Tax effects on the pricing of Australian stock index futures

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Abstract

This paper estimates the impact of the debt tax shield, cash dividends and imputation tax credits on the prices of Australian stock index futures. Relative to futures payoffs, the cost of financing the set of shares of the underlying index provides a mild tax shield, cash dividends are incompletely valued and imputation credits are worth at least fifty percent of their face value. The values that investors place on cash dividends and tax credits implied by index futures prices are remarkably close to those estimated in ex-dividend date stock price drop-off studies of the Australian share market.

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1. Introduction

To provide benchmarks to examine the pricing efficiency of index futures markets, an assessment is required of the value that investors place on the debt tax shield for the financing of the set of shares of the underlying index and on the cash dividends and imputation credits flowing from the index. These values are reflected in the prices of the futures relative to the underlying index values. The purpose of this paper is to adapt and extend the framework developed by Cannavan, Finn and Gray (2004) to infer the value of cash dividends and imputation tax credits using the prices of Australian individual share futures (ISFs) and low exercise price options (LEPOs). The estimates we derive using index futures prices are for a broad-based market portfolio that is more directly relevant to index fund managers. They provide a useful alternative to similar estimates of the value of cash dividends and tax credits from studies that analyse the ex-dividend behaviour of share prices. Hence this paper elucidates on the cost of equity capital and capital formation in Australia. Further, by assessing the value of the debt tax shield in conjunction with the dividend components, evidence is provided about the arbitrage pricing relationship for index futures in the presence of dividend imputation and the differential taxation of different forms of income.

1.1 Impact of taxes on futures prices

The basis of a stock index futures contract under the cost of carry model depends on the interest charge for the financing of the portfolio of underlying stocks and the dividends flowing from the stocks over the period to contract maturity. This paper demonstrates how these components of the basis are affected by the different tax treatment of interest, dividends and income from futures trading relative to capital gains on stocks. The interest on loans to purchase the underlying stocks provides a debt tax shield not necessarily available from futures losses. Dividends are taxed in the year they are paid at the shareholder's marginal tax rate while capital gains are taxed only when they are realised and at a lower rate. In Australia, a dividend imputation system has operated since 1987. Under dividend imputation, shareholders receive a gross dividend which consists of a cash dividend plus a franking credit to offset against their personal income tax liability[1]. The market may not value the franking credits in parity with cash dividends because foreign investors who hold a substantial proportion of the equity on issue in Australia have limited ability to access them[2]. It is a consequence of these different tax treatments of different forms of income that index futures prices provide information about the value to investors of the financing cost, cash dividends and franking credits involved in the equivalent cash and carry strategy.

Overseas studies estimate the value of the interest, dividends and tax credits implicit in the pricing of derivative securities[3]. Theobald and Yallup (1996) investigate the

[1] The franking credit is for the tax already paid on that income at the company level.
[2] Tax-exempt and non-resident stockholders can only extract value from imputation credits if they are somehow able to transfer them to resident stockholders. Of the total equity on issue by Australian enterprises at 30 June 2006, non-residents held equity valued at AUD 502 billion (27 percent) while residents held AUD 1,357 billion (73 percent), according to the Australian Bureau of Statistics (2007).
[3] In an early study, Barone-Adesi and Whaley (1986) fit an American call option pricing model to observed transaction prices for Chicago Board Options Exchange (CBOE) call options on dividend-

impacts of the settlement date and potential tax effects on the basis of FTSE 100 index futures, starting from a simple cost of carry formulation. They find the interest rate, dividend and settlement period have the correct directional impact and are close to unity in the early 1990s, consistent with the equalisation of capital gains and income tax rates in the United Kingdom in 1989. A puzzling feature of their results is the relatively low power of the cost of carry variables in explaining the basis of stock index futures. In order to assess the market valuation of tax credits carried by German dividends, McDonald (2001) uses stock, futures and options prices to examine the effect of dividend payments. He provides evidence that approximately one-half to two-thirds of the value of the dividend tax credit is reflected in the prices of the nearest-to-expiration DAX 30 index futures contract, consistent with German arbitrageurs facing tax risk associated with dividend capture transactions. This paper provides equivalent evidence for the Australian market and demonstrates that greater than four-fifths of the variation in the basis of Australian stock index futures is explained by the cost of carry components.

Cannavan, Finn and Gray (2004) infer the value of cash dividends and tax credits from the relative prices of Australian ISFs and LEPOs contracts and the individual stocks on which those contracts are written, to test whether a 1997 tightening of the tax laws making it more costly to transfer the imputation tax credits affected their value. The significant tightening of the tax laws concerned the imposition of a 45-day minimum holding period around the date of dividend entitlement for investors to qualify for the franking credits[4]. Cannavan, Finn and Gray find that (i) cash dividends are fully valued relative to futures payoffs, (ii) imputation credits were valued at up to 50 percent of face value for high-yielding firms before the 45-day rule and (iii) imputation credits are effectively worthless to the marginal investor in ISFs and LEPOs after the introduction of the 45-day rule. In contrast, Frino, Wearin and Fabre (2004) provide evidence that a synthetic position made up of an Australian stock index futures contract plus a bond delivers the value of capital gains and dividends, plus a proportion of the value of franking credits. Their results appear to reflect two further tax regime changes: a reduction in the capital gains tax rate from 1 July 1999 and allowing tax rebates for unused franking credits from 1 July 2000. This paper attempts to resolve the conflicting findings about the value of the imputation credits using four years of intraday transaction data for the most actively traded equity derivative in Australia.

1.2 Taxes and ex-dividend day stock price behaviour

The derivatives-based technique employed to infer the values of the cash dividends and tax credits flowing from a stock index is analogous to analysing the ex-dividend behaviour of share prices in pursuit of the same objective. A variety of theories

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paying stocks to estimate the expected relative ex-dividend stock price decline. They find that the decline is not meaningfully different from one.

[4] Days on which investors have less than 30 percent of the ordinary financial risks of loss and opportunities for gain from owning the shares, through hedging, are not counted in determining whether the required holding period is satisfied. The related payments rule also restricts the ability of Australian investors to pass the benefits of franking credits to other persons. However, McDonald (2001) outlines reasons that similar provisions reducing the ability of investors to use German tax credits are difficult to enforce: (i) firms can hold shares domestically and hedge offshore; (ii) proving that the different legs of a hedged position are in fact part of one position can be difficult; and (iii) transactions with foreigners accomplished on an exchange are hard to trace.

involving the differential tax treatment of dividends and capital gains on stocks have been proposed to explain the expected share price adjustment on ex-dates. In studies of share markets, the cash drop-off ratio is defined as the ratio of the price change at the ex-dividend date to the cash dividend[5]. Bellamy (1994) found that the cash drop-off for franked dividends (0.894) was significantly higher than for unfranked dividends (0.656) in the early post-imputation period in Australia from 1987 to 1992. His result suggests that the marginal investor attaches at least some value to the imputation credits. Walker and Partington (1999) use data on Australian shares trading contemporaneously with and without dividends to estimate an 'instantaneous drop-off ratio' that filters out the noise associated with price movements on ex-dividend days. The average instantaneous drop-off ratio across trades in their sample concentrated in large capitalisation stocks is 1.23, implying that one dollar of fully franked dividends has a market value significantly greater than one dollar.

