research Centre of Asia-Pacific, 1995 to 1997	Not Specified	0.88 – 0.96
Hathaway & Officer	2004	Australian Tax Office and ASX/S&P 500, 1986 - 2004	Generalised Least Squares	0.49
Bellamy & Gray	2004	1995 -2002	Unknown	0.00
Beggs & Skeels	2006	CommSec Share Portfolio 1986 - 2004	Generalised Least Squares	0.57
SFG	2007	Securities Industry Research Centre of Asia-Pacific and FinAnalysis, 1998 - 2006	Generalised Least Squares	0.23
Feuerherdt, Gray & Hall	2010	Securities Industry Research Centre of Asia-Pacific, 1995 - 2002	Generalised Least Squares	0.00
SFG	2011	DatAnalysis, 2000 - 2010	Generalised Least Squares	0.35

The authors consider that studies carried out after 2001 are more relevant to the estimate of current market value of franking credits. As such, other studies prior to 2001 were not considered in this study.

Market value of franking credits do vary significantly across studies. It is noted that one author, Gray, was involved in 4 different studies as presented in Table 2 above, studies implemented in 2004; 2007; 2010; and 2011.

(IV) Analysis

(i) Considerations

The company taxation and imputation credit system has undergone many changes as outlined in Beggs and Skeels (2006). A holding period of 45 days is necessary for total franking credit entitlements below $5,000 to qualify for franking credits. In addition, if an investor hedges the price risk of the security using derivatives, the franking credits are unable to be used. More recently, from 1 July 2000, any excess franking credit can be rebated for cash and from 1 July 2001 the company taxation rate has been reduced from 34 to 30 percent. As a consequence, the period considered in this analysis is from 1 July 2001 to 1 July 2012 to avoid structural changes in the company tax rate and imputation credit system.

Various studies have noted that thinly traded stocks can have a confounding effect on dividend drop off regressions (Hathaway & Officer 2004, Beggs & Skeels 2006, SFG 2011). Prices must be a reflection of an efficient trading mechanism which is unlikely to be the case when a stock trades infrequently. Hathaway and Officer (2004) noted that:

'There is no obvious reason why the cash dividend for Big Cap, Mid Cap and Small Cap stocks should vary. That the results do is testament to the difficulty of estimation among these smaller stock events. Implicit in our experimental design is that stocks trade over the ex-date period, but many stocks, particularly small cap stocks, are rather illiquid.'

They concluded that large capitalisation stocks to estimate the value of theta are the most reliable. In addition, SFG(2011) and Beggs and Skells (2006) utilise a criterion of only including stocks that have a market capitalisation greater than 0.03% market capitalisation of the All Ordinaries Index. As a consequence, the dividend sample used in this analysis has been constructed using the same 0.03% market capitalisation filter. Another important filter is the removal of stocks that undergo a capitalisation change (for example, undergo a stock split) 5 trading days before or after a dividend event. This ensures that the price drop off due to a capitalisation change has no impact on the estimate of theta.

Individual special cash dividends are considered unreliable, as they are an irregular distribution of excess cash reserves. As a consequence, dividend events that are classified as special cash only were removed, consistent with other DDO studies (Beggs & Skeels 2006). However, it is common for companies to distribute a special cash dividend in conjunction with a final or interim dividend. Removing special cash dividends in this scenario would imply that the price drop off is due solely to the other dividend, creating an upward bias in the estimate of theta. Therefore, special cash dividends that occur on the same day as a normal dividend event are aggregated in order to produce a combined dividend as described by Hathaway and Officer (2004). The remaining individual special cash dividends were then removed from the sample.

Filters that exclude observations based on "price sensitive" announcements have not been utilised in this study. SFG (2011) screen dividend observations based on price sensitive announcements that occur 5 days before the ex-dividend date. The price sensitive flag for announcements is available on the ASX website. After this initial screening, SFG observe each observation and decide if the announcement will have a material impact on the stock price. Observations that have a "price sensitive announcement" close to the cum- or ex-dividend date can be considered as unbiased noise, equally likely to be positive or negative. As a consequence, removing these observations is unnecessary; doing so may introduce a subjective element to the analysis that is undesirable. In principle, data points should not be removed after the final sample of dividends has been compiled. Rather, different econometric methodologies that are not sensitive to outliers should be employed, consistent with objective statistical analysis.

(ii) Regression Techniques

It has been noted that DDO studies are extremely sensitive to the sample of dividend events included in the sample (McKenzie & Partington 2010). This is due to the assumptions of traditional Ordinary Least Squares (OLS) regression analysis being violated; specifically the non-constant variance (heteroscedasticity); and non normality of errors (presence of outliers). In addition, due to the high level of multicolinearity between the cash dividend and the franking credit, the coefficient estimates are extremely sensitive to small changes in the model or data.

In mitigating the problems that exist with outliers, regression techniques that are less susceptible to their presence will be applied. Least Absolute Deviation (LAD) estimators of linear models minimise the sum of absolute values of the residuals which can be expressed formally as:

$$\min_{\beta} \sum_{i=1}^{n} | y_i - \beta^{'} x_i | \tag{24}$$

Where y_i is the response variable of observation i; β is a vector of regression coefficients to be estimated; and x_i is a vector of the covariates for observation i. In contrast to OLS, LAD regression does not give increasing weight to larger residuals. As a consequence, it is less sensitive to outliers then OLS regression.

The statistical literature has developed methodologies that are insensitive to small changes to model assumptions; including the presence of outliers. Robust statistics are methodologies designed to be insensitive to deviations from the assumptions made in a statistical analysis (Huber 1996). In particular, various forms of robust regression have been developed in order to limit the influence of outliers; and to deal with the violation of the normality assumption. Robust regression has also been proposed as a method for dealing with heteroscedasticity (Andersen 2008). A central concept of robust statistics is the breakdown point of an estimator; the smallest fraction of contamination that can cause the estimator to "break down" and no longer represent the trend in the bulk of the data. The efficiency of an estimator is defined as the ratio of its minimum possible variance to its actual variance. It is desirable for an estimator to have an efficiency ratio close to 1, as this ensures the estimator for the target parameter has the lowest variance possible.

MM regression is a form of robust regression described by Yohai (1987), which has a high breakdown point of 50% and high statistical efficiency of 95%. MM regression has the highest breakdown point and statistical efficiency of robust regression estimators currently available, and for this reason, it will be adopted in this analysis. A trade-off between the breakdown point and statistical efficiency of a MM estimator exists - a higher breakdown point can be achieved by a reduction in statistical efficiency; or conversely, a higher statistical efficiency can result from a lower breakdown point. The tuning parameter is the variable in MM regression that is chosen in order to achieve the desired breakdown point and statistical efficiency. The choice of tuning parameter is an overlooked component of conducting MM regression analysis, with the choice of 50% breakdown point and 95% statistical efficiency being standard. Introducing the estimator; Yohai (1987) discussed the choice of the tuning parameter and cautioned against relying on the standard choice.

(iii) Regression Models

The traditional form of the DDO equation is as below:[6]

$$P_{c,i} - P_{x,i} = \gamma_1 D_i + \gamma_2 FC_i + \varepsilon_i \tag{25}$$

Equation (25) does not satisfy the assumptions required to perform OLS due in part to the constant variance assumption being violated (Beggs & Skeels 2006, McKenzie & Partington 2010). The standard form of adjusting equation (25), assumes that the error variance is proportional to the size of the cum-dividend price, that is:

$$\varepsilon_i \sim N(0, \sigma_i^2) \qquad\qquad \sigma_i^2 = k \times P^2_{c,i} \tag{26}$$

Intuitively, this implies that the difference between the predicted value of the DDO and the actual value of the dividend drop off, the error, is likely to be larger for stocks with a higher stock price. To counter this, equation (25) is divided (scaled) by the cum-dividend price as follows:

$$\frac{P_{c,i} - P_{e,i}}{P_{c,i}} = \gamma_1 \frac{D_i}{P_{c,i}} + \gamma_2 \frac{FC_i}{P_{c,i}} + \varepsilon_i' \tag{27}$$

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[6] *This assumes no intercept term.*

Equation (27) is the standard choice of adjustment to the DDO equation which is used to mitigate the impact of heteroscedasticity. Other variables identified in the literature influencing the error variance include market capitalisation (Hathaway & Officer 2004), dividend yield (Michaely 1991, Hathaway & Officer 2004), and inverse stock return variance (Bellamy & Gray 2004). Intuitively, the dividend yield results in heteroscedasticity as stocks with larger dividends will cause a larger price drop-off, and as a consequence have a proportionally larger error. Stock price return variance refers to the historical volatility of the stock. A stock that is historically volatile over a long period of time is likely to have a larger error variance then a stock with low historical volatility, regardless of the size of the dividend paid. As a consequence a measure of historical stock return volatility is required in order to reduce this form of heteroscedasticity.

Market capitalisation is generally not used as a weighting variable in the DDO equation, as the 0.03% of the All Ordinaries index filter of the data applied in DDO studies reduces the impact that low market capitalisation has on stocks (Beggs & Skeels 2006, SFG 2011). Table 3 presents the results of applying these scaling, including joint scaling, to equation (25) as follows:

Table 3
Models used in this analysis.

Model	Parametric Form	Scaling Factor	Form of Heteroscedasticity
Model 1	$\dfrac{P_{c,i} - P_{e,i}}{P_{c,i}} = \gamma_1' \dfrac{D_i}{P_{c,i}} + \gamma_2' \dfrac{FC_i}{P_{c,i}} + \varepsilon_i'$	$P_{c,i}$	$\sigma_i^2 = k \times P_{c,i}^2$
Model 2	$\dfrac{P_{c,i} - P_{x,i}}{D_i} = \gamma_1'' + \gamma_2'' \dfrac{FC_i}{D_i} + \varepsilon_i''$	D_i	$\sigma_i^2 = k \times D_i^2$ [7]
Model 3	$\dfrac{P_{c,i} - P_{x,i}}{D_{ii} s_{e,i}} = \gamma_1''' \dfrac{1}{s_{e,i}} + \gamma_2''' \dfrac{FC_i}{D_i s_{e,i}} + \varepsilon_i'''$	$D_i s_{e,i}$	$\sigma_i^2 = k \times (D_i s_{e,i})^2$
Model 4	$\dfrac{P_{c,i} - P_{x,i}}{P_{c,i} s_{e,i}} = \gamma_1'''' \dfrac{D_i}{P_{c,i} s_{e,i}} + \gamma_2'''' \dfrac{FC_i}{P_{c,i} s_{e,i}} + \varepsilon_i''''$	$P_{c,i} s_{e,i}$	$\sigma_i^2 = k \times \left(P_{c,i} s_{e,i}\right)^2$

Where $P_{c,i}$ is the cum-dividend price of dividend event i, $P_{x,i}$ is the ex-dividend day price of dividend event i, D_i is the cash dividend of dividend event i, FC_i is the franking credit of dividend event i, γ_1 is the market value of the cash dividend, γ_2 is the market value of the franking credit, σ_i^2 is the variance of the error term of dividend event i, $Var[\varepsilon_i] = \sigma_i^2$ and $s_{e,i}$ is the historical excess return volatility of stock i.

