Market valuation of dividend imputation tax credits

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ABSTRACT

Estimating the market value of dividend imputation tax credits is an important component of cost of capital estimation for companies operating within a dividend imputation tax system. This paper infers the value of imputation credits from simultaneous trades of ordinary shares (which entitle the holder to imputation credits) and individual share futures contracts (which provide no such entitlement). We find that the implied value of imputation credits is less than 20% of their face value.

Current version: 14 October 2011

Key Words: Dividend Imputation; Cost of Capital.
JEL Classifications: G31; G38

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I. Introduction

Under a dividend imputation tax system, dividends that are paid out of profits that have been taxed at the corporate level have a tax credit attached to them. These tax credits allow certain shareholders to reduce the personal taxes that they would otherwise pay. Consequently, these imputation tax credits are of some value to some shareholders. However, a consensus estimate of the market value of imputation credits (to the representative, or price-setting, investor) has not yet been achieved in the academic literature.

Obtaining a reliable estimate of the market value of imputation credits is of considerable practical importance for two reasons. First, Officer (1994) demonstrates that the value of imputation tax credits, which he denotes as γ or "gamma," is an important component of firm valuation in dividend imputation tax systems.[1] Second, the estimated value of gamma is one of the key elements of the regulation of monopoly infrastructure assets – a change in the value of gamma can result in the allowed revenue for a single regulated business to change by tens of millions of dollars per year. For example, a recent Australian Competition Tribunal decision to reduce the value of gamma from 0.65 (as proposed by the Australian Energy Regulator) to 0.25 was the largest contributor to increased allowable revenues for three electricity distribution network operators by around $850 million over five years.[2]

[1] See the Appendix to Officer (1994) for an illustration of how the various cash flows and discount rate expressions are adjusted for imputation to value a firm under the assumption of a constant stream of cash flows in perpetuity.

[2] The Australian Competition Tribunal on 19 May 2011 handed down its decision on the appeals by the South Australian (ETSA Utilities) and Queensland electricity distribution network operators (Energex and

The value of imputation tax credits developed by Officer (1994), gamma, is the product of two components: the proportion of credits that are distributed to shareholders (the distribution rate, F) and the market value of those credits that are distributed (θ or "theta"). That is, $\gamma = F \times \theta$, where the F term recognizes that imputation tax credits can only be of value to shareholders if they are distributed, and the θ term is an estimate of the value of the tax credits once distributed to the representative investor. It is the θ parameter that is the focus of this study.

Two empirical approaches have been developed to estimate the market value of distributed imputation credits, θ. The first approach is the dividend drop-off method, whereby stock price changes over the ex-dividend day are compared with the associated cash dividend and any imputation tax credit that is attached to it. The second approach is the simultaneous pricing method, whereby the implied value of cash dividends and imputation credits is extracted from the simultaneous prices of two traded securities, one of which entitles the holder to receive the dividend and tax credit, and one of which does not.

In this study, we use the simultaneous pricing method to estimate the market value of distributed imputation credits, θ. In particular, we construct a sample of simultaneous traded prices of ordinary shares (which entitle the holder to cash dividends and imputation credits) and individual share futures contracts (which provide no such

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Ergon Energy). See the press release on the Australian Energy Regulator's website for more details: http://www.aer.gov.au/content/index.phtml/itemId/746345.

entitlement). We then infer the value of cash dividends and imputation credits from the difference between the prices of the two securities. In doing this, we follow Cannavan Finn and Gray (2004) (CFG).

Whereas the CFG sample period ends in 1999, we use an up-to-date sample that begins after the tax law change of 2000 took effect. From July 2000, resident individual taxpayers and superannuation funds became entitled to a cash refund of all imputation credits that were in excess of what was needed to reduce their tax obligations to zero. Prior to this change, all unused imputation credits expired and were worthless. Some low tax entities, such as superannuation funds, are likely to benefit from this tax law change, in which case it is possible that the market value of imputation credits may have been increased by the introduction of this rebate provision (see, for example, Cummings and Frino, 2008; Beggs and Skeels, 2006).

No major tax law changes have occurred in this area since July 2000, so we use a sample period from that date through to the present. Our results show that the market value of imputation credits is less than 20% of their face value. We also show that the value of cash dividends and the value of imputation credits are estimated jointly and that it is important that they are interpreted jointly.[3]

The remainder of the paper is structured as follows. Section 2 discusses the Australian dividend imputation tax system and focuses on its impact on the cost of capital. It

[3] For example, it would be inconsistent and wrong to take the estimate of theta from this study and another (inconsistent) estimate of the value of cash dividends from another study and to then try to use these two inconsistent estimates jointly when estimating the cost of equity capital.

discusses the potential impact of changes to the taxation laws since the study of CFG. Section 3 reviews the relevant literature on the market valuation of dividends, emphasizing the valuation of imputation credits. Section 4 provides a detailed explanation of our valuation framework, showing how individual share futures (ISFs) and low exercise price options (LEPOs) can be used to infer the market value of dividends and imputation credits and describes the data we use. Section 5 discusses the econometric specifications and presents our results. Section 6 concludes the paper.

II. Dividend Imputation in Australia

A. Overview

The dividend imputation tax system is designed to redress the unfavourable tax treatment that is otherwise applied to dividend distributions to shareholders. In a classical tax system, such as that operating in the United States, corporate profits are effectively taxed twice. They are taxed first by the application of company tax at the corporate level, and then taxed a second time when personal income taxes are levied on dividend income at the shareholder level.

Dividend imputation is designed to address this double taxation of dividends under the classical system. It does so by imputing the value of the tax already paid at the company level to the shareholder in the form of an imputation credit. Under a full imputation system, this credit is equal to the full amount of the corporate tax already paid on the income from which the dividend is paid, and therefore effectively eliminates the double taxation.

A dividend imputation tax system operates in many developed countries around the world.[4] Australia introduced a full dividend imputation tax system on 1 July 1987. Australian companies generate imputation credits upon the payment of corporate tax in Australia. These credits are then stored in what are termed "franking accounts" until they are attached to cash dividends and distributed to shareholders as "franked" dividends. Shareholders receiving the imputation (or "franking") credits are able to use them to offset their Australian personal tax obligations on dividend income or, since 1 July 2000, receive cash rebates once their personal tax obligations have been exhausted.

Under the relevant Australian legislation, every dollar of dividends that is paid out of profits that have been taxed at the corporate level in Australia can have $T/(1-T)$ dollars of imputation credits attached when it is distributed as a dividend – where T is the corporate tax rate. For example, at the current 30% corporate tax rate, such a one dollar cash dividend would have a 43 cent imputation credit attached. To see why this is the case, note that a company that earned a pre-tax profit of $1.43 would have to pay 43 cents of corporate tax (30%) leaving it with $1.00 of after-tax profits. When that dollar of after-tax profits is distributed as a dividend, a 43 cent imputation credit will be attached to it – reflecting the 43 cents of tax that has already been paid in relation to those profits.

A resident shareholder who receives this fully-franked dividend must then declare income of $1.43, even though they received only one dollar of cash. If the resident shareholder has a marginal rate of personal taxation of 50%, for example, the receipt of

[4] For example, Australia and New Zealand operate full imputation systems. Germany operated a full imputation system from January1977 until October 2000. Many other countries offer, or have offered, partial imputation systems, including the United Kingdom, France, Italy, Canada, Ireland, Mexico, Finland, Norway and Taiwan.

the dividend will produce a tax liability of 71.5 cents. The imputation credit can be used to offset 43 cents of this obligation, leaving the shareholder to pay the remaining 28.5 cents. Thus, the net effect is that the shareholder receives $1.00 of cash, makes a tax payment of 28.5 cents and retains the remaining 71.5 cents. Note that this is exactly equivalent to the shareholder receiving the entire initial $1.43 and paying tax at the marginal rate of 50%. That is, the imputation system has the effect of making the intervening company structure irrelevant for the tax consequences of resident shareholders.

Resident shareholders whose marginal personal tax rate is lower than the corporate tax rate can redeem excess franking credits against other income, or if tax payable is reduced to zero, they can be redeemed for cash.