The year 2000 tax change that provides for a rebate of unused franking credits may have finally allowed marginal investors to extract substantial value from the franking credits. Beggs and Skeels (2006) analyse the ex-dividend behaviour of share prices in the Australian market from 1986 to 2004. They find cash drop-off ratios consistently close to one and franking credit drop-off ratios consistently less than one. However, they find that the year 2000 tax change that allowed for a rebate of unused franking credits permanently increased the value of franking credits to the marginal investor and raised the estimated gross dividend drop-off ratio. In the recent period after the tax change from 2001 to 2004, they estimate the cash drop-off ratio $\gamma_1 = 0.800$ and the franking credit drop-off ratio $\gamma_2 = 0.572$. For an overlapping sample period, this paper examines whether these recent estimates are substantiated in the futures market.

The remainder of this paper is structured as follows. In section 2 a formula is developed for the basis of index futures in the presence of dividend imputation and the differential taxation of different types of income. Section 3 describes the institutional setting and data sources. The econometric method and the results of the empirical analysis are presented in section 4. Section 5 concludes.

2. Basis value

In this section, the standard cost-of-carry no-arbitrage framework employed by Cannavan, Finn and Gray (2004) for ISFs and LEPOs is adapted to derive a formula for the basis of Australian stock index futures. The choice of trading in stock index futures versus the physical portfolio of underlying stocks is contemplated. First, the analysis considers an investor who faces the same marginal tax rate of τ_p on dividend income, income from futures trading and short-term capital gains on stocks. Subsequently, it is demonstrated how the different treatment of interest and dividends versus capital gains for taxation purposes affects the value of the basis. The assumptions underpinning the analysis in this section include those necessary to treat the futures contract as a forward contract characterised by Cox, Ingersoll and Ross (1981): (i) investors do not default on any contract, (ii) no money changes hands through marking to market during the lifetime of the contract, only on the maturity date, (iii) all investors can borrow and lend at the same non-stochastic interest rate,

[5] Equally, Beggs and Skeels (2006) define the franking credit drop-off ratio as the ratio of the price change at the ex-dividend date to the franking credits; and the gross drop-off ratio as the ratio of the price change at the ex-dividend date to the gross dividend.

(iv) the cash dividend yield and imputation credit yield of the index over the remaining life of the near futures contract are known in advance, (v) no transaction costs and (vi) no restrictions on short sales.

The objective is to find the value of the basis of an index futures contract at time t, which matures at time T. Let $F_{t,T}$ be the futures price at time t for a contract that matures at time T, S_t is the spot index level at time t, r is the continuously compounded risk-free interest rate and D_s and IC_s are the cash dividends and imputation credits respectively for all the stocks in the index on the ex-dividend date s where $t < s \leq T$ which are assumed to be known at time t. Within the standard no-arbitrage framework, there are two methods to obtain ownership of a portfolio of index constituent stocks at time T. Given that both methods require a single net cash flow at time T, the amount of this net cash flow must be the same to rule out the possibility of arbitrage profits.

Method 1 Forward contract: The investor buys a forward contract on the index at time t. No money changes hands initially, but the price for future delivery is locked in at the time of purchase. This contract does not entitle the investor to the cash dividends or imputation credits flowing from the index between time t and time T. At time T, the contract matures and the investor pays the previously negotiated price $F_{t,T}$ and takes possession of one index replicating portfolio that can be sold for S_T at that time. The trading profit is taxed at the rate of τ_p, so the net cash flow after tax at time T is

$$\pi_T = (S_T - F_{t,T})(1 - \tau_p) \tag{1}$$

Method 2 Physical replication: At time t, the investor borrows S_t and uses the proceeds to buy one index replicating portfolio. At time T, the investor can sell the portfolio for S_T and pay capital gains tax of $(S_T - S_t)\tau_p$, because capital gains are assumed to be taxed as ordinary income in this instance. Also at time T, the investor must repay the original loan of S_t plus interest which amounts to $S_t(e^{r(T-t)} - 1)$. The interest component on the loan is tax deductible, so the after-tax interest charge is $S_t(e^{r(T-t)} - 1)(1 - \tau_p)$. At time s, the investor receives cash dividends of D_s and imputation credits of IC_s. The cash dividends are placed in an interest bearing account and are worth $D_s e^{r(T-s)}$ at time T. These dividends and accumulated interest are taxed at τ_p so the investor is left with $D_s e^{r(T-s)}(1 - \tau_p)$ after taxes. Let φ be the market value of one dollar of imputation tax credits distributed to the investor. At time T, the investor potentially extracts some value from the imputation credits by receiving φ in value for each one dollar of imputation credits she sells, before the taxes she pays on these sales. Thus, the after-tax value of the imputation credits is $\varphi IC_s(1 - \tau_p)$. The net after-tax payoff to this strategy at time T is

$$\begin{aligned}\pi_T = (S_T - S_t)(1 - \tau_p) - S_t(e^{r(T-t)} - 1)(1 - \tau_p) + \sum_{s=t+1}^{T} D_s e^{r(T-s)}(1 - \tau_p) \\ + \sum_{s=t+1}^{T} \varphi IC_s(1 - \tau_p)\end{aligned} \tag{2}$$

Since the net payoff from method 1 must equal the net payoff from method 2 to prevent arbitrage, it must be the case that

$$(S_T - F_{t,T})(1-\tau_p) = (S_T - S_t)(1-\tau_p) - S_t(\mathrm{e}^{r(T-t)} - 1)(1-\tau_p) + \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)}(1-\tau_p) + \sum_{s=t+1}^{T} \varphi IC_s (1-\tau_p) \quad (3)$$

The (1 - τ_p) term cancels out on both sides of this equation, which can be reduced to provide a formula for the value of the basis of a forward contract where the same marginal tax rates apply to interest, dividends and capital gains:

$$\begin{aligned} F_{t,T} - S_t &= S_t(\mathrm{e}^{r(T-t)} - 1) - \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)} - \sum_{s=t+1}^{T} \varphi IC_s \\ &= Interest_t^n - Cash_t^n - \varphi Franking_t^n \end{aligned} \quad (4)$$

where $Interest^n_t$ is the financing cost, $Cash^n_t$ is the accumulated value of cash dividends and $Franking^n_t$ is the value of imputation credits. Note that under these circumstances the same marginal tax rate faced by the investor on all forms of income is irrelevant to the value of the basis.

Next it is demonstrated how the differential tax treatment of different forms of income could affect the value of the basis. For example, consider an investor who faces a marginal tax rate of τ_p on interest payments, dividend income and income from futures trading and a different marginal tax rate of τ_g on capital gains from stocks[6]. In this case, the no-arbitrage analysis is adjusted as follows.