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[7] *Using equation (27), Model 2 can also be derived by scaling by the dividend yield, $D_i / P_{c,i}$.*

Table 3 contains the 4 models that will be employed in the analysis to estimate theta. SFG (2011) also utilised these models in their DDO study. Model 1 and 2 are equivalent to the models utilised by Hathaway and Officer in their 2004 study (Equation 16 and 17), although they use franking proportion as opposed to the franking credit variable.[8] The Feasible Generalised Least squares approach utilised by Beggs & Skeels (2006) is not attempted in this study.

Given the large multicolinearity that exists between the franking credit and net dividend, an analysis of the gross dividend is warranted. As discussed previously, multicolinearity is an issue if the purpose of regression is explanation, not prediction. By considering the gross dividend, an estimate of the expected price drop off caused by the combined package of the net dividend and franking credit can be obtained. This allows us to predict the impact the gross dividend has on the stock price, as opposed to explaining the impact each component has on the stock price.

In order to estimate the market value of the gross dividend, the models in table 3 are rewritten in terms of the gross dividend as shown in Table 4.[9] The coefficient of the gross dividend can be interpreted as the Gross Drop-Off Ratio (GDOR), defined in equation (18). Here, λ can be interpreted as the estimated market value of $1 of gross dividend.

Table 3
Models used in estimating value of gross dividend.

Model	Parametric Form	Scaling Factor	Form of Heteroscedasticity
Model 5	$\dfrac{P_{c,i} - P_{e,i}}{P_{c,i}} = \lambda \dfrac{G_i}{P_{c,i}} + \varepsilon_i'$	$P_{c,i}$	$\sigma_i^2 = k \times P^2_{c,i}$
Model 6	$\dfrac{P_{c,i} - P_{e,i}}{D_i} = \lambda \dfrac{G_i}{D_i} + \varepsilon_i''$	D_i	$\sigma_i^2 = k \times D_i^{2}$ [10]
Model 7	$\dfrac{P_{c,i} - P_{x,i}}{D_i s_{e,i}} = \lambda \dfrac{G_i}{D_i s_{e,i}} + \varepsilon_i'''$	$D_i s_{e,i}$	$\sigma_i^2 = k \times (D_i s_{e,i})^2$
Model 8	$\dfrac{P_{c,i} - P_{x,i}}{P_{c,i} s_{e,i}} = \lambda \dfrac{G_i}{P_{c,i} s_{e,i}} + \varepsilon_i''''$	$P_{c,i} s_{e,i}$	$\sigma_i^2 = k \times \left(P_{c,i} s_{e,i}\right)^2$

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[8] *It can be shown they are equal.*

[9] By definition, $G_i = FC_i + D_i$

[10] *Using equation (31), Model 2 can also be derived by scaling by the dividend yield, $D_i / P_{c,i}$.*

(iv) Market Returns Correction

Several DDO studies utilise an adjustment in their study for taking into account the market returns on the ex-dividend day price (Beggs & Skeels 2006, SFG 2011):

$$P_{x,i}^* = \frac{P_{x,i}}{1 + r_{m,t}} \tag{28}$$

Where $P_{x,i}$ is the price of the stock on the ex-dividend day, $r_{m,t}$ is the return of the All Ordinaries Index on the ex-dividend day.

This assumption assumes that each stock has a beta of 1, and returns are fully explained by the Sharp-Linter Capital Asset Pricing Model. This is an extremely strong assumption; especially given the dividend sample consists only of stocks that have a market capitalisation greater than 0.03% of the All Ordinaries Index. In addition, the error term of each regression represents all other factors that influence the DDO apart from the cash dividend and the franking credit, including market fluctuations. As a consequence, this adjustment is unnecessary. It has been argued by Mckenzie and Partington (2010) that this adjustment will have no impact on the final value of theta. Beggs and Skeels (2006) note that this adjustment is imperfect, however as the adjustment is a common practice across the financial literature; the adjustment is performed in order to enable comparison of results across the literature. As a consequence, the regression analysis will be performed by applying the market return correction as well as abstaining from it.

(v) Collection of Data

A list of Australian securities was developed by observing all securities listed on the Australian Stock Exchange (ASX) from 1 July 2001 up until 1 July 2012 using Bloomberg's equity screening function eqs. Only equities listed on the ASX were included. A list of 2,595 unique tickers was compiled by observing stocks listed on the ASX during this period. Of these, anything that was not classed as "common stock" was excluded. Dividend distribution events from 1 July 2001 to 1 July 2012 were obtained using the Bloomberg spreadsheet calculator "xdvd". Any distribution event that was not classed as regular cash, interim, final or special cash was removed.

It is common for companies to distribute a special cash dividend in conjunction with a final or interim dividend. As a consequence, all dividends that occurred on the same day for a particular stock were aggregated. Given that individual special cash dividends are considered unreliable they were removed from the sample, consistent with other DDO studies (Beggs & Skeels 2006). In addition, companies that engaged in stock splits/share buy backs 5 days either side of a dividend event where removed from the sample. This left a list of 8,224 dividend events for 827 unique tickers.

The following fields were collected for each dividend event:

- *The pre ex-dividend date price at the close of trading 1, 2 and 3 days previous.[11]*

- *The ex-dividend date closing price.[12]*

- *The gross dividend.[13]*

- *The net dividend.[14]*

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[11] *Using the PX_LAST field in Bloomberg.*

[12] Ibid.

[13] *Field part of the xdvd spreadsheet.*

- *The market capitalisation of the underlying stock on the ex-dividend date.*[15]

- *The market capitalisation of the all ordinaries index on the ex-dividend date.*[16]

- *The currency of the dividend event.*[17]

- *The exchange rate for the dividend currency on the ex-dividend date.*[18]

- *The return of the All Ordinaries Index on the ex-dividend date.*[19]

The cum-dividend price was calculated by observing the closing price of the relevant stock on the trading day prior to the ex-dividend date. For example, if the ex-dividend date fell on a Tuesday, the cum-dividend price would be the closing price of the stock the previous Monday. A stock with an ex-dividend date on Monday would have a cum-dividend date the previous Friday. The franking credit for each dividend event is the residual between the gross dividend and net dividend. Any dividend event which had missing data was removed from the sample.

The sample was further reduced to include only companies that make up at least 0.03% of the All Ordinaries index on the day of the ex-dividend date. This is consistent with other dividend drop off studies (Beggs & Skeels 2006, SFG 2011). Any stock found to be paying a dividend denominated in currency other than the Australian dollar was converted to Australian dollars using the closing price exchange rate on the ex-dividend date. The final sample contains 3,309 dividend events.

The stock return variance was estimated using a time series of each stocks historical prices, in addition to the historical value of the All Ordinaries Index. From this the daily returns of both the stock and All Ordinaries Index was calculated. The daily excess return of the stock is defined as the difference between the stocks daily return and the return of the All Ordinaries Index. The volatility of the excess returns is calculated, over a year interval as follows:[20]

$s_{i,t} = \sqrt{\dfrac{1}{N} \sum_{j=1}^{N} (er_{i,t-5-j} - \overline{er_{i,t}})}$ is the estimated standard deviation of excess returns of stock i over N

trading days; $\overline{er_{i,t}} = \dfrac{1}{N} \sum_{j=1}^{N} \overline{er_{i,t}}$ is the estimated mean of excess return of stock i over N trading

days; $er_{i,t} = r_{i,t} - r_{m,t}$ is the excess return of stock i over the market at time t; $r_{i,t}$ is the daily return of

stock i at time t; $r_{m,t}$ is the daily return of the All Ordinaries Index at time t.

This is the method employed by SFG (2011) in their DDO analysis when considering stock return volatility. This method allows for stocks volatility above the daily market fluctuations to be accounted for, and as such it is adopted in this analysis. Our notation is slightly different to avoid confusion with the variance of the error term.

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[14] Ibid.

[15] *Using the field in Bloomberg CUR_MKT_CAP.*

[16] Ibid.

[17] *Field part of the xdvd spreadsheet.*

[18] *Using the PX_LAST field for the given currency.*

[19] *Calculated by observing the price of the all ordinaries index on the ex-dividend day and the previous trading day using the PX_LAST field in Bloomberg.*

[20] *Calculated by observing all available excess returns within a one year interval, 5 days previous of the Ex-dividend date.*

(vi) Summary of Data

The data from DDO studies can be summarised by considering the drop-off ratio, dividend yield and franking proportion of each dividend event. The drop-off ratio is calculated by the change in stock price from the close of the cum-dividend day to the close of the ex-dividend day, divided by the amount of the gross dividend. Dividend yield is calculated by the amount of the net dividend divided by the stock price at the close of trading on the cum-dividend day. The franking proportion represents the fraction of dividends that have franking credits attached to them. A franking proportion of 1 indicates that the dividends are fully franked; a 0 franking proportion indicates no franking credits are attached to dividends. Table 5 below summarises these variables in addition to the market capitalisation and volatility of excess returns[21] for the dividend sample:

Table 4
Summary data of the dividend sample.