By contrast, non-resident shareholders, who have no Australian personal tax obligations, receive no benefit from imputation credits – they can neither use them to lower personal tax obligations nor redeem them for cash. Over time, various methods of transferring imputation credits from non-resident to resident investors have existed. For example, dividend stripping whereby the foreign (or tax-exempt) investor sells their shares immediately prior to the ex-date and immediately repurchases them afterwards. The dividend stripping resident tax payer then compensates the foreign investor for the dividend and an agreed portion of the credit. The most significant legislative response to such methods was the introduction of the 45-day holding period rule in 1997. This rule requires investors to hold an unhedged position in the shares for a minimum of 45 days should they wish to utilize the credits, and has been successful in preventing the effective transference of imputation credits among shareholder groups. CFG find that since the introduction of the rule, the value of distributed credits embedded in futures prices dropped to a value indistinguishable from zero.

B. The effect of dividend imputation on the cost of capital and value of equity

Officer (1994) provides an explicit formula for the effect of imputation on a firm's cost of equity capital and the value of equity. Essentially, in a classical tax system, the burden of providing the (after corporate tax) return required by its equity holders falls exclusively on the firm. Under a dividend imputation system, some of that burden is borne by the government (in the form of imputation credits).

Officer (1994) shows that the value of imputation credits enters the cost of capital equation via a parameter referred to as "gamma" or γ. This parameter is the value of an imputation credit at the time it is created when the firm pays a dollar of corporate tax. In particular, the required return on equity, r_e, is first estimated using the Capital Asset Pricing Model (CAPM) or some other asset pricing model. Officer then shows that, under the assumptions of his model[5], in a dividend imputation tax system the estimate of the required return on equity must be adjusted as follows:

$$r_e\left[\frac{1-T}{1-T(1-\gamma)}\right] \tag{1}$$

[5] The important assumptions are that the cash flows are defined as in the standard after corporate tax case and that all cash flows are level perpetuities.

where T is the relevant corporate tax rate and γ is the assumed value of franking credits to the relevant shareholder. This adjusted required return on equity is the return to the shareholder net of the franking credit whereas r_e is the total return to the shareholder.

The first task is to understand the source and role of this adjustment. This is best done in the context of an example. Consider a company that earns a pre-tax profit of $100, pays $30 corporate tax, and then pays the remaining $70 to its shareholder.[6] In a full imputation system, the shareholder will then receive a $70 dividend plus a $30 franking credit. This is because every dollar of fully-franked dividends (paid out of profits that have been taxed at the corporate level) has a franking credit of *T*/(1-*T*) attached to it.

Further suppose that the shareholder receiving this $30 franking credit values it at $15. We will discuss why the shareholder may or may not value the franking credit at half of its face value later. For now, we simply use this value in our illustration. The relevant information is summarized in Table 1.

[Table 1 about here]

In this case, the shareholder values the fully-franked dividend at $85. The firm provides $70 of cash, and the government provides $15 of value via the tax system. Using our generic notation, the shareholder receives a package of dividends plus franking credits that has a total value of $(1-T)+\gamma T$. Of this, the firm contributes $(1-T)$ and government

[6] For the moment we will ignore debt and focus only on equity financing to illustrate the point.

contributes the remaining γT. Thus, the proportion of the shareholder's total return that must be generated by the firm is:

$$\frac{1-T}{(1-T)+\gamma T}=\frac{1-T}{1-T(1-\gamma)}.$$

This simple example serves to explain the derivation of the adjustment to the estimated required return on equity above.

Finally, we note that this sort of adjustment is perfectly consistent with the adjustment that is applied to the required return on debt. The nominal after-tax WACC expression involves an adjustment to the required return on debt as $r_d(1-T)$. This recognizes that debt holders require a total return of r_d. When the firm pays this return to the debt holders, it generates a tax deduction which effectively involves the firm receiving $r_d T$ back from government. Thus, the *firm*'s contribution to the total return required by the debt holders is $r_d(1-T)$, and it is this expression that appears in the WACC equation. The adjustment to the estimated cost of equity above is in the same terms – we begin with the total required return and adjust it to reflect the portion of that return that must be generated by the firm. This is because the WACC is about the cost of capital to the *firm*.

There is a divergence of views relating to the value of the imputation tax credits. Generally, expert valuation experts,[7] corporate practice,[8] independent credit rating agencies[9] and government treasuries[10] set γ equal to 0. Australian regulators have

[7] See Lonergan (2001).
[8] See Truong, Partington and Peat (2008).
[9] See KPMG (2005).
[10] See Queensland Government Treasury (2006).

tended toward using a positive value of γ. Most recently, the Australian Energy Regulator, which regulates electricity transmission and distribution and some gas pipelines, proposed a figure of 0.65,[11] but the Australian Competition Tribunal has since concluded that the AER erred in adopting this value and has reduced the regulatory estimate of gamma to 0.25.[12] The Independent Pricing and Regulatory Tribunal (IPART) in New South Wales has adopted an estimate of 0.3 - 0.5,[13] and the Economic Regulation Authority (ERA) in Western Australia has adopted an estimate of 0.53.[14]

The impact on the cost of equity of such different estimates of γ can have a substantial impact on estimates of firm value. For example, consider the impact on the value of equity for a firm with no growth paying an annual stream of \$100 of dividends in perpetuity and a required annual return on equity of 11% .

Under the Officer (1994) framework, the after-tax cost of equity capital to the firm is computed as $r_e\left[\frac{1-T}{1-T(1-\gamma)}\right]$. To illustrate the effect that different values of gamma have on the estimated cost of equity and firm value, Table 2 sets out calculations that contrast the market practice value of gamma (0) with the proposed regulatory value of gamma (0.65). The difference in the estimated after-tax cost of equity to the firm is 2.4% and this leads to differences in the estimated value of equity in the order of 30%.

[Table 2 about here]

[11] See AER (2009).
[12] See Australian Competition Tribunal (2011).
[13] See Independent Pricing and Regulatory Tribunal (2008).
[14] See Economic Regulation Authority (2011).

In summary, there is a divergence of views about what represents an appropriate estimate of gamma, and the different values that have been proposed have a substantial impact on the estimates of the cost and value of equity.

III. Literature

A. Ex-dividend event studies

A number of studies seek to empirically estimate the market value of distributed imputation credits, θ, using the dividend drop-off technique. This technique infers the value of cash dividends and imputation credits from a comparison of the cum-dividend price (which includes the value of dividends and imputation credits) and the ex-dividend price (which does not). The dividend drop-off ratio is generally defined as the ratio of the difference in cum- and ex-dividend prices relative to the dividend amount, $\frac{P_{cum} - P_{ex}}{D}$, where P_{cum} is the share price at the close on the last day of trading before the ex-dividend day; P_{ex} is the share price at the open on the ex-dividend day; and D is the amount of the dividend.

In the US classical tax system, Elton and Gruber (1970) model the drop-off ratio as reflecting the relative valuation of dividends to capital gains to the providers of equity capital. They interpret their estimated drop-off of ratio of 0.77 as suggesting that, for the relevant equity investor, taxes on dividends are 23% greater than taxes on the corresponding capital gain. In this case, the investor would be indifferent between receiving a $1.00 dividend or a $0.77 capital gain as they would have an equivalent value after shareholder-level taxes.

The competing hypothesis, first advanced by Kalay (1982), argues that any difference between the implied value of dividends and capital gains should be arbitraged away by the substantial class of market participants that are taxed equally on both. This activity would lead to a dividend drop-off ratio close to 1.0.

Many studies have since examined this question in the context of the US classical tax system. One of the leading studies is Boyd and Jagannathan (1994), who use a comprehensive data set and develop an improved econometric technique.[15] They conclude that a drop-off ratio of close to 1.0 would have been an appropriate estimate over their 25 year sample period. Graham, Michaely and Roberts (2003) report drop-off ratios insignificantly different from 1.0 for observations with a dividend yield in excess of 2%. It is this result that has the most relevance for the Australian market, where the average dividend yield is in the order of 5% p.a. and dividends are paid twice per year. They report somewhat lower drop-off ratios for observations with lower dividend yields.

In a dividend imputation tax system, the value of the cash dividend and the associated tax credit must be jointly estimated. This is usually done by including un-franked dividends, which have no imputation credits attached to them, usually because they are paid out of foreign-sourced profits. These un-franked dividends tie down the estimate of the value of

[15] This study "takes explicit account of two of the stylized facts from the literature…(i) transactions costs are important, and (ii) there are several classes of traders with different transactions costs and/or tax treatments…(t)he third stylized fact – dividend capture trading of high yield stocks – is a property of the equilibrium"[Boyd and Jagannathan (1994) at p. 714].

cash dividends, and the franked dividends in the sample then tie down the value of imputation credits.