Revised method 1 Forward contract: The investor buys (1-τ_g)/(1-τ_p) forward contracts on the index at time t. At time T, the contracts mature and the investor pays the previously negotiated amount $F_{t,T}$(1-τ_g)/(1-τ_p) and takes possession of (1-τ_g)/(1-τ_p) index replicating portfolios that can be sold for S_T(1-τ_g)/(1-τ_p). The trading profit is still taxed at the rate of τ_p, so the revised net cash flow after tax at time T is

$$\pi'_T = (S_T - F_{t,T})(1-\tau_g) \quad (5)$$

Revised method 2 Physical replication: At time t, the investor borrows S_t and uses the proceeds to buy one index replicating portfolio. At time T, the investor can sell the portfolio for S_T and pay capital gains tax of $(S_T - S_t)\tau_g$. Also at time T, the investor repays the original loan of S_t plus interest. The after-tax interest charge remains $S_t(\mathrm{e}^{r(T-t)} - 1)(1 - \tau_p)$. At time s, the investor receives cash dividends of D_s which she places in an interest bearing account and franking credits of IC_s. At time T, the accumulated cash dividends and franking credits are taxed at τ_p so the investor continues to be left with $D_s\mathrm{e}^{r(T-s)}(1 - \tau_p)$ and $\varphi IC_s(1 - \tau_p)$ respectively after taxes. The revised net after-tax payoff to this strategy at time T is

[6] Whether or not the distinction is made between the tax rate on capital gains from stocks and the tax rate on futures profits, Cornell and French (1983) demonstrate that the futures price is not affected by the taxes on futures profits, because the trader can replicate a tax-free contract by adjusting the size of their position.

$$\pi'_T = (S_T - S_t)(1-\tau_g) - S_t(\mathrm{e}^{r(T-t)} - 1)(1-\tau_p) + \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)}(1-\tau_p) + \sum_{s=t+1}^{T} \varphi IC_s(1-\tau_p) \tag{6}$$

Equating the revised net payoff from method 1 to the revised net payoff from method 2 to prevent arbitrage, the outcome under the alternative tax regime is given by

$$(S_T - F_{t,T})(1-\tau_g) = (S_T - S_t)(1-\tau_g) - S_t(\mathrm{e}^{r(T-t)} - 1)(1-\tau_p) + \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)}(1-\tau_p) + \sum_{s=t+1}^{T} \varphi IC_s(1-\tau_p) \tag{7}$$

which can be reduced and rearranged to provide a formula for the value of the basis of a forward contract where different marginal tax rates apply to dividends and capital gains:

$$\begin{aligned} F_{t,T} - S_t &= S_t(\mathrm{e}^{r(T-t)} - 1)\frac{(1-\tau_p)}{(1-\tau_g)} - \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)}\frac{(1-\tau_p)}{(1-\tau_g)} - \sum_{s=t+1}^{T} \varphi IC_s \frac{\varphi(1-\tau_p)}{(1-\tau_g)} \\ &= Interest_t^n \frac{(1-\tau_p)}{(1-\tau_g)} - Cash_t^n \frac{(1-\tau_p)}{(1-\tau_g)} - Franking_t^n \frac{\varphi(1-\tau_p)}{(1-\tau_g)} \end{aligned} \tag{8}$$

In contrast to the earlier analysis, an important feature of this revised formula is that where different marginal tax rates apply to interest payments and dividend income versus capital gains they become relevant to the value of the basis[7]. Reassuringly, the common term $(1\text{-}\tau_p)/(1\text{-}\tau_g)$ is exactly the same as the statistic derived by Elton and Gruber (1970) representing the ex-dividend equilibrium behaviour that would cause a stockholder with a particular set of tax rates τ_p and τ_g to be indifferent as to the timing of purchases and sales of common stock before or after the stock goes ex-dividend. The value of dividends vis-à-vis capital gains to marginal stockholders is reflected in the fall in the price of a stock on its ex-dividend day. In the same way, it becomes apparent from our analysis that the relative tax rates on these two types of income are also reflected in the value of the basis for index futures.

The relatively favourable tax treatment of capital gains from stocks may be accentuated by tax timing options. Stockholders have the option to defer capital gains and realise capital losses thereby reducing the present value of the stream of tax payments on gains, which is not available in the futures market. In the futures market, all capital gains and losses must be realised at the end of the year in which they occur by marking to the market. The predicted effect of the tax timing option is to reduce

[7] Consistent with the implications drawn by Cornell and French (1983), an increase in the ordinary income tax rate τ_p reduces both the effective financing cost and the dividend flow with the two reductions being partially offsetting. The net effect is that the income tax rate reduces the absolute size of the basis. Conversely, the capital gains tax rate τ_g increases the absolute size of the basis.

the basis[8]. Constantinides (1983) demonstrates that the timing option is a substantial fraction of the bundle of benefits associated with stock ownership, at least for high variance stocks when forced liquidations are infrequent. Cornell and French (1983) provide evidence that the tax option reduces the prices of futures contracts on the S&P 500 index and New York Stock Exchange composite index relative to the underlying stocks, particularly for longer times to maturity. To the contrary, a later study by Cornell (1985a) concludes that the timing option no longer has a significant impact on the pricing of index futures. Traders could relinquish the option if they do not hold the cash security indefinitely.

In section 4, the formula for the basis represented in equation (8) is exploited to infer the relative values of the debt tax shield, cash dividends and imputation credits from the pricing of index futures relative to the underlying index.

3. Institutional setting and data

The S&P/ASX 200 index measures the performance of the 200 largest stocks listed on the Australian Stock Exchange (ASX). The index is float-adjusted and represents approximately 80 percent of the Australian equities market capitalisation. The stocks comprising the index are traded on the ASX's computerised trading system, known as the Stock Exchange Automated Trading System (SEATS) until October 2006. The level of the S&P/ASX 200 is calculated by Standard & Poor's and is reported to the market every 30 seconds as constituent prices change.

SFE SPI 200™ Index Futures are written over the S&P/ASX 200 index with a contract unit of 25 Australian dollars per index point. The contracts follow a March-June-September-December quarterly maturity cycle and are cash settled at a price calculated using the first traded price of each component stock in the index on the last trading day (denoted day 0 in this article). From the June 2003 expiry onwards, the last trading day is the third Thursday of the settlement month. Earlier contracts expired on the last business day of the settlement month[9]. Trading of SFE SPI 200™ futures in the daytime session commences at 9:50 a.m. and finishes at 4:30 p.m. on the Sydney Futures Exchange (SFE). In contrast, the stocks from which the index is constructed are traded on the ASX in a continuous double auction from 10:00 a.m. until 4:00 p.m..

3.1 Data description

Reuters trade and quote data for SFE SPI 200™ futures were obtained from the Securities Industry Research Centre of Asia-Pacific (SIRCA). The data covers the period 1 January 2002 to 15 December 2005, which provides a structural break free data set of sixteen contract maturities for analysis[10]. Though up to six maturities are listed at any particular time, our analysis is confined to the nearest-to-maturity

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[8] Hence the predicted effect of the tax timing option is in the same direction as the predicted effect of a decrease in the financing cost for the stock adopted for the no-arbitrage analysis in this section.
[9] An exception is the December 2002 contract which expired on 9 December 2002.
[10] Observations for 11 January 2002 and 2 May 2003 with residuals from the baseline regression represented in equation (19) of +10.3 index points indicating the futures contract was unusually expensive and -19.1 index points indicating the contract was unusually cheap respectively are excluded from the sample.

contract which has by far the most significant trading volume. Hence, each contract is followed from the expiry date of the previous contract until its expiration[11]. The data describes the time (to the nearest second), price and volume of each trade and the prices and aggregate sizes of the best available bids and offers.

S&P/ASX 200 stock index values, time-stamped approximately 30 seconds apart, were also obtained from SIRCA. While traders have access to the updated index level throughout the course of the day, the index calculation utilises stale prices especially for thinly traded stocks, so that the price at which one can buy or sell the index replicating basket of stocks can diverge temporarily from the instantaneously reported value[12]. The effect of this problem of non-synchronous trading in the stocks on the basis of stock index futures is lessened when averages over the course of the trading day are used in the analysis.