	Drop-off Ratio	Dividend Yield	Franking Proportion	Market Cap%	Volatility of excess returns (daily)	Net Dividend	Franking Credit
Mean	0.56	0.02	83.2%	0.57%	0.019	$0.27	$0.073
Median	0.70	0.02	1	0.13%	0.018	$0.10	$0.037
Standard deviation	1.81	0.013	0.34	1.55%	0.0076	$3.35	$0.20
Minimum	-50.4[22]	0.0001	0	0.03%	0.0061	$0.0025	$0.00
Maximum	16.2[23]	0.14	1	16.9%	0.11	$140	$9.65

The histogram of the franking proportion is shown in Figure 1. This demonstrates the extreme multicolinearity present in DDO studies, as a large proportion of the sample of franking credits are fully franked, approximately 75% of the entire sample. Recall that as the franking credit is a linear function of the net dividend and franking proportion (13), a wide distribution of the franking proportion is a necessary condition for low correlation between the franking credit and net dividend. Given the extreme distribution of the franking proportion below, we can conclude that this sample is inflicted with severe multicolinearity. The extreme multicolinearity between the net dividend and franking credit is confirmed by the value of the Pearson Correlation, 0.81. As previously discussed, a fully franked dividend does not contribute any information about the separate impact a net dividend and franking credit has on the price drop off. As a consequence, only the 25% of the sample that is not fully franked contains information that is used to distinguish the market value of the franking credit from the market value of the net dividend.

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[21] *As described in paragraph 73.*

[22] Coal & Allied Industries paid a gross dividend of $0.36 on 28 Feb 2008, with the Cum-dividend price of $82 and an Ex-dividend price of $100.

[23] NewCreast mining paid a gross dividend of $0.20, with the price falling from $36.10 from the cum-dividend day to $32.86 on the ex-dividend day.

Figure 1
Frequency distribution of franking proportion


Histogram of Franking Proportion
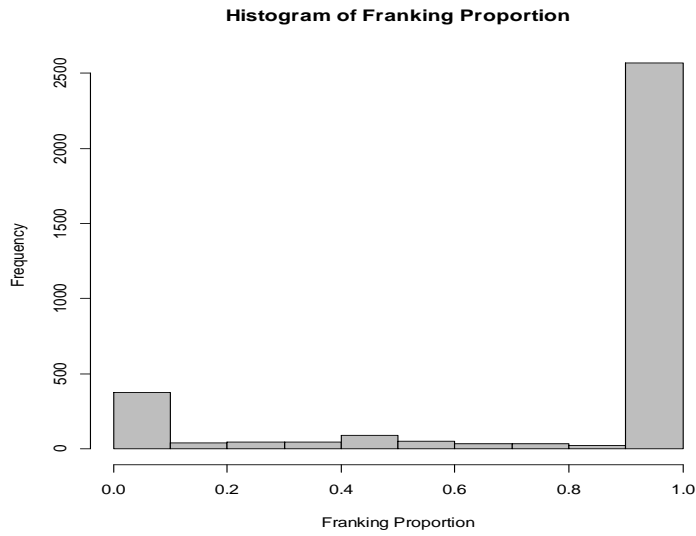
Whilst it is difficult to visualise multivariate data for Models 1 to 4, we can gain a general overview of the data by plotting the price drop off against the gross dividend, divided by the appropriate scaling factor. This corresponds to a visualisation of Models 5 to 8. The graph of the relevant variables is shown below:
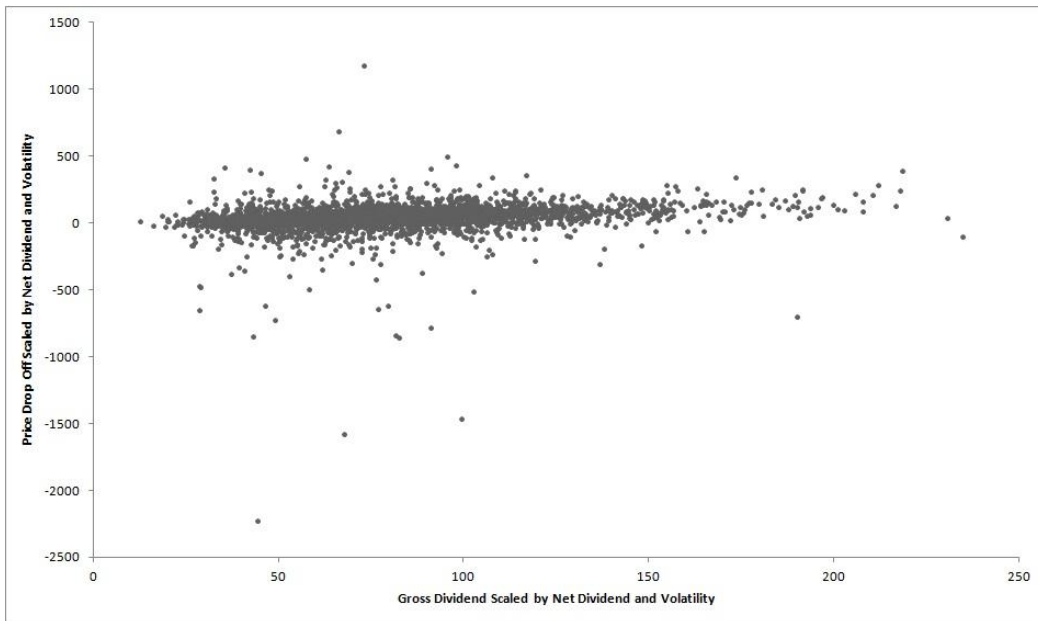
Figure 2
Scatter plot of price drop-off against gross dividend, scaled by cum price (Model 5)
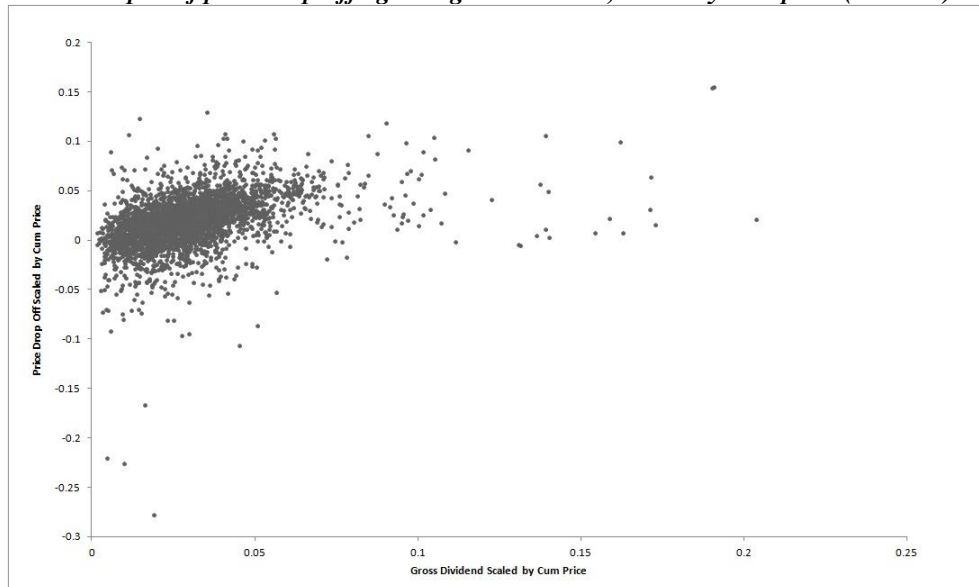
Figure 3
Scatter plot of price drop-off against franking credit, scaled by net dividend (Model 6)
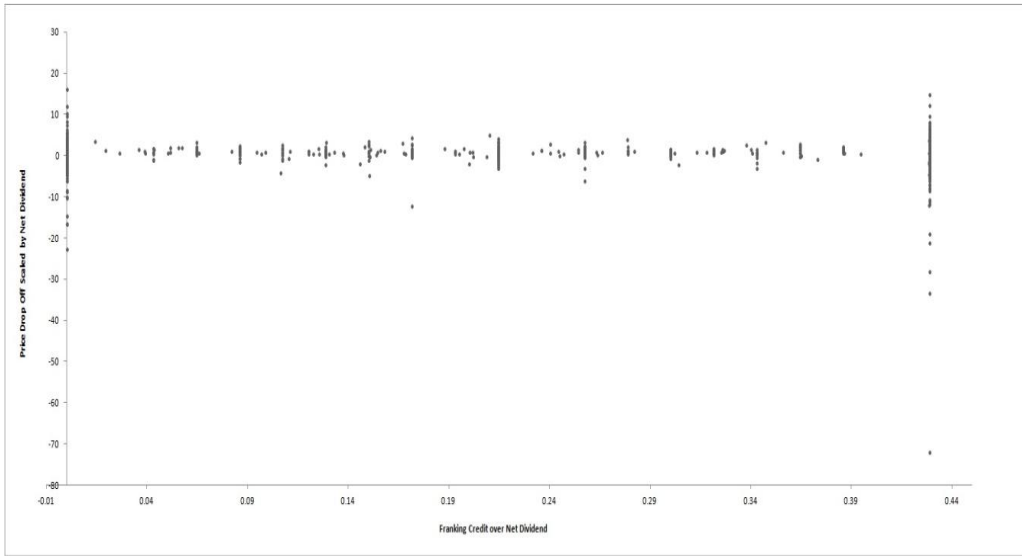
Figure 4
Scatter-plot of price drop-off against gross dividend, scaled by net dividend and volatility (Model 7)

Figure 5
Scatter-plot of price drop-off against gross dividend, scaled by cum-price and volatility (Model 8)
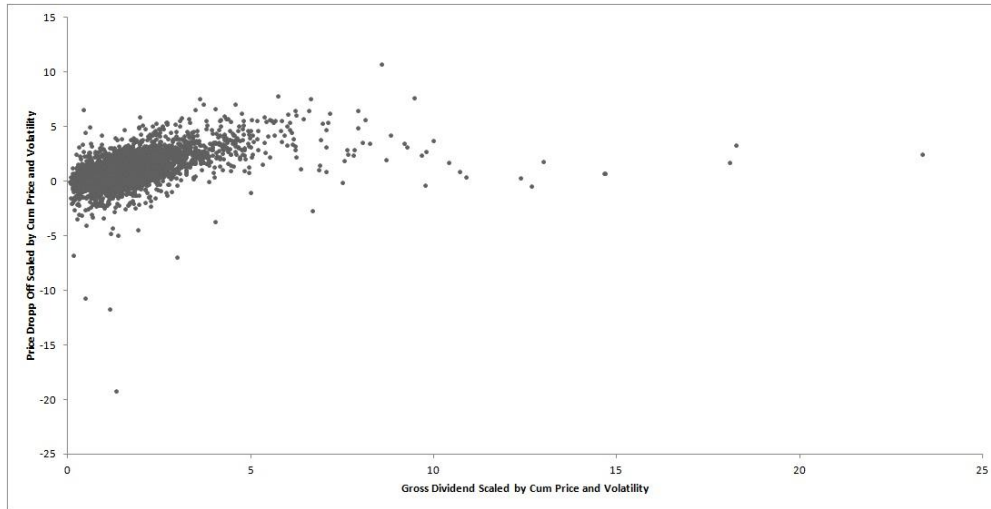
Figure 2, 4 and 5 demonstrates that a positive relationship exists between the price drop-off ratio and the gross dividend when scaled by the applicable variable. This is to be expected, given the empirical results of the literature attributing a positive value to both the net dividend and franking credit. It is however hard to decipher a positive relationship between the price drop-off ratio and the gross dividend when scaling by the net dividend, as illustrated in Figure 3.