Brown and Clarke (1993) study Australian data from 1973 to 1991 and compare average drop-off ratios before and after dividend imputation was introduced in 1987. They report that a material *decline* in the average dividend drop-off ratio coincided with the introduction of dividend imputation. This result is clearly inconsistent with the view that imputation credits increase the value of each dividend payment to the relevant investor.

Bellamy and Gray (2004) consider a number of statistical issues concerning the joint estimation of the value of the cash dividend and the value of the associated imputation credit. They show that the estimates of the two components are correlated and that there are a number of pairs of estimates that fit the data equally well. In particular, their full-sample results produce estimates of 0.83 and 0.36 for cash dividends and imputation credits respectively. However, a constrained model in which the values are fixed to 1 and 0 (i.e., full value for cash dividends and no value to franking credits) fits the data equally well.

Beggs and Skeels (2006) use the dividend drop-off technique to examine the effects of six changes to the Australian tax laws during the period from 1986 to 2004. They conclude that over their sample period cash dividends are close to fully valued and that the market value of imputation credits is generally insignificant.[16] Their results do

[16] "It was then found that cash drop-off ratios were consistently close to 1, but the franking credit drop-off ratios were significantly less than 1. Moreover, the franking credit drop-off ratios were not significantly different from zero for much of the sample data. This indicates that marginal investors did not value the

suggest a possible increase in the estimated value of imputation credits, coinciding with the introduction of the Rebate Provision in July 2000. However, closer examination of this result reveals that there is no evidence of an increase in the combined value of cash dividend plus imputation credit. Rather, the increase in the estimated value of imputation credits simply balanced a proportional decrease in the estimated value of cash dividends.[17] Consequently, the apparent increase in the value of imputation credits is more likely to be a statistical artifact associated with a small sample than due to a real increase in value caused by a change in the tax laws.

A number of recent papers use the dividend drop-off technique as part of the examination of various trading behaviors. For example, Jun, Alaganar, Partington and Stevenson (2008) report that dividend drop-off ratios are lower for American Depository Receipts (ADRs) on Australian stocks than for the underlying stocks. They find that the magnitude of the discrepancy is larger for high-yielding stocks that distribute imputation credits. They also find that the difference is driven by temporarily higher cum-dividend prices and temporarily lower ex-dividend prices in the Australian market. This, combined with the documented higher abnormal trading volume, is consistent with dividend capture trading. All else being equal, this result would imply that the estimated value of imputation credits which relies upon Australian sample data would have an

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franking credit, and provides an explanation as to why gross drop-off ratios less than 1 were observed." [Beggs and Skeels, 2004 at p. 249].

[17] The drop-off ratio for the cash dividend was estimated at 0.795 for the 1998-1999 period, this increased to 1.168 for the 2000 period, and then reverted to 0.8 for the 2001-2004 period. The drop-off ratio for the franking credit was estimated at 0.418 for 1998-1999, this decreased to 0.128 for 2000 and then reverted to 0.572 for 2001-2004. The combined package estimate was much more stable: 0.654 for 1998-1999, 0.743 for 1999, and 0.724 for 2001-2004. It was the unusually small estimate of the franking credit for 2000 (caused by the unusually large value of the cash dividend estimated for 2000) that is therefore causing the result.

upward bias. That is, estimates of the value of imputation credits from drop-off studies would be too high.

Conversely, Ainsworth, Fong, Gallagher and Partington (2008) conclude that there is no material dividend capture trading in the Australian market. Rather, the abnormal trading volumes around ex-dividend dates are caused by tax-disadvantaged investors advancing sales and tax-advantaged investors advancing purchases into the cum-dividend period, and vice versa in the ex-dividend period. Ainsworth, Fong, Gallagher and Partington (2009) examine the trading behaviour of institutional equity funds around the ex-dividend day. They find no evidence of dividend-capture trading by the funds in their sample, but do find some evidence that these institutions accelerate sales of long-term holdings to the cum-dividend period and delay purchases to the ex-dividend period. They also find evidence of short-term trading by these institutions in the cum-dividend period, which they attribute to benefits accruing from supplying liquidity and capturing capital gains that result from a run-up of prices approaching the ex-day. These studies do not specifically estimate the market value of imputation credits. However, they do indicate that dividend drop-off estimates of the value of imputation credits could be affected by the significant increases in trading volume around ex-dividend dates, and the fact that there is evidence of certain classes of investors shifting their trades to the cum-dividend period and other classes of investors shifting their trades to the ex-dividend period. If this results in cum-dividend trades being larger buyer-initiated and ex-dividend trades being largely seller-initiated, the magnitude of the dividend drop-off will be increased as a result of this trading behaviour. That is, drop-off estimates may be overstated in the sense that they recover the value to that subset of investors that values the credits most – those being the investors that are setting prices around the ex-dividend date.

B. Simultaneous security price studies

A number of studies seek to infer the implied value of cash dividends and imputation credits by comparing the simultaneous prices of two traded securities that are effectively identical in all respects other than one entitles the holder to receive the dividend and imputation credit and one does not.

For example, Walker and Partington (1999) examine a small sample of stocks that traded cum-dividend on the ex-dividend day. This enables them to observe simultaneous cum- and ex-dividend prices on the same stock. Their sample consists of matched trades in 50 stocks between January 1995 and March 1997. They report a mean drop-off ratio of 1.15, which is considerably higher than any other estimate. They also urge against generalizing this result, acknowledging that this trading of cum-dividend shares in the ex-dividend period is likely to be dominated by short-term dividend capture traders. Therefore the results are unlikely to reflect long-term equilibrium values useful for cost of capital estimation. Moreover, the study predates the 45-day rule that now prevents dividend capture trading.

CFG infer the value of cash dividends and imputation credits from the relative prices of individual share futures contracts and the underlying stocks on which they are based. The authors exploit no-arbitrage pricing relationships to estimate the market value of imputation credits in Australia over the period 1994 – 1999. They are also able to test for the effect of the introduction of the 45-day rule in 1997, which was designed to prevent trading in imputation credits. They report that the estimated value of imputation credits, after the introduction of the 45-day rule, is insignificantly different from zero.

One of the major advantages of this type of study is that a new observation is available every time there is a simultaneous trade of the futures contract and the underlying stock. Consequently, there are many observations that are available per dividend event, whereas each dividend event produces only a single observation for the dividend drop-off method. Another advantage is the fact that the simultaneous trades can occur well before the ex-dividend period. These prices are consequently less likely to be affected by the actions of any short-term trading activities. Of course, the downside is that individual share futures contracts exist only for the largest companies.

IV. Data description and valuation framework

A. Individual Share Futures / Low Exercise Price Options

Individual share futures contracts (ISFs) were traded on the Sydney Futures Exchange (SFE) between May 1994 and November 2008.[18] They are based on Australia's largest and most actively traded stocks and are typically written with 1,000 shares of an individual company as the underlying asset. Initially, the contracts were settled in cash, although over time most contracts switched to physical delivery, beginning in March 1996 (Lien and Yang, 2004). ISFs are not protected against dividend payments, but adjustments are made for all other capital reconstructions (e.g., share splits and bonus

[18] The SFE announced on 19 November 2007 its decision to delist all ISFs. Contracts with no open interest were delisted at the close of business on 20 November 2007. Contracts with open interest were maintained until expiry. The decision to delist ISFs followed the merger of the SFE with the ASX on 25 July 2006. Low exercise price options trading on the ASX provided a substantially identical product.

issues). ISFs trade on a quarterly maturity cycle, with at least two delivery contracts on each stock quoted at any one time.

Low exercise price options (LEPOs) are effectively identical to ISFs. They were introduced by, and have traded on, the Australian Stock Exchange (ASX) since 1995.[19] Technically, LEPOs are exchange-traded call options that give the holder the right to purchase 1,000 shares in a company at a predetermined exercise price and impose an obligation on the writer of the LEPO to sell those shares at the exercise price if the holder elects to exercise. LEPOs differ from standard call options in that they have a nominal exercise price of one cent and the option premium is paid when the contract matures. These two features mean that the option is certain to be exercised and the buyer will pay the option premium to the seller at maturity. Note that this feature is the same as a futures contract – the underlying asset is exchanged for the agreed-upon price at maturity. The ASX also arranges a margining and marking-to-market system that makes the cash flows between the parties for a LEPO contract identical to the cash flows under an ISF, but for the one cent exercise price to be paid at maturity. LEPOs currently trade on 47 stocks.