Daily series for the overnight cash, 30, 90 and 180 day bank accepted bills rates were obtained from the Reserve Bank of Australia. The interest rate for loans maturing at the expiration date of the futures was estimated using linear interpolation between these four reference interest rates. A daily dividend series was obtained from Bloomberg. The dividend series contains the total actual cash dividends and gross dividends (cash dividends plus imputation credits) paid each ex-dividend day by stocks in the S&P/ASX 200. The sample includes the distribution of untaxed income such as from listed property trusts and foreign sourced company income that does not attract tax credits. The inclusion of unfranked and partially franked amounts from these sources alleviates to some extent against the effect of multicolinearity between the cash dividends and franking credits when estimating their separate market values. Our analysis assumes that the dividend amounts and franking percentages are known from the expiry date of the previous contract[13]. The timing of ex-dividend dates relative to the maturity of the index futures contract is shown in figure 1. It is apparent from the figure that dividends are heavily clustered in the second half of the futures expiry cycle, following the periodic reporting of Australian company results around the middle of the quarter[14]. The discrete and seasonal dividend payments of the S&P/ASX 200 index portfolio are taken into account by using the actual ex-post daily dividend inflows for the basket stocks, which Harvey and Whaley (1992) show reduces pricing errors that occur when constant dividend yields are assumed.

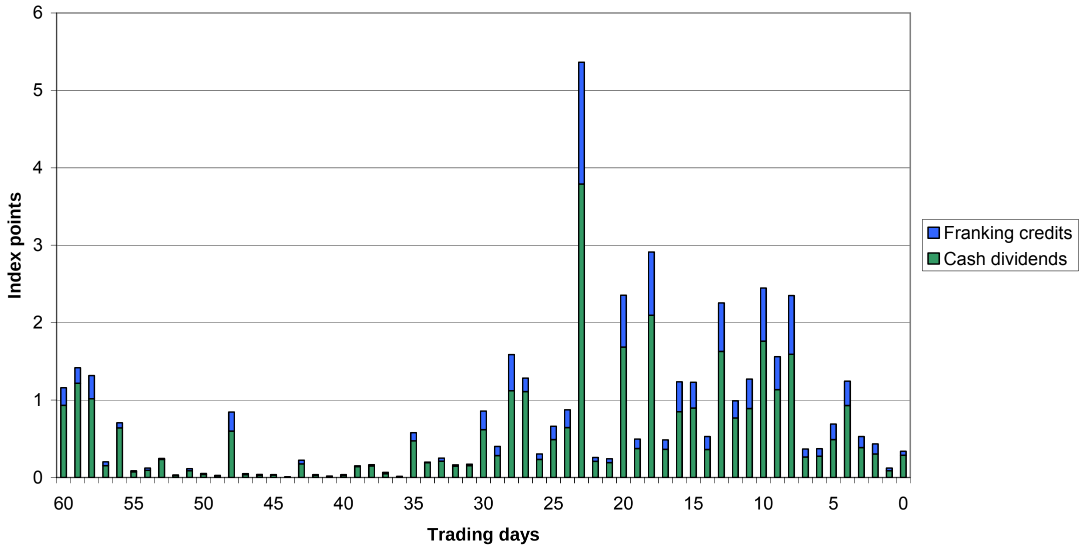
[11] Expiration day observations are not included.

[12] MacKinlay and Ramaswamy (1988) find that S&P 500 futures price changes are slightly negatively autocorrelated at the first lag across fifteen minute time intervals while the underlying index changes are positively autocorrelated, consistent with the presence of stale prices in the available index quotes. However, the autocorrelation disappears as the interval length is increased and becomes close to zero for one hour differencing intervals.

[13] Realised dividends are assumed not to differ materially from expected dividends over the relatively short life of the near futures contract (Yadav and Pope, 1994).

[14] Cornell and French (1983) and Harvey and Whaley (1992) show that dividend yields for the New York Stock Exchange composite index and S&P 100 index respectively are much larger in February, May, August and November than in the other months of the year since many firms issue their quarterly dividends at about the same time. A model that assumes the dividend yield is constant over the full year will overprice the contract across months with relatively high yields.

Figure 1
Time-to-futures-expiry pattern in dividends on the underlying stocks



In calculating the differences between actual and theoretical index futures prices, futures price quotes and index values that are approximately five minutes apart and that are the latest available before the end of each five minute mark are used. The bid-ask midpoint price prevailing at the end of each five minute interval is taken to represent the actual futures price. In the same way, the most recent index value reported to the market before the end of the five minute interval is taken to represent the actual spot market price. These price series are constructed for every five minute interval from 10:00 a.m. to 4:00 p.m. Sydney time, which is the segment of the trading day when both the futures and cash markets are open simultaneously in continuous auction mode.

3.2 Variable measurement

The before-tax cost of borrowing for the financing of the set of shares of the underlying index at the time T that the futures contract expires is calculated as[15]:

$$Interest_t^n = S_t(\mathrm{e}^{r(T-t)} - 1) \tag{9}$$

where S_t is the current stock index level, r is the annualised risk-free interest rate over the period from time t to time T; and $T - t$ is the time to maturity of the contract.

Futures traders do not receive dividends on the underlying stocks that have ex-dates falling prior to contract expiration. In order to estimate the value of these dividends, it is assumed: (i) the forecast dividends to maturity are identical to the actual ex-post daily dividend inflows for the S&P/ASX 200 basket stocks; and (ii) the forward interest rate at time t for loans made at time s to be repaid at time T is identical to the

[15] This measure of the cost of borrowing ignores the fact that settlement in the Australian share market occurs at time t + 3 business days after the trade date. Note however that the interest expense is only deferred slightly, not eliminated, because the equities portfolio trades required to unwind the arbitrage position described in section 2 are also settled at time T + 3 business days after futures expiry.

spot interest rate at time s for loans maturing at time T. On the basis of these assumptions, the value of the cash dividends on the underlying stocks over the remaining life of the contract at time T is calculated as[16]:

$$
\begin{aligned}
Cash_t^n &= \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)} \\
D_s &= \sum_{i=1}^{200} (Dividend_{i,s} \times Shares_{i,s}) \times \frac{IndexLevel_s}{IndexMarketValue_s}
\end{aligned}
\tag{10}
$$

where D_s are the aggregate cash dividends for the basket stocks in the index, $Dividend_{i,s}$ is the cash dividend per share for stock i, $Shares_{i,s}$ is the number of shares of stock i included in the index calculation, $IndexLevel_s$ is the closing stock index level and $IndexMarketValue_s$ is the float-adjusted market capitalisation of the index on the ex-dividend date s where $t < s \le T$[17]. In contrast to the cash dividends which accumulate interest until the maturity of the futures contract, it is assumed as per Cannavan, Finn and Gray (2004) that the imputation credits remain idle until they are redeemed or otherwise disposed at the maturity date. The face value of the franking credits on the underlying stocks over the remaining life of the contract is:

$$
\begin{aligned}
Franking_t^n &= \sum_{s=t+1}^{T} IC_s \\
IC_s &= \sum_{i=1}^{200} (TaxCredit_{i,s} \times Shares_{i,s}) \times \frac{IndexLevel_s}{IndexMarketValue_s}
\end{aligned}
\tag{11}
$$

where IC_s is the aggregate imputation credits for the basket stocks in the index and $TaxCredit_{i,s}$ is the franking credit per share for stock i on the ex-dividend date s. The value of the gross dividends is defined as the sum of the values of the cash dividends and the dividend tax credits:

$$
GrossDiv_t^n = \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)} + \sum_{s=t+1}^{T} IC_s \tag{12}
$$

Summary statistics for the financing cost and the values of cash dividends, imputation credits and gross dividends for the nearest-to-maturity futures contract are shown in table 1. The correlation between $Interest^n_t$ and $Cash^n_t$ is close to the level reported by Theobald and Yallup (1996) for the interest rate and dividend yield of constituent stocks in the FTSE 100 index. Although the variables $Cash^n_t$ and $Franking^n_t$ are also

[16] This measure overstates the interest that accumulates on cash dividends up to the expiry of the futures contract because it assumes interest is earned between the ex-dividend date and the relevant dividend payment dates. The interval between the ex-date and the payment date averages 29 calendar days for the stocks in our sample. However, Yadav and Pope (1994) show that the difference in estimated futures contract mispricing resulting from the misspecification of this time interval by up to eight weeks is immaterial. Indeed, ignoring the interest on dividends entirely does not substantially change the results for the near contract.