Figure 3 reveals the extreme clustering of the data found when using model 2. The dependent variable can be expressed as:

$$\frac{FC_i}{D_i} = \frac{\dfrac{t_c}{1-t_c}D_i.f_i}{D_i} = \frac{t_c}{1-t_c}.f_i$$

(29)

As the tax rate is constant, the dependent variable in model 2 is a linear function of the franking proportion, f_i. Given that the franking proportion is between 0 and 1, clustered around whole percentages, this results in model 2 being clustered, explaining the clustering found in figure 3. Clustering of this form is undesirable in regression as it results in high standard errors of the estimated coefficients, in addition to being sensitive to the observations present.

(vii) Statistical Packages Used

The R statistical package has been used in order to implement the required regression methodologies. OLS was performed using the lm() function which is built into R.[24] Robust regression was performed using the rlm() function found in the MASS package, using the MM regression setting, with all options set to default.[25] Least absolute deviations regression was applied using the rq() function in the quantreg package, using a value of tau=0.5. [26]

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[24] *lm() function documentation can be found at:* http://127.0.0.1:20803/library/stats/html/lm.html.

[25] r*lm() function documentation can be found at:* http://127.0.0.1:20803/library/MASS/html/rlm.html.

[26] *rq() function documentation can be found at:* http://127.0.0.1:20803/library/quantreg/html/rq.html.

(V) Results

The results of applying OLS, LAD and MM robust regression to the data set using the models in Tables 3 and 4 are shown below. It is noted that no weight is placed on the results derived from applying OLS to the various models, due to the assumptions for OLS not being met. However, as other DDO studies have utilised OLS it is included for comparison.

Table 5
Regression results for Models 1 to 4

Regression Model	Regression Methodology	No Market Correction			Market Correction		
		Estimated Value of Cash Dividend	Estimated Value of Franking Credit	Standard Error of Franking Credit	Estimated Value of Cash Dividend	Estimated Value of Franking Credit	Standard Error of Franking Credit
Model 1	Ordinary Least Squares	0.83	**0.11**	0.13	0.84	**0.12**	0.11
	Robust Regression using MM Estimator	0.84	**0.35**	0.09	0.90	**0.30**	0.08
	LAD Regression	0.84	**0.38**	0.16	0.90	**0.29**	0.08
Model 2	Ordinary Least Squares	0.57	**0.54**	0.28	0.66	**0.37**	0.27
	Robust Regression using MM Estimator	0.77	**0.39**	0.11	0.85	**0.35**	0.11
	LAD Regression	0.77	**0.53**	0.16	0.83	**0.44**	0.15
Model 3	Ordinary Least Squares	0.64	**0.60**	0.22	0.74	**0.45**	0.21
	Robust Regression using MM Estimator	0.79	**0.44**	0.11	0.86	**0.39**	0.10
	LAD Regression	0.79	**0.49**	0.15	0.87	**0.38**	0.13
Model 4	Ordinary Least Squares	0.88	**-0.11**	0.11	0.90	**-0.07**	0.1
	Robust Regression using MM Estimator	0.87	**0.32**	0.09	0.92	**0.33**	0.08
	LAD Regression	0.86	**0.33**	0.15	0.94	**0.21**	0.12
Average (excluding OLS)		0.82	**0.40**	-	0.88	**0.34**	-

Table 6
Regression results for Models 5 to 8

Regression Model	Regression Methodology	No Market Correction		Market Correction	
		Estimated Value of Gross Dividend	Standard Error of Gross Dividend	Estimated Value of Gross Dividend	Standard Error of Gross Dividend
Model 1	Ordinary Least Squares	0.63	0.01	0.65	0.01
	Robust Regression using MM Estimator	0.68	0.01	0.73	0.01
	LAD Regression	0.70	0.01	0.73	0.01
Model 2	Ordinary Least Squares	0.56	0.03	0.58	0.03
	Robust Regression using MM Estimator	0.68	0.01	0.71	0.01
	LAD Regression	0.70	0.01	0.72	0.01
Model 3	Ordinary Least Squares	0.63	0.02	0.66	0.02
	Robust Regression using MM Estimator	0.69	0.01	0.73	0.01
	LAD Regression	0.70	0.01	0.73	0.01
Model 4	Ordinary Least Squares	0.60	0.01	0.62	0.01
	Robust Regression using MM Estimator	0.72	0.01	0.76	0.01
	LAD Regression	0.70	0.01	0.73	0.01
Average (excluding OLS)		.70	-	0.73	-

The robust MM estimation method produces an estimate of the franking credit between 0.32 to 0.44, whilst applying the market correction produces a robust MM estimation of between 0.30 to 0.39. LAD regression produces an estimate of the franking credit between 0.33 to 0.53 and using the market correction produces estimates between 0.21 to 0.44.

With the exception of OLS, the results of applying robust MM regression and LAD regression to the gross dividend models show only a small variation, between 0.68 and 0.72. The variation between the models and regression types for the estimated value of the gross dividend is considerably less than the variation in the estimated value of the franking credit.

Whilst not directly comparable, the standard error of the estimate of theta tends to be lower for robust MM regressions than for LAD regressions. Producing estimates of confidence intervals and p-values, as is standard in statistical analysis, is not appropriate for LAD and MM regression. Doing so requires strong assumptions on the asymptotic distribution of the regression coefficients and standard errors, which could give misleading results. The coefficient of determination, R^2, quoted in other dividend drop off studies is also inappropriate as a measure of model reliability given that OLS models will always maximise this statistic. However, as OLS is inappropriate in DDO studies, the coefficient of determination is also inappropriate as a measure of model reliability. Variance inflation factors are also quoted when data is inflicted with multicolinearity, in order to gauge the impact multicolinearity has on the estimated regression coefficients. Given that this is only appropriate for OLS models, variance inflation factors are not calculated.

The improved confidence in the estimation of the market value of the gross dividend over the franking credit can be seen by the comparatively smaller standard errors of the regression coefficients. This confirms the impact of multicolinearity; on average we expect $1 of gross dividend to cause a reduction in price from the cum-dividend price to the ex-dividend price of $0.70. However it is difficult to isolate the contribution of the net dividend and the franking credit to the price-drop off, with the market value of the franking credit varying substantially between models and regression procedures employed.

Interestingly, the use of the market correction results in a significant reduction in the estimate of theta, contradicting Mckenzie and Partington (2010) and the analysis conducted by Skeels (2009) in analysis of SFG's first report. The market value of the gross dividend generally increases upon application of the market correction.

(VI) Sensitivity Analysis

(i) DFBETAS

It is undesirable that the estimates of theta show considerable variation across the different models. This variation is compounded further if the market correction is utilised. It is valuable to investigate the impact on the estimate of theta on removing significant observations from the data set. This analysis was performed in order to ascertain the sensitivity of the estimates to changes in the underlying sample of dividend events.

As noted previously, DDO studies are extremely sensitive to the choice of the underlying sample of dividend events. As a consequence, it is necessary to use a statistical criterion in order to assess the impact that each observation has on the estimated value of theta. In particular, how would removing a specific dividend event impact the estimated value of theta? The DFBETAS criterion is appropriate as by definition chooses the point that has the most impact on the value of a regression coefficient. It is also applicable across a range of different regression methodologies, unlike other criterions such as Cooks Distance.

DFBETAS is a standardised measure of the amount by which a regression coefficient changes if a particular observation is removed. Formally, $\text{DFBETAS}_{i,k}$ is the standardised measure of the amount

by which the kth regression coefficient changes if the ith observation is omitted from the data set (Harell 2011):

$$\text{DFBETAS}_{i,k} = \frac{\hat{\beta}_k - \hat{\beta}_{k(i)}}{SE(\hat{\beta}_{k(i)})} \tag{30}$$

Where $\hat{\beta}_k$ is the kth regression coefficient from regressing on the entire data set; $\hat{\beta}_{k(i)}$ is the kth regression coefficient by removing the ith observation; $SE(\hat{\beta}_{k(i)})$ is the standard error of the regression coefficient by removing the ith observation.

Within the context of DDO studies, DFBETAS measures the standardised change in the estimated value of theta by deleting the ith dividend event from the sample. Removing the observation with the highest absolute value of DFBETAS will result in the largest change in the estimated value of theta. It is desirable that the final estimate of theta would be robust to the removal of observations based on this criterion. The sensitivity analysis is also performed to the gross dividend models in Table 4. Here, DFBETAS measures the standardised change in the estimated market value of the gross dividend, by deleting the ith dividend event from the sample.

The sensitivity analysis was performed by removing the observation with the largest absolute DFBETAS value, then refitting the model and observing the new estimate of the market value of franking credit. Due to the extremely high computational intensity of the DFBETAS statistic, 30 observations is seen as an appropriate cut-off for studying the robustness of the estimated value of theta. The result of this sensitivity analysis for removing 30 observations is shown below. The result of applying this method is shown graphically in Appendix 2.