B. Contract Valuation

To derive a valuation formula for ISFs and LEPOs we rely on the standard cost-of-carry no-arbitrage framework developed in CFG. We begin by considering a representative investor who faces the same marginal tax rate τ_p on dividend income, income from futures trading, and short-term capital gains on stocks. We also make the standard

[19] At that time, the ASX and SFE were independently owned and competed with each other for trading volume. The LEPO product was introduced to compete with the ISF product trading on the rival exchange.

assumptions required to consider a futures contract to have the same value as an otherwise identical forward contract as outlined in Cox, Ingersoll and Ross (1981).

The contract maturing at time T is to be valued at time *t*. We define $F_{ij}(t,T)$ to be the futures price at time t for a contract over stock i that matures at time T where the index *j* denotes any dividend that is paid by stock *i* between times *t* and *T*; $S_i(t)$ is the spot price of the underlying stock i at time t; and $D_{ij}(s)$ and $IC_{ij}(s)$ are the dividend and the associated imputation credit, respectively, for stock i and dividend j at the ex-dividend date s, where ($t < s < T$) which is assumed to be known at time t. We define X to be the exercise price, so X =0 for the ISF contracts in our sample and X =0.01 for the LEPO contracts. We denote the continuously-compounded risk-free rate of interest between times *t* and *T* as $r_{t,T}$, with an analogous definition for other time periods.

The no-arbitrage cost-of-carry framework is based on the notion that there are two equivalent methods for obtaining ownership of one share at time T, where each method requires a single net cash flow at time T. Since both methods require a single net cash flow to be made at the same time, and they both result in the acquisition of an identical share in the same company, the two cash flows must be equal in a standard no-arbitrage setting.

Method 1: forward contract

Under this method, the investor purchases a forward contract at time t, which involves locking-in a price for future delivery at time T, but requires no payment until then. The purchaser of the forward contract does not receive the dividend or the imputation credit at time s because they do not own the physical shares at that time. When the contract matures at time T, the purchaser pays the agreed-upon price of $F_{ij}(t,T)$, and the strike price $X = 0.01$ if the contract is a LEPO, and receives one share in the underlying company, which is worth $S_i(T)$ at that time. We denote transactions costs as c_F (in time T dollars). All short-term trading profits are taxed at the rate of τ_p. Consequently, the net cash flow at maturity for the buyer of the forward contract is:

$$\left(S_i(T) - \left[F_{ij}(t,T) + X + c_F\right]\right)\left(1 - \tau_p\right) \tag{1}$$

Method 2: physical replication.

Under this method, the investor borrows $S_i(t)$ and uses these funds to purchase one share at time *t*. This means at time *s* the investor receives a cash dividend $D_{ij}(s)$ and the associated imputation credit $IC_{ij}(s)$. If the cash dividend is placed in a risk-free interest-bearing account, it will have accumulated to $D_{ij}(s)e^{r_{s,T}(T-s)}$ at time T. This dividend and accumulated interest is taxed at τ_p meaning that the investor is left with $D_{ij}(s)e^{r_{s,T}(T-s)}(1-\tau_p)$ after-tax.

We use θ to denote the value of one dollar (face value) of imputation credits paid to the investor. The receipt of imputation credits does not result in an immediate cash benefit to the investor – rather, it enables a resident investor to reduce their personal tax obligations when filing their next personal tax return. We assume that this coincides with the maturity date of the forward contract. We also note that imputation credits are taxable in the hands of resident investors in that the investor's taxable income is increased by the amount of the credit.[20] Consequently, net of taxes the time T value of the imputation credit is $\theta IC_{ij}(s)(1-\tau_p)$.[21]

At time T the investor must repay the original loan along with the interest, which totals $S_i(t)e^{r_{t,T}(T-t)}$. Since the interest on the loan is tax-deductible, the after-tax payment required to repay the loan is $S_i(t)e^{r_{t,T}(T-t)}\left(1-\tau_p\right)$. Lastly, the investor can sell the share for $S_i(T)$ at time T and pay capital gains tax of $\left[S_i(T)-S_i(t)\right]\tau_p$ since capital gains are treated as ordinary income over short horizons. We denote transactions costs as c_S (in time T dollars). This means that the net after-tax payoff at time T is:

$$\left(S_i(T)-\left[S_i(t)e^{r_{t,T}(T-t)}-D_{ij}(s)e^{r_{s,T}(T-s)}-\theta IC_{ij}(s)+c_S\right]\right)\left(1-\tau_p\right) \tag{2}$$

As the net payoff from Method 1 must equal the net payoff from Method 2 to prevent arbitrage, it must be the case that:

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[20] For example, consider an investor with a marginal personal tax rate of 40% who receives a \$100 imputation credit. This investor would have to increase their taxable income by \$100, but can then reduce their personal tax bill by \$100, producing a net benefit of \$60. The receipt of an imputation credit is, therefore, the same as the receipt of a dividend or any other income – in this case, the investor effectively receives \$100, pays tax of \$40, and is left with \$60.

21 An alternative derivation for the after tax value of the dividend and imputation credit is as follows:
Net after tax value of Dividend (ignoring interest and assuming IC is fully valued)

$= \quad D_{ij}(s)-\left[\left(D_{ij}(s)+IC_{ij}(s)\right)\tau_p-IC_{ij}(s)\right]$

$= \quad D_{ij}(s)-D_{ij}(s)\tau_p-IC_{ij}(s)\tau_p+IC_{ij}(s)$

$= \quad D_{ij}(s)\left(1-\tau_p\right)+IC_{ij}(s)\left(1-\tau_p\right)$

Since dividend earns interest and IC may not be fully valued – value to investor is
$D_{ij}(s)e^{r_{s,T}(T-s)}\left(1-\tau_p\right)+\theta IC_{ij}(s)(1-\tau_p)$

$$F_{ij}(t,T) + X + c_F = S_i(t)e^{r_{t,T}(T-t)} - D_{ij}(s)e^{r_{s,T}(T-s)} - \theta IC_{ij}(s) + c_S \tag{3}$$

which defines the valuation formula for the forward contract:

$$F_{ij}(t,T) = S_i(t)e^{r_{t,T}(T-t)} - D_{ij}(s)e^{r_{s,T}(T-s)} - \theta IC_{ij}(s) - X + (c_S - c_F) \tag{4}$$

Of course, the analysis for a seller rather than a buyer leads to the same result except with the reverse sign on the transactions cost term. This produces an expression, bounded by transaction costs, for the value of the futures contract in terms of the spot price of the underlying stock, cash dividends and imputation credits:

$$\begin{aligned} &S_i(t)e^{r_{t,T}(T-t)} - D_{ij}(s)e^{r_{s,T}(T-s)} - \theta IC_{ij}(s) - X - (c_S - c_F) \\ &\qquad \le F_{ij}(t,T) \le \\ &S_i(t)e^{r_{t,T}(T-t)} - D_{ij}(s)e^{r_{s,T}(T-s)} - \theta IC_{ij}(s) - X + (c_S - c_F) \end{aligned} \tag{4a}$$

Crucially, these no-arbitrage relationships do not require knowledge of, and are unaffected by, te size of the ex-dividend drop-off. A disparity between the expected drop-off and the value of the cash dividend and imputation credit to an investor may motivate trading in the stock (e.g., short-term dividend capture strategies) but it does not affect the no-arbitrage futures price for that investor. Regardless of whether the investor buys a futures contract or the stock itself, the terminal payoff involves the same ex-dividend stock price, meaning the price of the futures contract (relative to the current stock price) is independent of the size of the drop-off. We exploit this fact in our valuation framework and set the cost of obtaining the ex-dividend stock to be the same under both methods, thereby eliminating arbitrage possibilities.

We also note that these no-arbitrage relationships are independent of the risk preferences of investors, the volatility of the underlying stock, and the stochastic process that governs the evolution of stock prices. All that is required is the assumption that riskless arbitrage opportunities are not easily available in financial markets.

C. Data description

Our sample consists of all trades in all ISF and LEPO contracts that occurred during the period 1 July 2000 to 28 August 2008. Trades in the derivative contracts and the underlying stocks were obtained from Securities Industry Research Centre of Asia-Pacific (SIRCA). The majority of trades occur in the contract that is nearest to maturity. Consequently, observations with no ex-dividend date between the trade date and maturity of the contract are relatively common and are useful in testing the pricing accuracy of the cost-of-carry no-arbitrage pricing model. Conversely, trades where more than one ex-dividend event occurs between the trade date and contract maturity are infrequent and are excluded from the sample.