[17] The term $IndexLevel_s/IndexMarketValue_s$ in this expression is the inverse of the index divisor, which is adjusted to account for corporate actions such as stock splits and stock dividends and changes in the index composition.

highly collinear (with correlation of 0.877), the parameter estimates are reasonably well defined for our entire sample spanning four years.

Table 1
Summary statistics for entire dataset

	Panel A: Descriptive statistics			Panel B: Correlation matrix		
	Mean	Median	Std dev	$Interest^n_t$	$Cash^n_t$	$Franking^n_t$
$Interest^n_t$	22.2	21.0	13.9			
$Cash^n_t$	20.5	21.9	12.1	0.8188		
$Franking^n_t$	7.5	8.5	4.4	0.7409	0.8774	
$GrossDiv^n_t$	28.1	30.5	16.1	0.8178	0.9913	0.9330

Where the same tax treatment is attributed to interest payments, income from dividends and capital gains, equation (4) can be used to provide the theoretical price of a futures contract written over an index with zero dividends, cash dividends and gross dividends (with imputation credits fully valued so $\varphi = 1$) respectively:

$$\begin{aligned} f_{t,T}(z) &= S_t + Interest_t^n \\ &= S_t e^{r(T-t)} \end{aligned} \tag{13}$$

$$\begin{aligned} f_{t,T}(c) &= S_t + Interest_t^n - Cash_t^n \\ &= S_t \mathrm{e}^{r(T-t)} - \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)} \end{aligned} \tag{14}$$

$$\begin{aligned} f_{t,T}(g) &= S_t + Interest_t^n - Cash_t^n - Franking_t^n \\ &= S_t \mathrm{e}^{r(T-t)} - \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)} - \sum_{s=t+1}^{T} IC_s \end{aligned} \tag{15}$$

where $f_{t,T}(z)$ is the current price of the futures contract with zero dividends; $f_{t,T}(c)$ is the current price of the futures contract with cash dividends; $f_{t,T}(g)$ is the current price of the futures contract with gross dividends; and $T - t$ is the time to maturity of the contract.

In the alternative case where different marginal tax rates apply to interest and dividends versus capital gains, equation (8) is rewritten to provide the theoretical price of a futures contract with a lower effective financing cost and partially valued cash dividends and imputation credits:

$$\begin{aligned} f_{t,T}(p) &= S_t + (1-\tau_1) Interest_t^n - \gamma_1 Cash_t^n - \gamma_2 Franking_t^n \\ &= S_t + (1-\tau_1) S_t (\mathrm{e}^{r(T-t)} - 1) - \gamma_1 \sum_{s=t+1}^{T} D_s \mathrm{e}^{r(T-s)} - \gamma_2 \sum_{s=t+1}^{T} IC_s \end{aligned} \tag{16}$$

where $f_{t,T}(p)$ is the current price of the futures contract with partially valued carry components; τ_1 is the reduction in the financing cost achieved through the tax deductibility of one dollar of interest on loans, γ_1 is the value of one dollar of accumulated cash dividends, γ_2 is the value of one dollar of franking credits; and $T - t$ is the time to maturity of the contract.

4. Econometric method and results

4.1. Econometric method

In our empirical estimations, the difference between contemporaneous index futures prices and the underlying index values are considered. Initially two forms of 'mispricing' are computed. The first form of mispricing is the absolute basis for the index futures:

$$M_t^n(b) = F_t^n - S_t \tag{17}$$

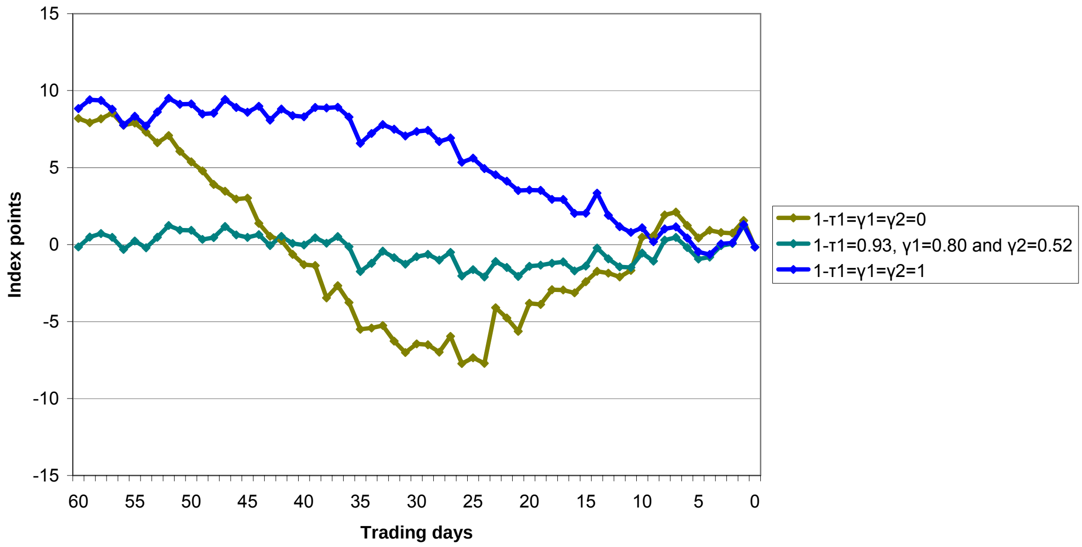
where F^n_t is the actual futures price and S_t is the current stock index level. Note at this stage that the spot index level S_t in equation (17) also represents the theoretical futures contract price under the conventional cost of carry model assuming zero financing cost and zero dividend yield over the period to the maturity of the futures. The average intraday basis of the near contract is calculated for each day. The change in the basis over the time to contract maturity is shown in figure 2, as the mispricing where the financing cost ($1 - \tau_1 = 0$), cash dividends ($\gamma_1 = 0$) and franking credits ($\gamma_2 = 0$) are excluded from the theoretical value of the futures. On average, the contract begins the expiry cycle in contango (with a positive basis), in which case the 'perfect markets' model derived by Cornell and French (1983) implies that the dividend yield is smaller than the interest rate. By the middle of the expiry cycle, futures prices are typically in a state of normal backwardation (below the spot price) implying that the dividend yield to maturity is larger than the interest rate from this point forward. The latter observation reflects the considerably higher dividend yield of the index during the last six weeks prior to futures maturity (seen in figure 1).