Table 8
Sensitivity analysis of value of franking credit

Regression Model	Regression Methodology	Minimum Value of Franking Credit	Maximum Value of Franking Credit	Mean Value of Franking Credit	Median Value of Franking Credit	Standard Deviation of Franking Credit
Model 1	*Ordinary Least Squares*	0.11	0.33	0.21	0.19	0.065
	Robust Regression using MM Estimator	0.30	0.46	0.40	0.41	0.046
	LAD Regression	0.34	0.49	0.41	0.39	0.05
Model 2	*Ordinary Least Squares*	0.18	0.54	0.29	0.27	0.090
	Robust Regression using MM Estimator	0.36	0.47	0.41	0.41	0.033
	LAD Regression	0.52	0.55	0.54	0.53	0.01
Model 3	*Ordinary Least Squares*	0.29	0.73	0.42	0.40	0.10
	Robust Regression using MM Estimator	0.37	0.47	0.42	0.43	0.032
	LAD Regression	0.38	0.52	0.48	0.49	0.053
Model 4	*Ordinary Least Squares*	-0.11	0.37	0.18	0.18	0.14
	Robust Regression using MM Estimator	0.32	0.53	0.43	0.42	0.059
	LAD Regression	0.30	0.33	0.32	0.32	0.015
Average (excluding OLS)		**0.36**	**0.48**	**0.42**	**043**	-

Table 9
Sensitivity analysis of value of gross dividend

Regression Model	Regression Methodology	Minimum Value of Gross Dividend	Maximum Value of Gross Dividend	Mean Value of Gross Dividend	Median Value of Gross Dividend	Standard Deviation of Gross Dividend
	Ordinary Least Squares	0.63	0.70	0.67	0.68	0.019
Model 5	*Robust Regression using MM Estimator*	0.70	0.72	0.71	0.71	0.0054
	LAD Regression	0.70	0.70	0.70	0.70	N/A
	Ordinary Least Squares	0.56	0.63	0.61	0.62	0.017
Model 6	*Robust Regression using MM Estimator*	0.68	0.69	0.69	0.69	0.0034
	LAD Regression	0.70	0.70	0.70	0.70	N/A
	Ordinary Least Squares	0.63	0.67	0.66	0.66	0.011
Model 7	*Robust Regression using MM Estimator*	0.69	0.69	0.69	0.69	0.00077
	LAD Regression	0.70	0.70	0.70	0.70	N/A
	Ordinary Least Squares	0.61	0.72	0.69	0.70	0.032
Model 8	*Robust Regression using MM Estimator*	0.72	0.72	0.72	0.72	0.0020
	LAD Regression	0.70	0.70	0.70	0.70	N/A
Average (excluding OLS)		0.70	0.70	0.70	0.70	-

The results of the DFBETAS analysis confirm that the estimate of theta is highly sensitive to the choice of the underlying sample of dividend events. Removing just 30 observations from a sample of 3309 can result in a dramatically different estimate of theta. In the course of this process, the value of theta can vary between 0.3 to 0.55. It is important to note that these points represent less than 1% of the entire dividend sample. Whilst by design the removed dividend event has the most extreme impact on the estimate of theta it is undesirable for the estimate to be vulnerable to the removal of observations. Removing observations from a comparatively large sample in conjunction with the robust regression techniques applied still produce estimates of theta that are unreliable.

The estimated value of the gross dividend is considerably more robust to the removal of observations than the estimated value of the franking credit. The removal of 30 observations from the sample of 3309 causes the estimated market value of the gross dividend to vary between 0.68 and 0.72.

(ii) Discussion of Robust Regression

The results of the sensitivity analysis highlight that despite the regression types being chosen for being robust to influential points, removing observations from the sample results in a highly variable estimate of theta. In addition, the results confirm a lack of consensus on the value of theta between the different drop-off models and regression procedures employed.

The statistical literature notes that while the theoretical properties of MM regression are impressive, in reality, its actual performance can be worse due to the theory being based on asymptotic large sample theory (Olive & Hawkins 2008). In addition, MM regression is not robust to multicolinearity; it is only robust to the presence of outliers and heteroscedasticity. This lack of robustness to the sample may be explained by the choice of tuning parameter and the trade-off between robustness and statistical efficiency, as explained previously. Recall that in introducing the MM estimator, Yohai (1987) cautioned relying on the standard choice of the tuning parameter, a = 4.685. Applying a lower tuning constant of a = 3.42, as opposed to a = 4.685 results in an 84.7% asymptotic efficiency and a higher breakdown point. The results of applying MM regression with this tuning point are shown in the tables below:

Table 7
MM regression results using a tuning constant of 3.42

Regression Model	No Market Correction			Market Correction		
	Estimated Value of Cash Dividend	Estimated Value of Franking Credit	Standard Error of Franking Credit	Estimated Value of Cash Dividend	Estimated Value of Franking Credit	Standard Error of Franking Credit
Model 1	0.82	**0.43**	0.090	0.91	**0.31**	0.084
Model 2	0.80	**0.418**	0.11	0.88	**0.32**	0.104
Model 3	0.82	**0.39**	0.11	0.81	**0.41**	0.11
Model 4	0.83	**0.43**	0.09	0.92	**0.33**	0.08
Average	0.82	**0.42**		0.88	**0.34**	

These results indicate that consensus between the models has improved, with the variation from not using the market correction varying from 0.39 to 0.43 (from 0.32 to 0.44 using the original tuning constant). Applying the market correction results in the estimates varying between 0.31 to 0.40 between models (0.30 to 0.39 using the original tuning constant) slightly reducing the consensus.

Applying the tuning constant of a = 3.42 is arbitrary; of more interest is how the estimated value of the franking credit changes when the value of the tuning constant varies. The tuning constant is defined between $1.548 < a < 4.685$. As noted in section 4.3, a reduction in the tuning constant results in an increase of the breakdown point and a reduction in the statistical efficiency of the estimator. Plots of the estimated value of theta against the tuning constant are shown graphically in appendix 2. The table below summarises the value of the franking credit by manipulating the tuning constant between $1.548 < a < 4.685$.

Table 8
Results of varying the tuning constant in MM regression

Regression Model	Minimum Value of Franking Credit	Maximum Value of Franking Credit	Mean Value of Franking Credit	Median Value of Franking Credit	Standard Deviation of Franking Credit
Model 1	0.35	0.55	0.45	0.45	0.064
Model 2	0.38	0.42	0.40	0.40	0.013
Model 3	0.38	0.44	0.40	0.39	0.02
Model 4	0.32	0.64	0.46	0.45	0.1
Average	0.36	0.51	0.43	0.42	-

The results of this analysis show wide variation between the models and do not converge to a particular value. If the large variation in the franking credit estimate was due to the presence of outliers and heteroscedasticity, reducing the size of the tuning constant would help to alleviate these issues.

(VII) Conclusion

We have estimated a market value of franking credits that across different robust regression procedures, averages to be approximately $0.45 per $1 of face value. Implementing the market returns correction, the estimated market value falls to $0.34 per $1 of face value. The market value of the combined package of the net dividend and franking credit, the gross dividend, is estimated to be $0.70 per $1 of gross dividend. Applying the market correction, this value increases to $0.73 per $1 of gross dividend.

Sensitivity analysis was performed by removing dividend events that results in the largest change to the estimated market value of franking credits. Upon the removal of approximately 1% of the sample size, the estimated market value of franking credits fluctuated between $0.30 to $0.55 per $1 of face value. Performing the same analysis for the gross dividend, the market value varies between $0.68 and $0.72 per $1 of gross dividend.

The estimated market value of gross dividend is far more robust to the removal of significant observations than the estimated market value of franking credits. This result indicates that two of the issues from DDO studies have been mitigated: (i) heteroscedasticity and (ii) the presence of outliers. However, the application of robust regression techniques does not resolve the sensitivity of the estimated value of theta to the underlying dividend sample. Taking the extreme position of manipulating the tuning constant in robust regression does not reduce the sensitivity of the estimated value of theta. We can therefore conclude that it is not the presence of outliers or heteroscedasticity that is the result of our imprecision; rather it is the strong multicolinearity between the franking credit and the net dividend.

The extreme multicolinearity was demonstrated by the 0.81 Pearson correlation between the net dividend and franking credit. Multicolinearity makes estimating the isolated impact correlated variables have extremely difficult; however estimating the combined impact is relatively simple. This result can be seen in the above analysis. The value of franking credit and net dividend are extremely sensitive to changes in the underlying sample, whilst the value of the gross dividend is relatively robust. This implies that we can be relatively confident in predicting the price drop-off caused by both the net dividend and franking credit in aggregate. However, we cannot be confident in our estimates of the relative effect the net dividend and the franking credit have on the price drop off in isolation. The impact of multicolinearity has been demonstrated in the analysis by the high standard errors of the regression coefficients relative to the standard errors of the gross dividend; and the extreme sensitivity of the franking credit estimate to changes in the underlying sample.

Other studies have removed observations based on "Price Sensitive" announcements around the ex-dividend date, or removed outliers based upon an economic reasoning. This approach cannot reduce the imprecision of the DDO approach as extreme multicolinearity will still be present.

In estimating the value of theta for the WACC, the authors do not recommend using the results derived from applying the market correction. Whilst market fluctuations will mask investor's true valuations of franking credits, they are accounted for by the error term in the regression models. Hence, applying the market correction is an unnecessary complication to an already complex econometric task.

We have confirmed that estimating theta using the DDO methodology cannot give us a precise estimate for the value of theta. This result explains the large divergence and lack of consensus in the economic and financial literature found in DDO studies in the past. In relation to the value of theta, it may make sense to use a range for the value of theta rather than a derived point estimate. The appropriate range suggested by this study is a value of theta between 0.35 to 0.55 based on the range of estimates encountered in the sensitivity analysis. If, however, a point estimate of theta is required, then the estimated value of theta should be that based on an average across the robust regression models, which is 0.45.