Every futures trade must be matched with the contemporaneous stock price. We do this, by taking a volume-weighted average of the prices of the five stock trades immediately before and the five stock trades immediately after the futures trade, conditional on those stock trades occurring within five minutes of the futures trade. Where any of these ten stock trades fall outside the +/- five minute window, they are omitted from consideration and the average is taken over those trades within the window. Where less than four stock trades occur within the window, the observation is deleted from our sample. We use the volume weighted-average prices to smooth short-term stock price volatility and to dampen the effects of bid-ask bounce.

Given that the ISF and LEPO contracts are only written on Australia's most heavily traded stocks, the matched trades tend to be closely contemporaneous to the futures trade. In particular, Table 4 shows that in almost 95% of cases there are five or more separate stock trades in the five minutes prior to the futures trade and in almost 90% of cases there are five or more stock trades in the five minutes after the futures trade.

[Table 4 about here]

The sample includes stocks that pay fully franked, partially franked and unfranked dividends. The data on dividend amounts, franking and ex-dividend dates are sourced from Capital IQ. Our primary analysis assumes that all information about dividends is known at the time of the futures contract trades. Given that ex-dividend dates (Kalay and Lowenstein, 1985), dividend amounts (Brav, Graham, Harvey and Michaely, 2005; Leary and Michaely, 2011) and franking percentages (CFG) are relatively predictable, this is not a strong assumption. As a robustness check, we also restrict our analysis to futures contract trades occurring fewer than 21 days before the ex-dividend date to ensure the dividend information is known and find that the results are immaterially different. We also examine a sub-sample of observations within 10 days of the ex-dividend date and again find no material difference in the results.

We obtain proxies for the risk-free rate of interest from the Reserve Bank of Australia (RBA). Specifically, we obtain daily values of the RBA 11 a.m. Cash Rate, the RBA 30-day Dealers' Bill Rate, the RBA 90-day Dealers' Bill Rate, and the RBA 180-day Dealers' Bill Rate for the sample period. We use interest rates that match as closely as possible the time between the trade or the dividend payment and contract maturity. The cash rate is used if the relevant number of days is 15 or less; the 30-day rate if the number is between 16 and 60; the 90-day rate if the number is between 61 and 120; and the 180-day rate if the number is greater than 120.

Table 5 contains a range of summary statistics for the ISF and LEPO observations in our sample. The majority of observations are for contracts on 20 large and actively-traded companies. Whereas a range of industries are represented, there is a concentration of banks and mining stocks. However, this is unlikely to affect our results as the no-arbitrage framework on which they are based is independent of any industry characteristics. Observations are grouped into those with no dividend event for that company occurring between the trade and the maturity of the futures contract and those with one dividend event occurring between the trade and maturity. The first sub-sample is used to test the accuracy of the pricing model in the absence of dividends.

[Table 5 about here]

Table 6 sets out the distribution of ex-dividend events in our sample by month of year. While there is a clear dividend season in July and August, our sample contains a substantial number of observations from every month. The time series distribution of ex-dividend dates is also unlikely to affect our results as the no-arbitrage framework is independent of the month of the year or whether the particular stock or broad market might be rising or falling.

[Table 6 about here]

V. Econometric method and results

A. Econometric method

We begin by testing the accuracy of the cost-of-carry no-arbitrage pricing model in the absence of dividends. To do this, we form a sub-sample of all observations for which there is no dividend event between the trade date and the maturity of the contract. From Equation (4) we know that in the absence of dividends and transactions costs:

$$F_i(t,T) = S_i(t)e^{r_{t,T}(T-t)} - X \quad . \tag{5}$$

We then compute the relative pricing error which, in the absence of dividends and transactions costs, we define as:

$$RPE_i(t) = \frac{S_i(t)e^{r_{t,T}(T-t)} - X - F_i(t,T)}{S_i(t)} . \tag{6}$$

For our sample of non-dividend observations, the mean relative pricing error is 0.05% and for 90% of the observations the relative pricing error is between -0.3% and 0.3%. This is consistent with pricing errors being within the bounds of transactions costs (Bessembinder, 2003; Lesmond, Ogden and Trzcinka, 1999; Hasbrouk, 1993). The average mispricing on a $20 stock, for example, amounts to one cent per share. We conclude from these results that the pricing of the ISF and LEPO contracts is consistent with the Equation (4) no-arbitrage pricing relationship.

Figure 1 presents a histogram of the pricing errors expressed as a percentage of the stock price. We note that there are a small number of observations for which the relative pricing error exceeds 2% in magnitude. Almost all of these observations relate to relatively thinly traded ISF or LEPO contracts on stocks outside the top 20 and tend to be caused by a single small futures trade at an unusually high or low price.[22] Figure 1 shows that for the vast majority of observations the relative pricing error is well within the bounds of transactions costs.

[Figure 1 about here]

Substituting our definition of relative pricing error from Equation (6) into the no-arbitrage valuation framework in Equation (4) and scaling appropriately produces the following equation:

[22] For example,

$$RPE_i(t) = \beta_0 + \delta \frac{D_i(s)e^{r_{t,T}(T-s)}}{S_i(t)} + \theta \frac{IC_i(s)}{S_i(t)} \tag{7}$$

with β_0 representing an equilibrium transactions cost differential, which is discussed further below. The regression form of this equation is:

$$RPE_{ij}(t) = \beta_0 + \beta_1 \frac{D_{ij}(s)e^{r_{s,T}(T-s)}}{S_i(t)} + \beta_2 \frac{IC_{ij}(s)}{S_i(t)} + \varepsilon_{ij}(t) \tag{8}$$

where β_1 measures the value of one dollar of cash dividends relative to the value of one dollar of futures payoff. It is important to remember that this differs from the interpretation in dividend drop-off studies, which measure the value of cash dividends relative to the value of capital gains. The coefficient β_2 is an estimate of the value that the representative investor obtains from receiving one dollar of imputation credits.

Since the composition of the shareholder base varies across companies, it is possible that the value of dividends and imputation tax credits varies across the companies in our sample. For example, larger companies are more likely to have a greater proportion of non-resident investors who are unable to utilize imputation tax credits. Also, higher dividend yields make dividend capture more cost effective for investors whose tax position makes such a strategy attractive. To account for these possibilities, we allow the slope coefficients in (8) to vary with the size of the company and the dividend yield. In particular, for observation $i\ (i = 1,...N)$, $\beta_k\ (k = 1,2)$ becomes $\beta_k = \beta_{k0} + \beta_{k1} DY_i + \beta_{k2} \ln(MKTCAP_i)$; where DY_i is the dividend yield for observation i

scaled by subtracting the mean and then dividing by the standard deviation of dividend yields across our sample; and $\ln(MKTCAP_i)$ is the log-market capitalization of the relevant firm at the end of the month of observation i, also scaled by subtracting the mean and dividing by the standard deviation across our sample. In this setting, β_{k0} $(k=1,2)$ is interpreted as the slope coefficient for a firm of average dividend yield and size.

B. Parameter estimates

The parameter estimates of our various regression specifications are presented in Table 7. The first three columns present results for all dividend events in our sample and the final column presents results only for those dividend events where the dividend paid was un-franked.

[Table 7 about here]

The results in the first column are for a model that sets each of the value of cash dividends and the value of franking credits to be the same across all dividend events. The second column allows the value of cash dividends to vary according to dividend yield and firm size and the third column allows similar variation in the value of franking credits.

Intercept/Transaction cost differential

When providing for the possibility that short-term traders may influence the implied value of dividends or franking credits, an intercept is interpreted as a transaction cost differential – in this case, the relative cost of trading futures contracts and ordinary shares. We have included such an intercept term in Table 7 and note that, while the intercept terms are statistically significant, they are economically very small – more than 1,000 times smaller than the value of the cash dividend, which itself is small relative to the stock price. This is consistent with the results of CFG.

Some studies, such as those that are more focused on providers of longer-term equity capital rather than on short-term trading around the ex-dividend date, do not include an intercept term. These studies take the view that in a large sample it is only the dividend and franking credit that should have a systematic effect on pricing. Consequently, we repeat our analysis without an intercept term and report the results in Table 8. The results in Table 8 are immaterially different from those reported in Table 7, which is expected given the economically insignificant magnitudes of the intercept terms in Table 7.