The second form of mispricing computed is the difference between the market price of the index futures contract and its theoretical price incorporating the full financing cost together with gross dividends:

$$M_t^n(g) = F_t^n - f_{t,T}(g) \tag{18}$$

where $f_{t,T}(g)$ is the theoretical futures price specified in equation (15). Equation (18) represents the level of mispricing assuming that the debt tax shield is worthless in reducing the effective interest expense and that both the cash dividends and franking credits are fully valued. The average intraday mispricing of the near contract is calculated for each day and is used in the empirical estimations. Figure 2 shows that the futures contract is consistently overpriced, especially for longer times to maturity, if we accept the most conservative assumption about the financing charge ($1 - \tau_1 = 1$) together with the most liberal assumptions about the values of the cash dividends ($\gamma_1 = 1$) and franking credits ($\gamma_2 = 1$).

Figure 2
Time-to-expiry patterns in M_t of near futures contracts



The formula that separates the cost-of-carry components of a forward contract in equation (8) is the foundation for our empirical tests. For each form of mispricing, parameters are estimated for the model

$$M_t^n = (1-\tau_1)Interest_t^n + \gamma_1 Cash_t^n + \gamma_2 Franking_t^n + \sum_{i=1}^{5}\delta_i D_i + \varepsilon_t \qquad (19)$$

where

$M_t^n =$ $\sum_{j=1}^{N_t} M_t^n(j)/N_t$ is the average intraday mispricing in index points of the near index futures contract on day t;

$M_t^n(j) =$ mispricing at the jth five minute mark during day t, for the near futures contract;

$N_t =$ number of observations in day t; and

$D_i =$ zero-one dummy variables to test whether there are systematic mispricing patterns related to each day of the week (D_1 = Monday, …, D_5 = Friday).

The coefficient $(1-\tau_1)$ measures the value of one dollar of financing cost allowing for a reduction achieved through the tax deductibility of interest on loans relative to futures losses. Conversely, γ_1 measures the value of one dollar of accumulated cash dividends relative to futures payoffs[18]. Notice that this differs from the interpretation in dividend drop-off studies, which estimate the value of dividends relative to capital gains rather than futures payoffs. The coefficient γ_2 measures the value that the marginal investor obtains from one dollar of franking credits relative to futures payoffs. This regression model is an extension of the model formed by Cannavan, Finn and Gray (2004: 186,

[18] The theoretically valid restriction $(1-\tau_1) = \gamma_1$ is not imposed on equation (19) because we have a sufficiently large dataset to estimate these parameters separately.

equation 10) to measure the value of cash dividends and franking credits paid on individual stocks relative to the payoffs on ISFs and LEPOs contracts[19]. In addition to the variable $Interest^n_t$ that allows for the value of the debt tax shield, day-of-the-week dummy variables are also included to allow comparisons with domestic and overseas studies which identify day of the week effects in the mispricing series.

The generalised method of moments is used to improve the efficiency of the parameter estimation in the presence of heteroskedasticity and autocorrelation in the mispricing[20]. The Bartlett kernel with bandwidth parameter $l(n) = 7$ is used to estimate consistent covariance matrices of the parameter estimates as outlined by Newey and West (1987). This bandwidth value corresponds to the smallest lag selection parameter $n = [4(T/100)^{2/9}]$ proposed by Newey and West (1994), taking into account the degree of first order autocorrelation in the residuals and the size of our sample T (Andews, 1991). All t-statistics are adjusted accordingly.

4.2. Results

Table 2 provides descriptive statistics for each form of mispricing (in panel A) together with the regression results (in panel B). The first column of the table focuses on the absolute basis for the index futures defined in equation (17) and hence the regression coefficients in this column can be interpreted as follows. If we assume that the cost of borrowing for the financing of the set of shares of the underlying index is zero, the futures contract is 93 cents overpriced for every dollar of financing cost over the period to maturity of the contract. This implies that 93 percent of the financing cost is embedded in futures prices. The remaining 7 percent is conceivably made up by a small tax saving from borrowing to fund the underlying stocks relative to the tax treatment of futures losses. If we assume furthermore that both the cash dividends and franking credits are worthless, the futures contract is 80 cents underpriced for every dollar of accumulated cash dividends and 52 cents underpriced for every dollar of franking credits. That is, the futures price is reduced by approximately 80 percent of the cash and approximately 52 percent of the franking credits. Each of the regression coefficients in our model for the financing cost, the accumulated cash dividends and the franking credits are highly significant at conventional levels. Moreover, the R^2 statistic indicates that 84 percent of the variation in the basis for the near futures contract is explained by the baseline cost-of-carry model[21].

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[19] Cannavan, Finn and Gray (2004) are obliged to scale their mispricing measure, accumulated cash dividends and imputation credits by the current stock price and focus on 'relative pricing errors' because they collect data for derivatives written over individual stocks that are unweighted to any particular index. In contrast, the dividends we analyse are multiplied by the number of shares included in the index calculation and divided by the index divisor. Moreover, it follows from our analysis in section 2 that differential tax treatments impact upon absolute rather than relative amounts in the cost of carry model. Therefore it is natural for us to focus on absolute contract mispricing and absolute cost of carry components in this case.

[20] Brenner and Kroner (1995) argue that any persistence in the difference between the interest rate and dividend yield will manifest itself as persistence in the basis for equity futures. More generally, they show that spot and futures prices should not be cointegrated if the expected net cost of carry has a stochastic trend.

[21] If we exclude the day of the week effects captured by the dummy variables, the reduced model still explains 84 percent of the variation in the basis for the futures contract.

Table 2
Value of financing cost, cash dividends and imputation tax credits and day-of-the-week patterns in futures contract mispricing

	Assuming zero after-tax financing cost and cash and franking credits are worthless ($1-\tau_1=\gamma_1=\gamma_2=0$)		Assuming debt tax shield and cash and franking credits are partially valued ($1-\tau_1=0.93$, $\gamma_1=0.80$ and $\gamma_2=0.52$)		Assuming debt tax shield is worthless and cash and franking credits are fully valued ($1-\tau_1=\gamma_1=\gamma_2=1$)	
	M^n_t	$\lvert t \rvert$	M^n_t	$\lvert t \rvert$	M^n_t	$\lvert t \rvert$
Panel A: Descriptive statistics						
Mean	-0.1		-0.4		5.7	
Median	0.4		-0.1		5.6	
st. dev.	8.2		3.3		4.9	
N	979		975		975	
Panel B: Cost of carry and day-of-the-week patterns						
$Interest^n_t$	0.93	29.60*	-0.00	0.00	-0.07	2.07*
$Cash^n_t$	-0.80	15.74*	0.00	0.00	0.20	3.83*
$Franking^n_t$	-0.52	4.27*	-0.00	0.00	0.48	3.93*
D_1	-0.15	0.37	-0.15	0.37	-0.15	0.37
D_2	0.07	0.18	0.07	0.18	0.07	0.18
D_3	-0.62	1.67	-0.62	1.67	-0.62	1.67
D_4	-0.78	1.91	-0.78	1.91	-0.78	1.91
D_5	-0.64	1.55	-0.64	1.55	-0.64	1.55
adj R^2	0.84		0.00		0.55	
F	637.30*		3.14*		516.24*	

Panel A presents some summary statistics for the average intraday mispricing of the near futures contract (M^n_t).
Panel B presents the results of the regression equation $M^n_t = (1-\tau_1)Interest^n_t + \gamma_1 Cash^n_t + \gamma_2 Franking^n_t + \sum\delta_i D_i + \varepsilon_t$ where $Interest^n_t$ is the cost of borrowing for the financing of the set of shares of the underlying index defined as the difference between the theoretical price of the futures contract estimated from zero dividends and the spot index value, $Cash^n_t$ is the theoretical value of cash dividends paid out by the stocks over the remaining life of the contract defined as the difference between the theoretical price of the futures contract estimated from zero dividends and the theoretical price of the futures contract estimated using cash dividends, $Franking^n_t$ is the theoretical value of franking credits paid out by the stocks over the remaining life of the contract defined as the difference between the theoretical price of the futures contract estimated from cash dividends and the theoretical price of the futures contract estimated using gross dividends and D_i is a day-of-the-week dummy variable. *Denotes significance at the 5% level.