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Figure 6
Sensitivity analysis of Model 1 using OLS regression, observations removed through DFBETAS criterion
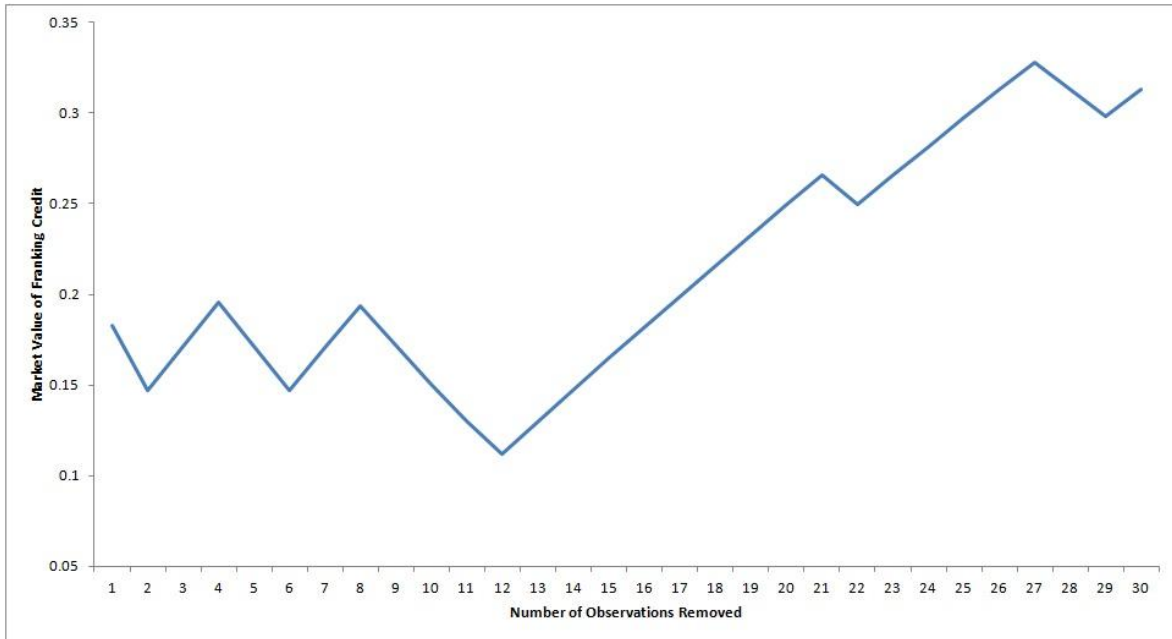
Figure 7
Sensitivity analysis of Model 1 using MM Robust Regression, observations removed through DFBETAS criterion
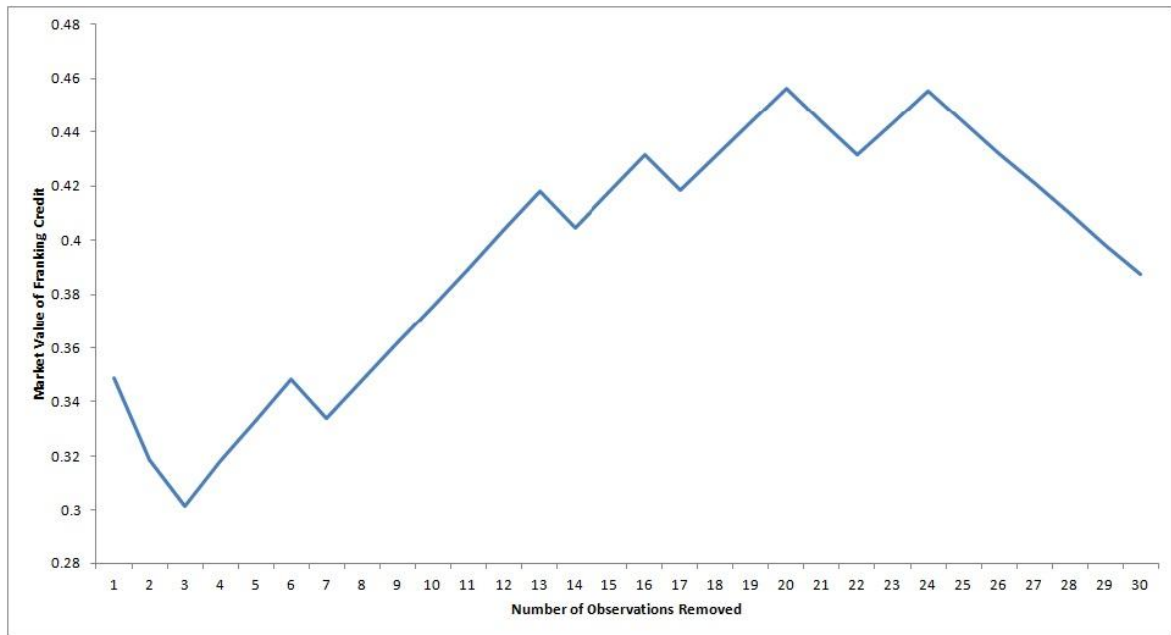
Figure 8
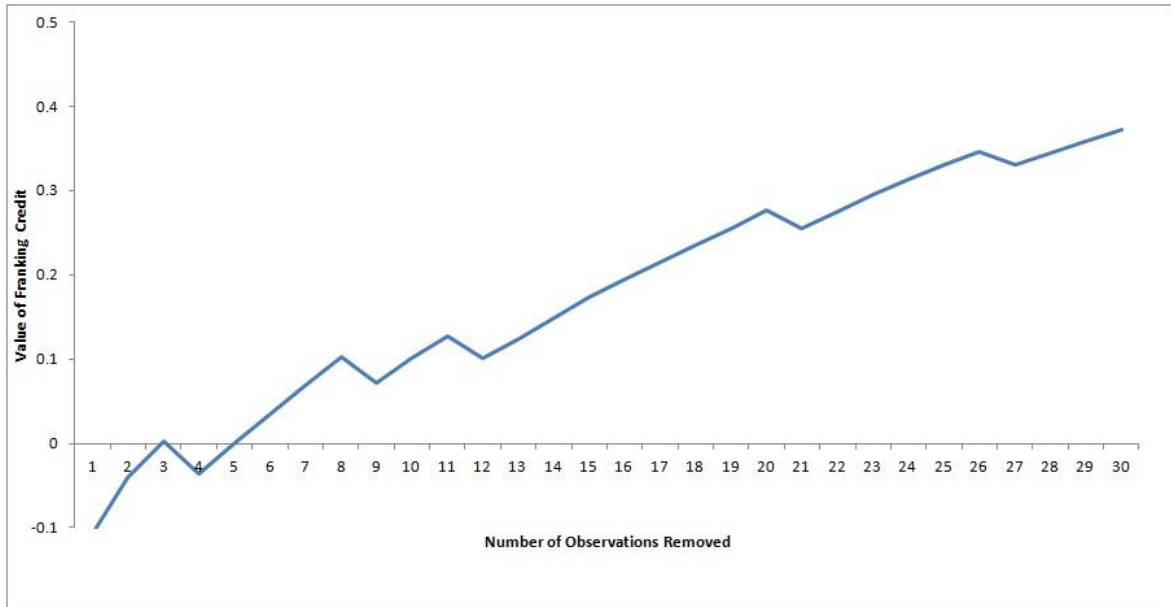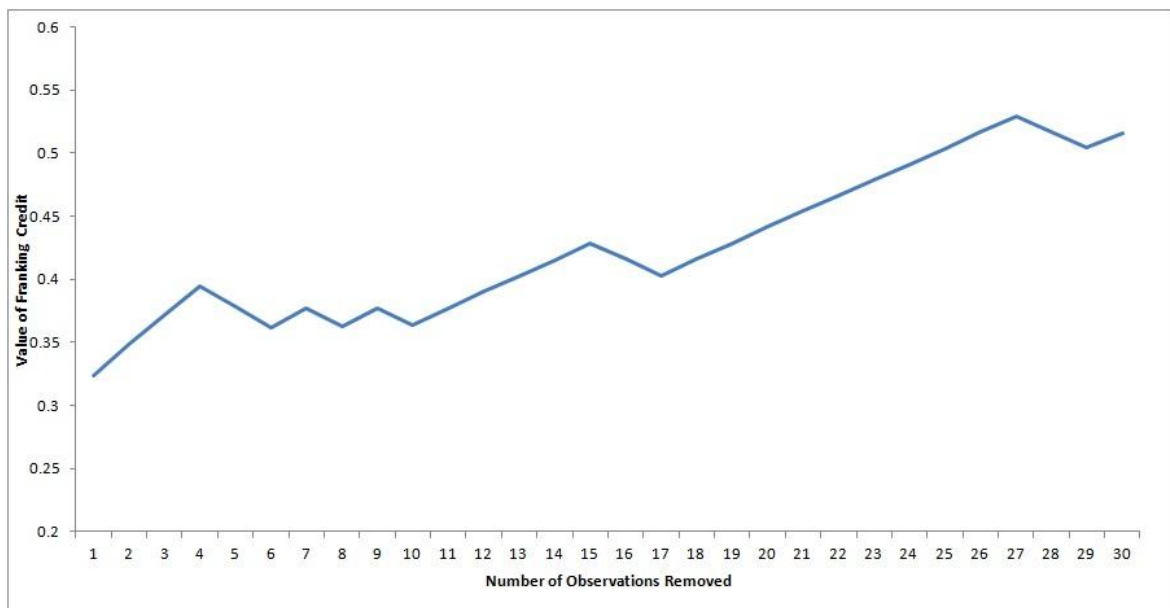*Sensitivity analysis of Model 1 using LAD regression, observations removed through DFBETAS criterion*
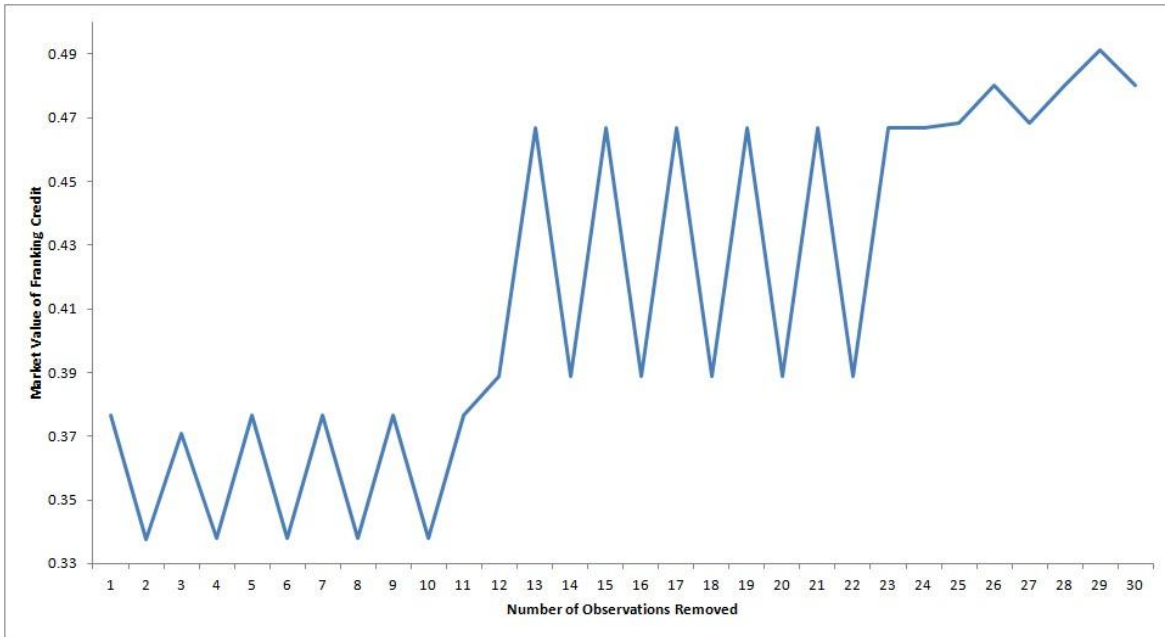
Figure 9
*Sensitivity analysis of Model 2 using OLS regression, observations removed through DFBETAS criterion*