Value of Cash Dividend

Under the various model specifications, cash dividends are valued in the range of 90-95% of their face value for the average firm. In all models, the estimated cash dividend values are statistically significantly different from one. The estimate of 0.90 in Column 1 is an average estimate across the entire sample. As mentioned, we also allow the estimate to vary with the firm characteristics of size and dividend yield. In Column 2 we report the results for this model. The value of cash dividends increases (decreases) by around 1% of face value for an observation with a dividend yield one standard deviation above (below) the average. Likewise the value of cash dividends increases by around 4% of face value for every standard deviation above the average (log) market capitalization the observation is. The results for the variable slope model in Column 2 suggest that cash dividends are worth relatively more in high-yielding and large firms, which is consistent with the institutional investor clientele that is attracted to large high-yielding firms placing a relatively higher value on cash dividends (Ainsworth et al., 2008; Ainsworth et al., 2009). However, in the subsequent section we demonstrate that the economic significance of these effects is small.

Value of Franking Credits

Under the various model specifications, franking credits are valued in the range of 6-17% of their face value for the average firm. The estimate of around 17% of face value reported in Column 1 is an average estimate across the entire sample. In Column 3 we report the results for the model where we allow the estimate to vary with the firm characteristics of size and dividend yield. All estimates are of the same order of those in CFG where the franking credits where found to be valued around 15% of their face value prior to the introduction of the 45-day holding rule, and around zero afterwards. It is difficult to directly compare the estimates with those from Beggs and Skeels (2006) as their point estimates fluctuate greatly from year to year. However their "result suggests that the market placed no value on the franking credits during most of the sample period"[23] which is not too dissimilar from our estimates. The estimates of Hathaway and Officer (2004) of around 50% of face value are considerably higher than ours. The results for the variable slope model in Column 3 suggest that, like cash dividends, franking credits are worth relatively more in high-yielding and large firms, which is again consistent with the institutional investor clientele that is attracted to large high-yielding firms placing a relatively higher value on franking credits (Ainsworth et al., 2008;

[23] Beggs and Skeels (2006) at page 245.

Ainsworth et al., 2009). Again, in the subsequent section we examine the economic significance of these effects.

C. Sensitivity analysis

The estimates of the value of cash dividends and the value of distributed imputation credits from the variable slope models in Table 7 are summarized in Table 9. In Table 9, the top value in each cell is the estimated value of cash dividends, conditional on the relevant firm size and dividend yield. There is relatively little variation in the estimated value of cash dividends – whether the firm is well above or below the mean value for firm size and/or dividend yield, the estimated value of cash dividends is generally in the range of 90-100% of firm value.

The estimated value of distributed imputation credits, theta, ranges from being insignificantly different from zero for the smaller low-yielding firms in our sample to 36% of face value for larger high-yielding firms. Ainsworth et al., (2008) report that large high-yielding firms tend to experience the greatest increase in trading volume around the ex-dividend date. They find that, for these firms, excess buying pressure in the cum-dividend market and excess selling pressure in the ex-dividend market exacerbates the size of the measured dividend drop-off, increasing the estimate of theta. This finding is consistent with our results.

D. Joint estimation

It is important to note that our analysis produces estimates of two parameters: theta and the value of cash dividends. That is, the estimates come in pairs. For example, the point estimate of 0.17 for theta in the first column of Table 7 is not independent of the estimated value of cash dividends. Rather the estimate of 0.17 for theta corresponds with the estimate of 0.90 for the value of cash dividends. Consequently, the pair of estimates must be considered jointly. This is particularly important in light of the strong correlation between the pairs of estimates. For example, the correlation between the estimates of the value of cash dividends and theta in the first column of Table 7 is 0.96. The high negative correlation between parameter estimates is inescapable since it is the value of the combined package of dividend plus imputation credit that is actually being estimated and hence a lower estimate for one component of the package will result in a higher estimate of the other component, leaving the estimated value of the package essentially unchanged.

Because the two key parameters are highly correlated, we plot the joint confidence interval for the estimates of theta and the value of cash dividends (from the first column of Table 7) in Figure 2. Specifically, the joint confidence region is that set of values $\beta = (\beta_1, \beta_2)'$ for which $\frac{1}{2}(b-\beta)'\Omega^{-1}(b-\beta)$ is less than the critical value of $F[2, n-K]$, where b represents the parameter estimates, Ω is the estimated covariance matrix of the relevant parameters, n is the number of observations in the sample, and K is the number of parameters being estimated. This joint confidence region shows the pairs of parameter estimates (value of cash dividends and value of theta) that fit the data equally well. There is no statistically significant difference between any pair of estimates within the joint confidence interval in terms of their ability to fit the data.

[Figure 2 about here]

The strong negative correlation between the estimates of the two parameters means that there is a range of pairs that fit the data equally well. For example, setting the value of cash dividends and theta to (0.92, 0.12) or to (0.88, 0.21) are insignificantly different in their ability to fit the data. Both of these pairs of estimates imply a package value of 0.97.

The first column of Table 7 shows that the unfranked dividends in our sample tie down the estimated value of cash dividends to the range of 0.88 to 0.92, and that the 95% confidence interval for theta is 0.12 to 0.21. Figure 2 then shows that estimates of the value of cash dividends that are towards the top end of the range must be paired with estimates of theta from the bottom end of the range. That is, the estimate of theta is conditional on the estimated value of cash dividends.

Finally, we note that there is a difference between the concept of correlation between parameter estimates and the statistical problem of multicollinearity in the data. Multicollinearity occurs when there is high correlation between two or more independent variables causing the standard error of parameter estimates to be mis-estimated. In such a case, the parameter estimates themselves are consistent, but statistical inference is difficult. One common way of testing for whether multicollinearity is a problem in a specific case is to estimate variance inflation factors (VIFs). Bowerman and O'Connell (1990) show that multicollinearity is a concern when VIFs exceed 10. In our sample of observations that have a dividend between the futures trade and maturity, the variance inflation factors of both parameters are approximately 4.5, indicating that multicollinearity is not a problem with our data.

E. Robustness checks

As a further check of the robustness of our results, we perform a stability analysis to examine the sensitivity of our estimates to the most influential observations in the sample. We do this by first determining which single observation, if removed, would result in the greatest increase in our estimate of theta. We then determine which single observation, if removed, would result in the greatest decrease in our estimate of theta. We then remove both observations and re-estimate theta. We then repeat this process by removing another pair of observations. We continue in this manner, removing pairs of observations, until 100 pairs have been removed.

The results of applying this process to the constant slope model in the first column of Table 7 are summarised in Figure 3. The solid lines represent the estimates of the value of cash dividends, the value of theta, and the value of the combined package, as indicated. In each case, the corresponding dashed lines represent the 95% confidence interval around the point estimate.

[Figure 3 about here]

It is clear from Figure 3 that our results are not driven by a small number of influential data points. The point estimates and 95% confidence intervals are stable and largely insensitive to the removal of up to 100 pairs of the most influential observations. If anything, the estimated value of cash dividends increases and the estimate of theta decreases as a small number of the most influential data points are removed from the sample.

VI. Conclusions

In this paper, we infer the value of cash dividends, and the imputation tax credits that are attached to them, from simultaneous trades of ordinary shares (which entitle the holder to dividends and imputation credits) and individual share futures contracts (which provide no such entitlement). Our sample contains more than 30,000 observations from the period subsequent to the 2001 change in tax laws that allowed a rebate for unused credits. Over this sample, we estimate the value of cash dividends to be 90% of face value and the value of distributed imputation credits (theta) to be 17% of face value.

Given that a reasonable estimate of the imputation tax credit distribution rate (*F*) for the average firm is 70%,[24] our results imply a point estimate for gamma of:

$$\gamma = F \times \theta = 0.7 \times 0.17 = 0.12.$$

[24] Hathaway and Officer (2004) estimate a distribution rate of 71%, Hathaway (2010) estimates a rate of 69%. The Australian Competition Tribunal (2011) has endorsed a value of 70%.

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Table 1. Summary of Franking Credit Example

Item	Dollar Value	Symbol
Corporate Level		
Company Profit	100	1
Corporate Tax	(30)	(T)
After Tax Profit	70	$(1-T)$
Shareholder Level		
Dividend Received	70	$(1-T)$
Franking Credit Received	30	T
Value of Franking Credit to Shareholder	15	γT
Total Value of Fully-Franked Dividend	85	$(1-T)+\gamma T$

Table 2. Summary of Franking Credit Example

Item	Cost of Equity Capital	Value of Equity	Difference in Value of Equity
No growth [a]			
$\gamma=0$	11.0%	909	
$\gamma=0.65$	8.6%	1,163	28%

a Value of Equity = $100/Cost of Equity Capital

Table 2. Relative trading times of stock and futures contracts

The middle column reports the time (in seconds) between the fifth stock trade before the futures trade and the time of the futures trade itself. The right column reports the time (in seconds) between the fifth stock trade after the futures trade and the time of the futures trade itself. There are a total of 31,773 futures trades in our sample. Data is provided by SIRCA.