The third column in table 2 describes the difference between the market price of the index futures contract and its theoretical price with fully valued carry components, specified in equation (18). The regression coefficients in the third column of panel B can be interpreted as follows. If we assume that the debt tax shield is worthless in reducing the effective financing cost, the futures contract is 7 cents underpriced for every dollar of financing cost. Again this implies that 93 percent of the financing cost is reflected in futures prices. Although the coefficient on the interest charge is statistically significant which indicates that not all of the charge is priced, the implied debt tax shield is not likely to be economically significant except for longer times to maturity. The significant coefficient against the financing cost in this regression is consistent with the early United States evidence provided by Cornell and French

(1983) that the tax timing option offers some value to physical stockholders[22]. If we assume that both the cash dividends and franking credits are fully valued, the futures contract is 20 cents overpriced for every dollar of accumulated cash dividends and 48 cents overpriced for every dollar of franking credits. Again this implies the market prices the cash at 80 cents and the franking credits at 52 cents relative to a futures profit of one dollar. The relevant coefficients are both significant, which attests that neither the cash dividends nor the franking credits are fully valued. In this instance, the R^2 statistic indicates that 55 percent of the variation in the mispricing against fair values based on the full financing cost and the full value of cash dividends and franking credits is explained by the model.

To expand upon the interpretation of these results and isolate any day of the week effects, the variation in the basis for the index futures attributed to the market valuations placed on the three carry components is netted out by computing a third form of mispricing. The third form of mispricing is the difference between the market price of the index futures contract and its theoretical price with partially valued carry components:

$$M_t^n(p) = F_t^n - f_{t,T}(p) \qquad (20)$$

where $f_{t,T}(p)$ is the theoretical futures price specified in equation (16) substituting $1 - \tau_1 = 0.93$ for the effective financing cost, $\gamma_1 = 0.80$ for the market value of the cash dividends and $\gamma_2 = 0.52$ for the market value of the franking credits obtained from the preceding regressions. This third form of mispricing which allows for tax effects on the basis is appreciably more stable than the previous two forms of mispricing. Its overall daily standard deviation (reported in the second column of table 2 panel A) is 3.3 index points, compared with 8.2 index points for the basis and 4.9 index points for the mispricing based on the fully valued carry components. The average mispricing taking account of the implied market values of the carry components is consistently close to zero during the first six weeks of the expiry cycle and is small and negative during the last six weeks before expiry as shown in figure 2[23]. Consistent with our specification for this regression which is effectively a linear transformation of the earlier regressions, the coefficients in the second column of table 2 panel B for the financing cost, the values of accumulated cash dividends and franking credits as well as the corresponding *t*-statistics are all zero. All of the variation in mispricing attributed to the carry components has been extracted, leaving a model that highlights day of the week effects alone.

In contrast to Brailsford and Hodgson (1997) who document significantly lower mispricing spreads of Australian stock index futures on Fridays, there is not any evidence of systematic biases associated with days of the week after controlling for the values placed on the carry components. Nor is there any evidence to corroborate Cornell's (1985b) finding that the basis of United States S&P 500 futures tends to

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[22] That is, the incomplete value of the financing cost effectively reduces the contract basis for longer times to maturity in much the same way that is predicted if the tax option is beneficial to the marginal investor.

[23] Given that the value of cash dividends and franking credits are based on actual ex-post daily inflows for the S&P/ASX 200 basket stocks, slightly higher residual mispricing for longer times to maturity could simply indicate that dividends were larger than anticipated by the market on average over the sample period.

widen on Mondays and narrow on Tuesdays[24]. Negative residual mispricing of less than one index point on Wednesdays, Thursdays and Fridays (shown in table 2 panel B) is statistically insignificant on each of these days.

4.3 Robustness tests

Additional regression analysis is reported in this section to provide results that are directly comparable with the gross drop-off ratios, cash drop-off ratios and franking credit drop-off ratios estimated by Beggs and Skeels (2006) for the Australian share market and the values of cash dividends and imputation tax credits inferred by Cannavan, Finn and Gray (2004) from ISFs and LEPOs prices.

To focus on the role played by the gross dividends flowing from the index constituents, a fourth form of mispricing is computed as the difference between the market price of the index futures contract and its theoretical price incorporating the full financing cost and zero dividends:

$$M_t^n(z) = F_t^n - f_{t,T}(z) \tag{21}$$

where $f_{t,T}(z)$ is the theoretical futures price specified in equation (13). Descriptive statistics are shown in the first column of table 3 panel A, with the contract underpriced by an average of 22.3 index points on the assumption of zero dividends. This time the regression specification concentrates on the gross dividend amount as the key explanatory variable in the same way that Beggs and Skeels (2006: 242, equation 3) perform for the share price drop-off on ex-dividend days:

$$M_t^n = \beta_1 GrossDiv_t^n + \sum_{i=1}^{5} \delta_i D_i + \varepsilon_t \tag{22}$$

The results are shown in the first column of table 3 panel B. The futures price is reduced by approximately 78 cents for every dollar of gross dividends. This estimate is slightly higher than Beggs and Skeels' (2006) estimate for the gross drop-off ratio in share prices of 72 cents from 2001 to 2004. Our result is verified by regressing the mispricing incorporating the fully valued carry components (equation 18) against the gross dividends to produce the estimates in the third column of table 3 panel B. Further, the mispricing incorporating the partially valued carry components with $1 - \tau_1 = 1$ and $\gamma_1 = \gamma_2 = 0.78$ (equation 20) is assigned as the dependent variable to net out the variation attributed to the average market valuation of the gross dividends in the second column.

[24] Cornell (1985b) shows that the weekly pattern in the S&P 500 futures basis is primarily due to significantly negative returns in the cash market during the weekend non-trading hours. However, Maberly, Spahr and Herbst (1989) observe negative non-trading returns on Mondays for both S&P 500 futures and the spot index, suggesting that negative news dominates positive news over the weekend.

Table 3
Value of gross dividends and day-of-the-week patterns in futures contract mispricing

	Assuming gross dividend is worthless (β_1=0)		Assuming gross dividend is partially valued (β_1=0.78)		Assuming gross dividend is fully valued (β_1=1)	
	M^n_t	$\|t\|$	M^n_t	$\|t\|$	M^n_t	$\|t\|$
Panel A: Descriptive statistics						
Mean	-22.3		-0.5		5.7	
Median	-24.6		-0.2		5.6	
st. dev.	13.0		3.4		4.9	
N	979		975		975	
Panel B: Gross dividends and day-of-the-week patterns						
$GrossDiv^n_t$	-0.78	59.16*	-0.00	0.00	0.22	16.88*
D_1	-0.22	0.61	-0.22	0.61	-0.22	0.61
D_2	0.00	0.01	0.00	0.01	0.00	0.01
D_3	-0.66	1.89	-0.66	1.89	-0.66	1.89
D_4	-0.80	2.10*	-0.80	2.10*	-0.80	2.10*
D_5	-0.73	1.88	-0.73	1.88	-0.73	1.88
adj R^2	0.93		0.00		0.53	
F	9,281.30*		4.68*		650.30*	

Panel A presents some summary statistics for the average intraday mispricing of the near futures contract (M^n_t). Panel B presents the results of the regression equation $M^n_t = \beta_1 GrossDiv^n_t + \sum \delta_i D_i + \varepsilon_t$ where $GrossDiv^n_t$ is the theoretical value of gross dividends paid out by the stocks over the remaining life of the contract defined as the difference between the theoretical price of the futures contract estimated from zero dividends and the theoretical price of the futures contract estimated using gross dividends and D_i is a day-of-the-week dummy variable. *Denotes significance at the 5% level.