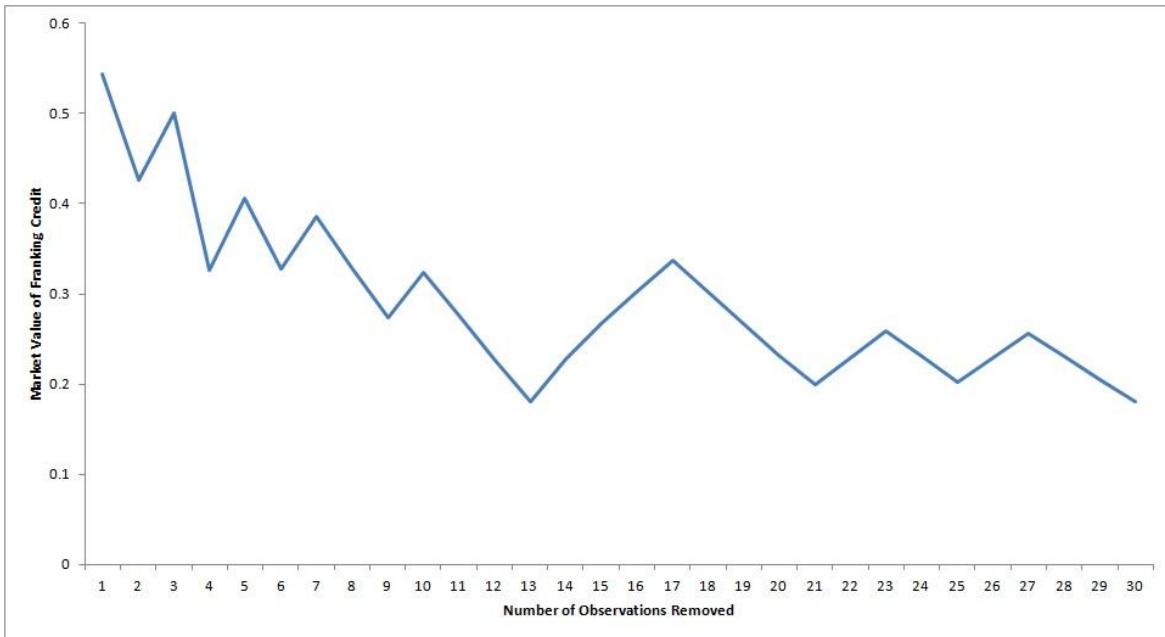
Figure 10
Sensitivity analysis of Model 2 using LAD regression, observations removed through DFBETAS criterion
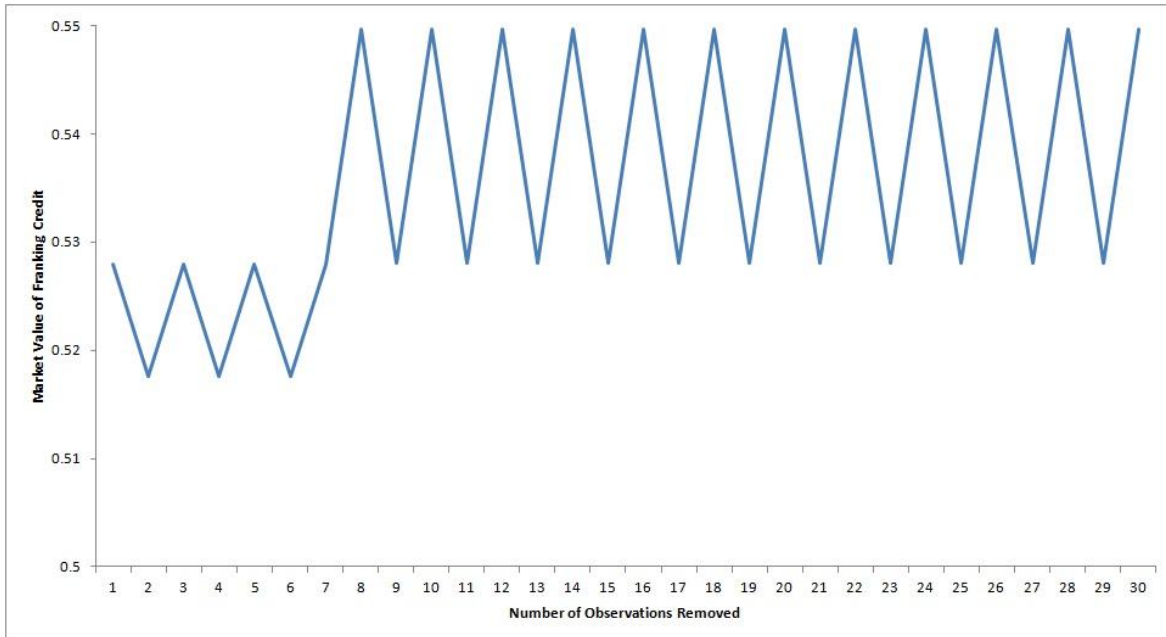
Figure 11
**Sensitivity analysis of Model 2 using MM regression, observations removed through DFBETAS criterion**
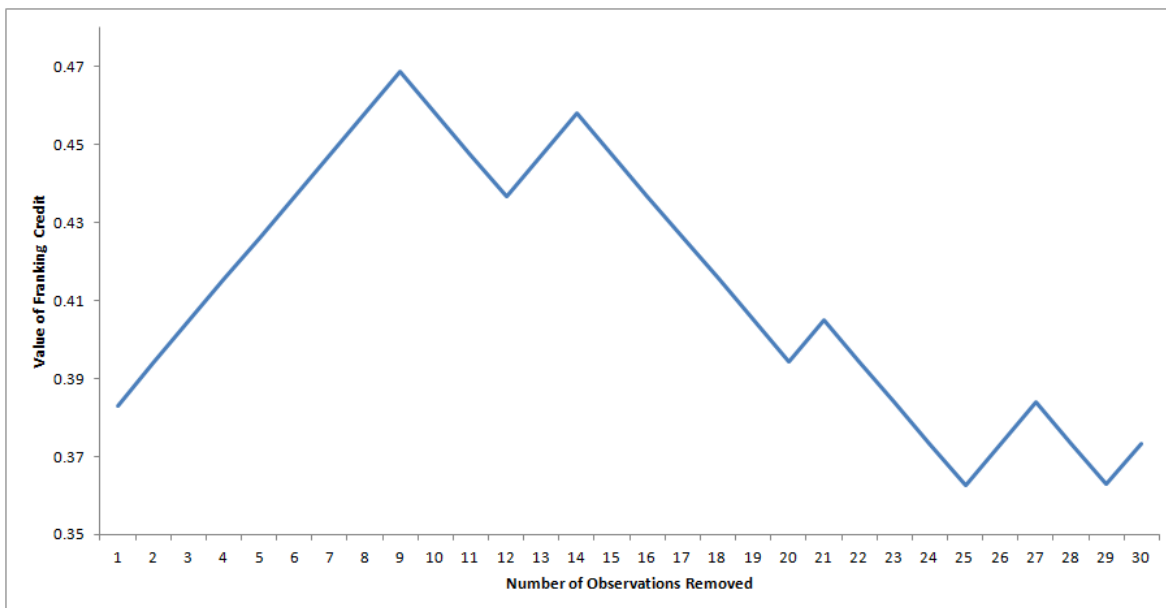
Figure 12
Sensitivity analysis of Model 3 using OLS regression, observations removed through DFBETAS criterion
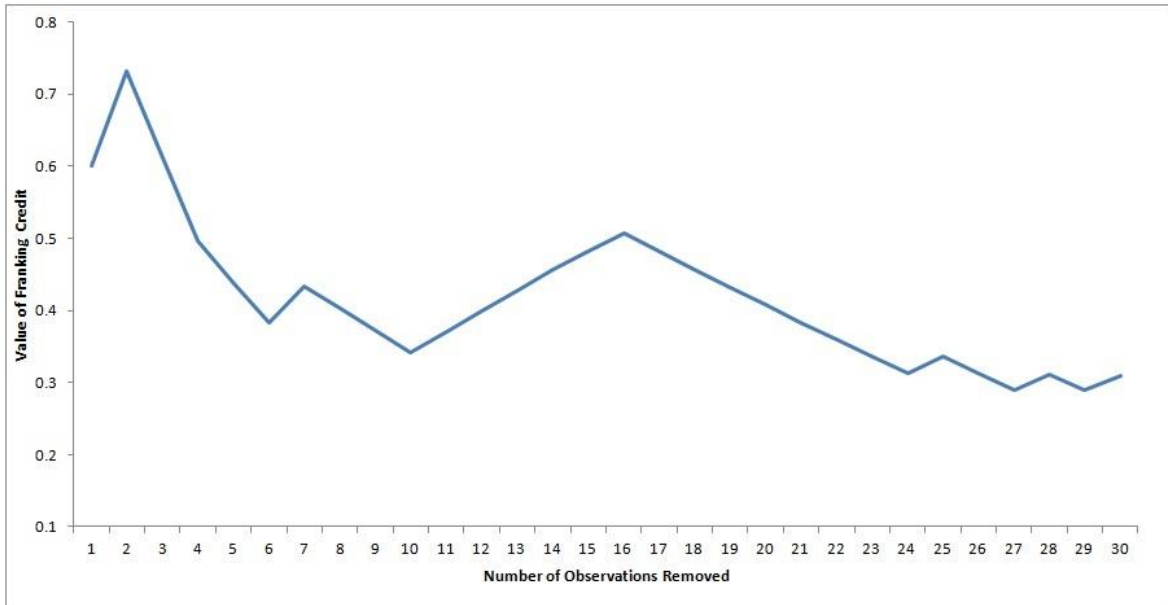
Figure 13
Sensitivity analysis of Model 3 using MM regression, observations removed through DFBETAS criterion
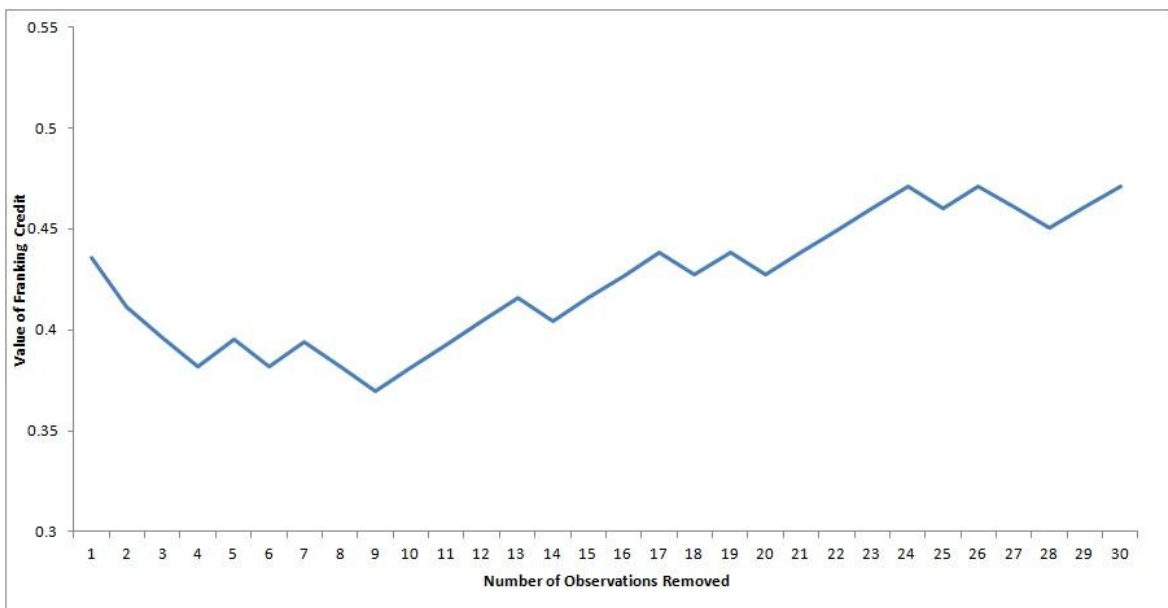
Figure 14