Percentile	**Fifth trade prior to futures (seconds)**	**Fifth trade after futures (seconds)**
Max	3,532.1	3,757.7
99%	573.6	882.7
95%	310.5	478.1
90%	228.0	340.8
75%	123.9	188.5
50%	57.4	91.9
25%	22.5	39.4
10%	7.7	17.6
5%	3.1	9.9
1%	0.2	2.5
Min	0.0	0.0

Table 3. Summary statistics for individual companies.

This table contains summary statistics for the individual companies in the sample. Averages are computed over the number of observations of the individual share futures (ISFs) and low exercise price options (LEPOs) written on the stock of the company. The dividend yield is reported per dividend event not per year. All companies in our sample pay two dividends per year. Special dividends are excluded from our sample.

Company	Industry	Market Capitalization at 31 December 2008 ($ million)	2008 Annual Trading Volume ($ volume)	Observations with no dividend prior to maturity	Observations with one dividend prior to maturity	Mean dividend yield (% per event)	Mean franking percentage
AMP	Insurance	10,801	10,849	770	461	1.87	39
ANZ Banking Group	Banks	32,997	44,387	1,570	376	2.54	100
BHP Billiton	Metals and mining	102,159	124,345	2,561	1,834	1.05	98
Brambles Industries	Commercial services and supplies	2,706	13,364	185	294	1.72	100
Boral	Materials	10,275	4,335	62	204	2.47	100
Commonwealth Bank	Banks	42,518	42,811	1,726	514	2.83	100
Coles Myer	Food and staples retailing	N/A		412	162	1.77	100
National Australia Bank	Banks	15,347	50,456	2,515	916	2.53	96
Newcrest Mining	Metals and mining	10,780	24,848	1,047	144	0.30	35
News Corporation	Media	5,128	8,389	1,780	503	0.11	24
Qantas	Transportation	17,359	8,908	185	168	2.51	100
Rio Tinto	Metals and mining	12,528	28,680	1,856	1,201	1.39	100
St George Bank	Banks	8,512	12,700	439	294	2.64	100
Suncorp	Insurance	47,657	9,786	192	195	3.66	100

Telstra	Telecommunication services	48,879	44,592	706	599	2.37	100
Westpac Bank	Banks	11,938	43,083	1,151	488	2.50	100
Wesfarmers	Food and staples retailing	2,029	13,893	556	189	2.50	100
Western Mining	Metals and mining	N/A		261	151	1.48	100
Woolworths	Food and staples retailing	25,637	25,175	396	352	1.71	100
Woodside Petroleum	Energy	10,801	22,927	558	424	1.58	100
Other (42 companies)				2,520	856	2.01	55
Total				**21,448**	**10,325**	**1.82**	**84**

Table 4. Ex-dividend dates

This table shows the distribution of each observation's ex-dividend date, for those observations in our sample with one ex-dividend date occurring before expiry of the futures contract. Panel A reports the ex-dividend dates, by calendar month. Panel B reports the ex-dividend dates by year.

Panel A:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
825	1,131	759	589	1,034	1,013	1,338	1,406	502	642	661	425	10,325

Panel B:

2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
255	566	1,484	1,970	1,573	1,970	823	1,255	329	10,325

Table 5. Coefficient estimates

This table reports coefficient estimates from the OLS regression model:

$$RPE_i(t) = \beta_0 + \beta_1 \frac{D_{ij}(s)e^{r_{s,T}(T-s)}}{S_i(t)} + \beta_2 \frac{IC_{ij}(s)}{S_i(t)} + \varepsilon_i(t)$$

where $RPE_i(t)$ is the relative pricing error at time t for observation i and is defined as $RPE_i(t) = (S_i(t)e^{r_{t,T}(T-t)} - X_i - F_i(t,T))/S_i(t)$. The intercept β_0 measures the average transaction cost differential, β_{1t} measures the relative value of one dollar of cash dividends, and β_{2t} measures the relative value of value of one dollar of imputation tax credits. For k=1, 2; $\beta_{ki} = \beta_{k0} + \beta_{k1}DY_i + \beta_{k2}\ln(MKT\ CAP_i)$ where DY_i is the difference between the dividend yield applicable to observation *n* and the mean dividend yield scaled by the standard deviation of dividend yields over our sample, and $\ln(MKT\ CAP_i)$ is the difference between the log-market capitalization of the relevant firm at the end of the end of the financial year of observation *n* and the mean log-market capitalization in our sample, scaled by the standard deviation of log market capitalization over our sample. R^2 statistics are computed as 1- RSS/TSS where RSS = residual sum of squares and TSS = total sum of squares, where the sum is taken over observations that paid a dividend between the trade date and the futures maturity date, and adjusted R^2 statistics are reported with the usual adjustments for degrees of freedom. The data are obtained from the prices of individual share futures contracts traded on the SFE and the prices of low exercise price options traded on the ASX over the period 1 July 2001 to 31 December 2008.

Coefficient	All dividends			Un-franked dividends only
	Constant slope model	Variable slope model		
Intercept/Transaction cost differential				
β_0	0.0007***	0.0007***	0.0007***	0.0007***
(std. error)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Value of Cash Dividends				
β_{10}	0.9001***	0.9454***	0.9054***	0.9161***
(std. error)	(0.0087)	(0.0094)	(0.0087)	(0.0342)
β_{11}	—	0.0105**	—	0.0690**
(std. error)		(0.0022)		(0.0269)
β_{12}	—	0.0390***	—	0.0158
(std. error)		(0.0025)		(0.0205)
Value of imputation credits				
β_{20}	0.1727***	0.0610***	0.1557***	—
(std. error)	(0.0210)	(0.0221)	(0.0213)	
β_{21}	—	—	0.0219***	—
(std. error)			(0.0052)	
β_{22}	—	—	0.0833***	—
(std. error)			(0.0061)	—
F	83,804***	42,280***	42,196***	3,899***
Adjusted R^2	0.729	0.734	0.733	0.814
N	31,773	31,773	31,773	22,083

***Significant at 0.01 level. **Significant at 0.05 level. Significance for β_1 is tested against 1.0.

Table 6. Coefficient estimates – no intercept

This table reports coefficient estimates from the OLS regression model:

$$RPE_i(t) = \beta_0 + \beta_1 \frac{D_{ij}(s)e^{r_{s,T}(T-s)}}{S_i(t)} + \beta_2 \frac{IC_{ij}(s)}{S_i(t)} + \varepsilon_i(t)$$

where $RPE_i(t)$ is the relative pricing error at time t for observation i and is defined as $RPE_i(t) = (S_i(t)e^{r_{t,T}(T-t)} - X_i - F_i(t,T))/S_i(t)$. The coefficient β_{1t} measures the relative value of one dollar of cash dividends and β_{2t} measures the relative value of value of one dollar of imputation tax credits. For k=1, 2; $\beta_{ki} = \beta_{k0} + \beta_{k1}DY_i + \beta_{k2}\ln(MKT\ CAP_i)$ where DY_i is the difference between the dividend yield applicable to observation n and the mean dividend yield scaled by the standard deviation of dividend yields over our sample, and $\ln(MKT\ CAP_i)$ is the difference between the log-market capitalization of the relevant firm at the end of the end of the financial year of observation n and the mean log-market capitalization in our sample, scaled by the standard deviation of log market capitalization over our sample. R^2 statistics are computed as 1- RSS/TSS where RSS = residual sum of squares and TSS = total sum of squares, where the sum is taken over observations that paid a dividend between the trade date and the futures maturity date, and adjusted R^2 statistics are reported with the usual adjustments for degrees of freedom. The data are obtained from the prices of individual share futures contracts traded on the SFE and the prices of low exercise price options traded on the ASX over the period 1 July 2001 to 31 December 2008.