The model expressed in equation (22) assumes that cash dividends and their accompanying franking credits can be combined into a single gross dividend variable. However, there are reasons to suspect the market might not value equally a dollar of cash dividend and a dollar of franking credit as outlined by Beggs and Skeels (2006). Although a change to the tax laws in 1988 allows access for superannuation funds, it remains the case that foreign investors have limited ability to access Australian franking credits. So in equation (8), we expect the value the investor places on the credits to be $\varphi = 1$ for Australian taxpaying individuals and fund managers who can fully utilise them while $\varphi < 1$ for non-residents who might be able to extract some value but only by incurring costs in the process. Therefore, the regression is respecified to allow for the differential market valuations of the cash dividends and franking credits:

$$M_t^n = \gamma_1 Cash_t^n + \gamma_2 Franking_t^n + \sum_{i=1}^{5} \delta_i D_i + \varepsilon_t \qquad (23)$$

The results are shown in the first column of table 4. The futures price is reduced by approximately 86 cents for every dollar of accumulated cash dividends and approximately 54 cents for every dollar of franking credits. These estimates are slightly higher than Beggs and Skeels' estimate for the cash drop-off ratio of 80 cents and slightly lower than their estimate for the franking credit drop-off ratio of 57 cents relative to capital gains in the Australian share market from 2001 to 2004[25]. Our result accommodating the differential market valuations is verified by regressing the mispricing incorporating the fully valued carry components (equation 18) against the accumulated cash dividends and franking credits to produce the estimates in the third column of table 4. Finally, the mispricing incorporating the partially valued carry components with $1 - \tau_1 = 1$, $\gamma_1 = 0.86$ and $\gamma_2 = 0.54$ (equation 20) is assigned as the dependent variable to net out the variation attributed to the representative market valuations in the second column.

Table 4
Value of cash dividends and imputation tax credits and day-of-the-week patterns in futures contract mispricing

	Assuming cash and franking credits are worthless (γ_1=γ_2=0)		Assuming cash and franking credits are partially valued (γ_1=0.86 and γ_2=0.54)		Assuming cash and franking credits are fully valued (γ_1=γ_2=1)	
	M^n_t	$\|t\|$	M^n_t	$\|t\|$	M^n_t	$\|t\|$
Panel A: Descriptive statistics						
Mean	-22.3		-0.6		5.7	
Median	-24.6		-0.2		5.6	
st. dev.	13.0		3.4		4.9	
N	979		975		975	
Panel B: Cash dividends, franking credits and day-of-the-week patterns						
$Cash^n_t$	-0.86	20.12*	-0.00	0.00	0.14	3.28*
$Franking^n_t$	-0.54	4.54*	-0.00	0.00	0.46	3.85*
D_1	-0.31	0.85	-0.31	0.85	-0.31	0.85
D_2	-0.10	0.29	-0.10	0.29	-0.10	0.29
D_3	-0.78	2.24*	-0.78	2.24*	-0.78	2.24*
D_4	-0.93	2.42*	-0.93	2.42*	-0.93	2.42*
D_5	-0.81	2.10*	-0.81	2.10*	-0.81	2.10*
adj R^2	0.93		0.00		0.54	
F	8,131.61*		5.53*		572.68*	

Panel A presents some summary statistics for the average intraday mispricing of the near futures contract (M^n_t). Panel B presents the results of the regression equation $M^n_t = \gamma_1 Cash^n_t + \gamma_2 Franking^n_t + \sum \delta_i D_i + \varepsilon_t$ where $Cash^n_t$ is the theoretical value of cash dividends paid out by the stocks over the remaining life of the contract defined as the difference between the theoretical price of the futures contract estimated from zero dividends and the theoretical price of the futures contract estimated using cash dividends, $Franking^n_t$ is the theoretical value of franking credits paid out by the stocks over the remaining life of the contract defined as the difference between the theoretical price of the futures contract estimated from cash dividends and the theoretical price of the futures contract estimated using gross dividends and D_i is a day-of-the-week dummy variable. *Denotes significance at the 5% level.

In contrast to Cannavan, Finn and Gray (2004), cash dividends are found to be less than fully valued relative to index futures payoffs. There is also evidence of significant value in the franking credits to the marginal investor. Cannavan, Finn and Gray's finding that the implied value of imputation tax credits was insignificantly different from zero after the introduction of the 45-day minimum holding period is based on a sample of ISFs and LEPOs trades before two further tax changes that could

[25] Our estimate for the value of one dollar of franking credits relative to futures payoffs falls well within the standard error reported by Beggs and Skeels (2006) of 12.1 percent for their franking credit drop-off ratio in the Australian share market.

have increased their value: a reduction in capital gains tax from 1 July 1999; and rebates for unused franking credits from 1 July 2000. These recent tax regime changes could explain why our results are much more consistent with the ex-dividend behaviour of share prices from 2001 to 2004 reported by Beggs and Skeels (2006) and the proportion of the value of franking credits delivered by a synthetic position reported by Frino, Wearin and Fabre (2004).

5. Conclusion

This study uses the observed basis of Australian stock index futures to infer the values of the debt tax shield, accumulated cash dividends and franking credits for the underlying stocks over the remaining life of the futures contract. If all investors were Australian taxpaying individuals who faced the same tax rate on interest, dividends and capital gains and could utilise the imputation credits, we would expect index futures prices to reflect the full cost of financing the underlying stocks and the gross dividends. Instead, it is evident that the cost of financing the set of shares of the underlying index provides a mild tax shield, the accumulated cash dividends are incompletely valued and the franking credits are worth at least fifty percent of their face value relative to futures payoffs. These findings are consistent with the harsher tax treatment of interest and dividend income relative to capital gains on stocks and dividend imputation tax credits that are partially valued by the marginal investor. In the Australian market, the timing option held by stockholders to defer capital gains and realise capital losses possibly accentuates the reduction in the effective financing cost brought about by the tax deductibility of interest on loans. From the practical standpoint of valuing SFE SPI 200™ futures, the valuation method needs to account for the taxation treatment of the financing charge and dividend flow from the underlying index reflected in market prices.

The values of the accumulated cash dividends and franking credits implied by index futures prices are very close to the ex-dividend date cash drop-off ratio and franking credit drop-off ratio respectively estimated by Beggs and Skeels (2006) for the Australian share market. The similarity with the ex-dividend behaviour of share prices confirms: (i) that marginal investors in the form of arbitrageurs do not trade up to the theoretical value of gross dividends; and (ii) that franking credits are unambiguously valuable to marginal investors after recent tax regime changes including a reduction in the capital gains tax rate and the establishment of tax rebates for unused franking credits. Overall, it is concluded that tax effects are as pervasive in the futures market as they are in the cash market.

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