Sensitivity analysis of Model 4 using OLS regression, observations removed through DFBETAS criterion

Figure 15

Sensitivity analysis of Model 4 using MM regression, observations removed through DFBETAS criterion

Figure 16
16Manipulating the tuning constant in MM robust regression for Model 1, value of theta
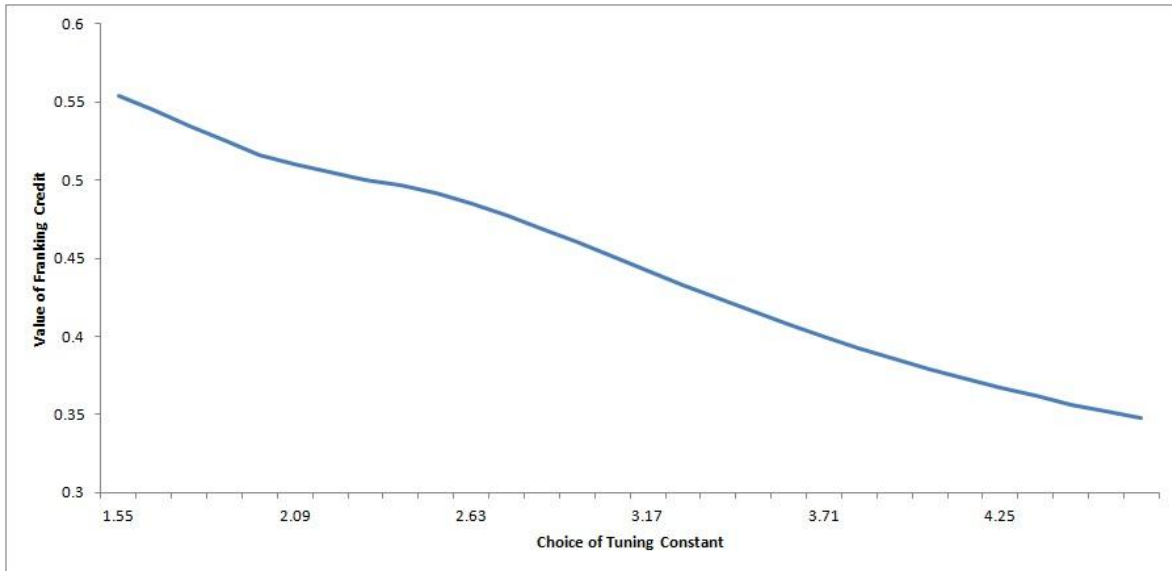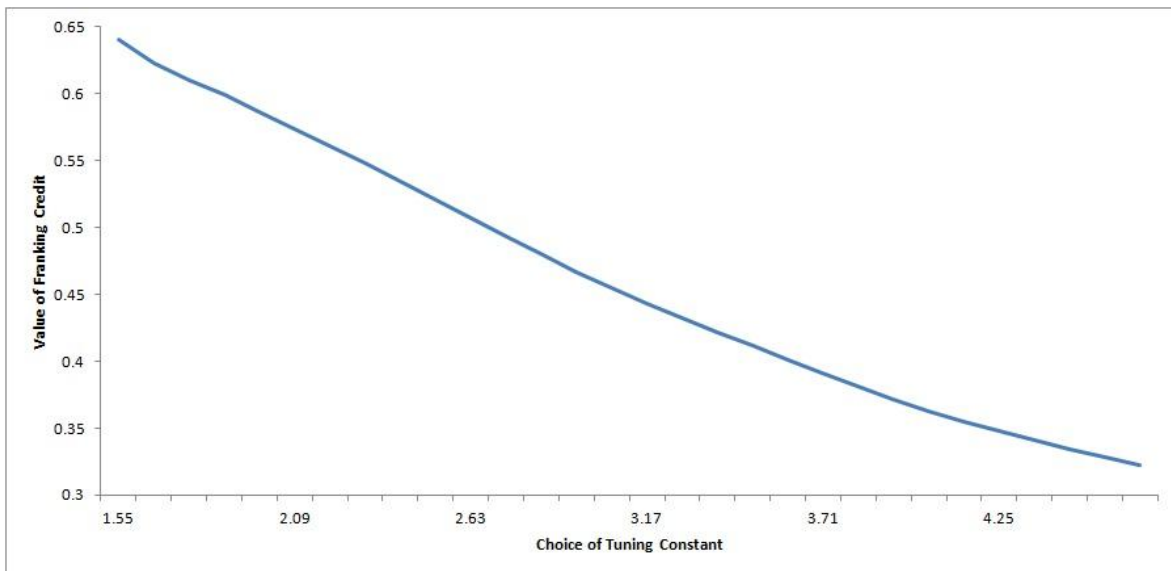

Figure 17
Manipulating the tuning constant in MM regression for Model 2, value of theta
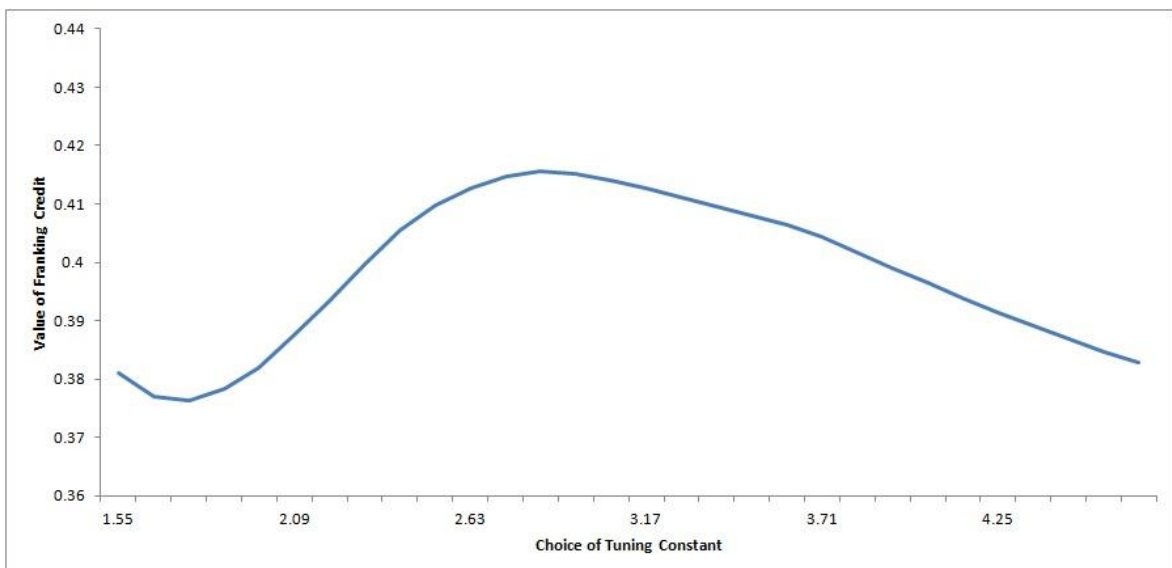
Figure 18
Manipulating the tuning constant in MM regression for all models, value of theta