Coefficient	All dividends			Un-franked dividends only
	Constant slope model	Variable slope model		
Value of Cash Dividends				
β_{10}	0.9343***	0.9898	0.9404***	0.9660
(std. error)	(0.0087)	(0.0093)	(0.0087)	(0.0347)
β_{11}	—	-0.0015	—	0.0176
(std. error)		(0.0021)		(0.0273)
β_{12}	—	0.0409**	—	0.01115
(std. error)		(0.0025)		(0.0209)
Value of imputation credits				
β_{20}	0.1677	0.0579***	0.1736***	—
(std. error)	(0.0212)	(0.0223)	(0.0215)	
β_{21}	—	—	-0.0054	—
(std. error)			(0.0051)	
β_{22}	—	—	0.0877***	—
(std. error)			(0.0062)	—
F	118,248***	59,698***	59,590***	1,386***
Adjusted R^2	0.937	0.938	0.938	0.873
N	31,773	31,773	31,773	22,083

***Significant at 0.01 level. **Significant at 0.05 level. Significance for β_1 is tested against one.

Table 7. Sensitivity Analysis of estimates

This table shows the value of one dollar of cash dividends and one dollar of imputation credits respectively, according to the coefficient estimates from the variable slope models in Table 7, for various dividend yield and firm size interactions. Each column represents increasing orders of firm size - the first column representing estimates where firm size (measured as ln(Market Capitalization) is two standard deviations lower than the average firm size across the entire sample, the second representing one standard deviation lower, the third representing estimates for an average firm in the sample and so on. Each row represents increasing orders of dividend yield. In each cell the top number is the estimate for one dollar of cash dividends and the second number is the estimate for one dollar of imputation credits.

Dividend Yield	Market Capitalization: -2 SD	-1SD	Avg	+1 SD	+2 SD
-2 SD	0.8664	0.8954	0.9244	0.9534	0.9824
	-0.0547	0.0286	0.1119	0.1952	0.2785
-1 SD	0.8769	0.9059	0.9349	0.9639	0.9929
	-0.0328	0.0505	0.1338	0.2171	0.3004
Avg.	0.8874	0.9164	0.9454	0.9744	1.0034
	-0.0109	0.0724	0.1557	0.239	0.3223
+1 SD	0.8979	0.9269	0.9559	0.9849	1.0139
	0.011	0.0943	0.1776	0.2609	0.3442
+2 SD	0.9084	0.9374	0.9664	0.9954	1.0244
	0.0329	0.1162	0.1995	0.2828	0.3661

Figure 1. Distribution of Relative Pricing Error for Individual Share Futures Contracts and Low Exercise Price Options.

This figure reports the distribution of relative pricing error for all observations which have no dividend event occurring between the trade and the maturity/expiry of the ISF or LEPO. Relative pricing error measures the difference between the actual derivative security's price and its fair value as a proportion of the underlying stock's price as in Equation (6). This histogram is based on ISFs and LEPOs that traded between 1 July 2000 and 31 December 2008. For enhanced readability, relative pricing errors less than -0.02 are reported as -0.02 and relative pricing errors greater than 0.02 are reported as 0.02.

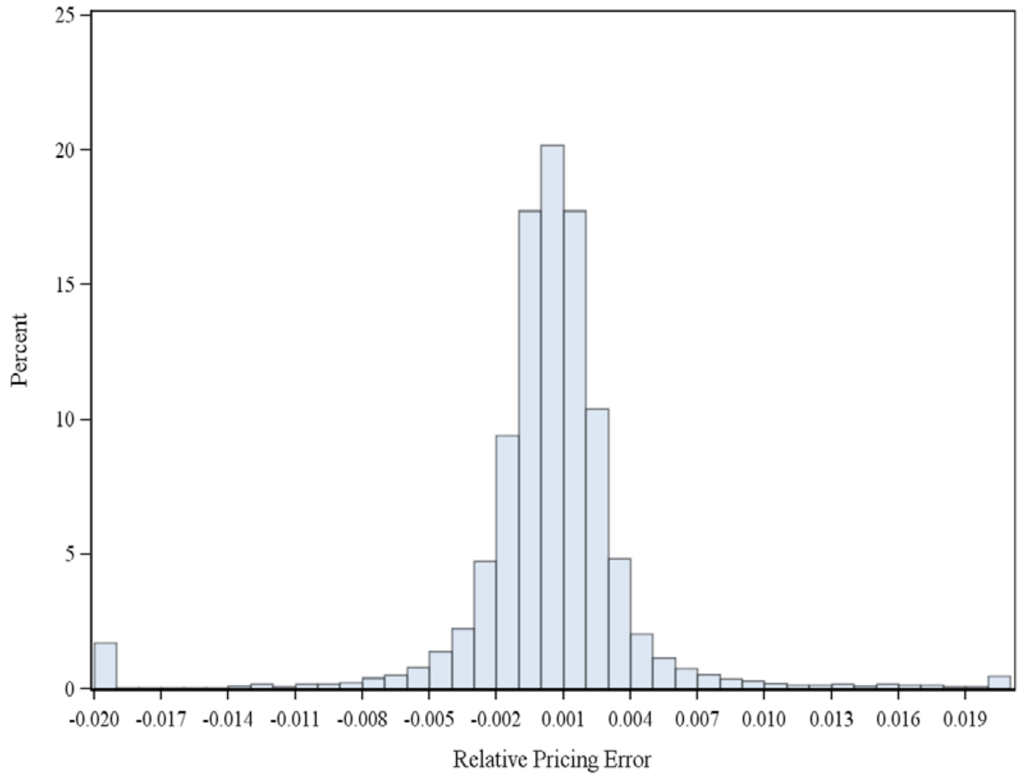

Figure 2. Joint Confidence Region for Estimates of Value of Cash Dividend and Imputation Credits.

This figure reports the 95% joint confidence region for the estimates β_{10} (the value of one dollar of cash dividends relative to futures payoffs) and β_{20} (the value of value of one dollar of imputation tax credits relative to futures payoffs).

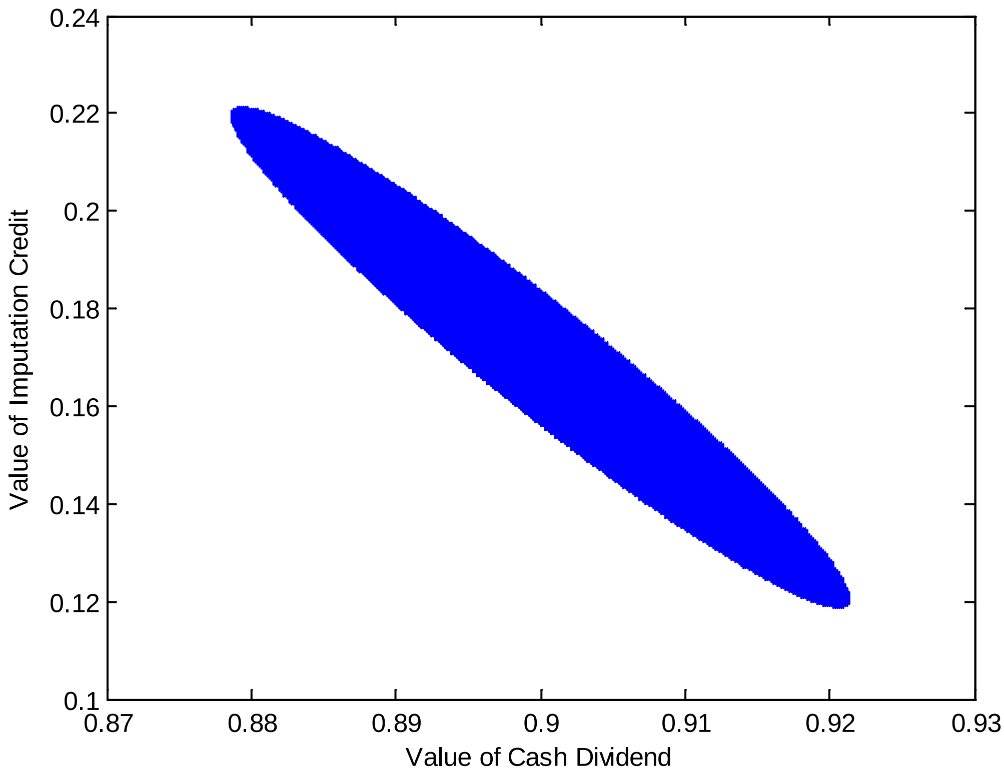

Figure 3. Joint Confidence Region for Estimates of Value of Cash Dividend and Imputation Credits.

This figure reports the 95% joint confidence region for the estimates β_{10} (the value of one dollar of cash dividends relative to futures payoffs) and β_{20} (the value of value of one dollar of imputation tax credits relative to futures payoffs).