

Chapter 3

Tax effects on the pricing of Australian stock index futures

3.1 Introduction

The first study for this dissertation develops a tax-adjusted cost-of-carry model for Australian stock index futures and estimates the value of the debt tax shield, cash dividends and imputation tax credits flowing from the basket stocks in the index. As discussed in the previous chapter, the study relaxes the assumption made in previous research that interest and dividends receive the same tax treatment as capital gains on stocks. Empirical evidence is provided using two important changes to the tax regime which provide for ‘natural experiments’: a reduction in the capital gains tax rate from 1 July 1999 and the introduction of tax rebates for unused franking credits from 1 July 2000. The results of the study relate to a broad-based market portfolio that is directly relevant to index fund managers.

The remainder of this chapter is structured as follows. In section 3.2 a formula is developed which models the basis of index futures in the presence of dividend imputation and the differential taxation of different types of income. Section 3.3 describes the institutional setting and data. The econometric method and the results of the empirical analysis are presented in section 3.4. Section 3.5 summarises.

3.2 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 modelled. 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 that 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, (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

$$\pi_T = (S_T - F_{t,T})(1 - \tau_p) \quad (3.1)$$

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 $\phi IC_s(1 - \tau_p)$. The net after-tax payoff to this strategy at time T is

$$\begin{aligned} \pi_T = & (S_T - S_t)(1 - \tau_p) - S_t(e^{r(T-t)} - 1)(1 - \tau_p) + \sum_{s=t+1}^T D_s e^{r(T-s)}(1 - \tau_p) \\ & + \sum_{s=t+1}^T \phi IC_s(1 - \tau_p) \end{aligned} \quad (3.2)$$

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

$$\begin{aligned} (S_T - F_{t,T})(1 - \tau_p) = & (S_T - S_t)(1 - \tau_p) - S_t(e^{r(T-t)} - 1)(1 - \tau_p) \\ & + \sum_{s=t+1}^T D_s e^{r(T-s)}(1 - \tau_p) + \sum_{s=t+1}^T \phi IC_s(1 - \tau_p) \end{aligned} \quad (3.3)$$

The $(1 - \tau_p)$ 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:

$$F_{t,T} - S_t = S_t(e^{r(T-t)} - 1) - \sum_{s=t+1}^T D_s e^{r(T-s)} - \sum_{s=t+1}^T \phi IC_s \quad (3.4)$$

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.²⁶ In this case, the no-arbitrage analysis is adjusted as follows.

Revised method 1 Forward contract: The investor buys $(1 - \tau_g)/(1 - \tau_p)$ forward contracts on the index at time t . At time T , the contracts mature and the investor pays the previously negotiated amount $F_{t,T}(1 - \tau_g)/(1 - \tau_p)$ and takes possession of $(1 - \tau_g)/(1 - \tau_p)$ index

²⁶ 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.

replicating portfolios that can be sold for $S_T(1-\tau_g)/(1-\tau_p)$. The trading profit is still taxed at the rate of τ_p , so the revised net cash flow after tax at time T is

$$\pi'_T = (S_T - F_{t,T})(1 - \tau_g) \quad (3.5)$$

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 $S_t(e^{r(T-t)} - 1)(1 - \tau_p)$. 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 $D_s e^{r(T-s)}(1 - \tau_p)$ and $\phi IC_s(1 - \tau_p)$ respectively after taxes. The revised net after-tax payoff to this strategy at time T is

$$\begin{aligned} \pi'_T = & (S_T - S_t)(1 - \tau_g) - S_t(e^{r(T-t)} - 1)(1 - \tau_p) + \sum_{s=t+1}^T D_s e^{r(T-s)}(1 - \tau_p) \\ & + \sum_{s=t+1}^T \phi IC_s(1 - \tau_p) \end{aligned} \quad (3.6)$$

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

$$\begin{aligned} (S_T - F_{t,T})(1 - \tau_g) = & (S_T - S_t)(1 - \tau_g) - S_t(e^{r(T-t)} - 1)(1 - \tau_p) \\ & + \sum_{s=t+1}^T D_s e^{r(T-s)}(1 - \tau_p) + \sum_{s=t+1}^T \phi IC_s(1 - \tau_p) \end{aligned} \quad (3.7)$$

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:

$$F_{t,T} - S_t = S_t(e^{r(T-t)} - 1) \frac{(1 - \tau_p)}{(1 - \tau_g)} - \sum_{s=t+1}^T D_s e^{r(T-s)} \frac{(1 - \tau_p)}{(1 - \tau_g)} - \sum_{s=t+1}^T \phi IC_s \frac{(1 - \tau_p)}{(1 - \tau_g)} \quad (3.8)$$

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.²⁷ The common term $(1-\tau_p)/(1-\tau_g)$ is exactly the same as that 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 the analysis in this section 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 the basis.²⁸ 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 NYSE 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 3.4, the formula for the basis represented in equation (3.8) 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.

²⁷ 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.

²⁸ 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.

3.3 Institutional setting and data

The S&P/ASX 200 index measures the performance of the 200 largest stocks listed on the ASX. The index is float-adjusted and represents approximately 80 percent of the Australian equities market capitalisation at the end of the sample period. 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 2006.²⁹ 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 chapter). 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.³⁰ 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 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..

3.3.1 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 cover the period 1 January 2002 to 15 December 2005, which provides sixteen contract maturities for analysis.³¹ Though up to six maturities are listed at any particular time, the analysis is confined to the nearest-to-maturity 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.³² The data describe 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.

²⁹ In October 2006 ASX replaced SEATS with the Integrated Trading System (ITS).

³⁰ An exception is the December 2002 contract which expired on 9 December 2002.

³¹ Observations for 11 January 2002 and 2 May 2003 with residuals from the baseline regression represented in equation (3.19) 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.

³² Expiration day observations are not included.

S&P/ASX 200 stock index values, time-stamped approximately 30 seconds apart, were also provided by 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.³³ 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 (www.rba.gov.au). 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 the effect of multicollinearity between the cash dividends and franking credits when estimating their separate market values. The analysis assumes that the dividend amounts and franking percentages are known from the expiry date of the previous contract.³⁴ The timing of ex-dividend dates relative to the maturity of the index futures contract is shown in figure 3.1. 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.³⁵ 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

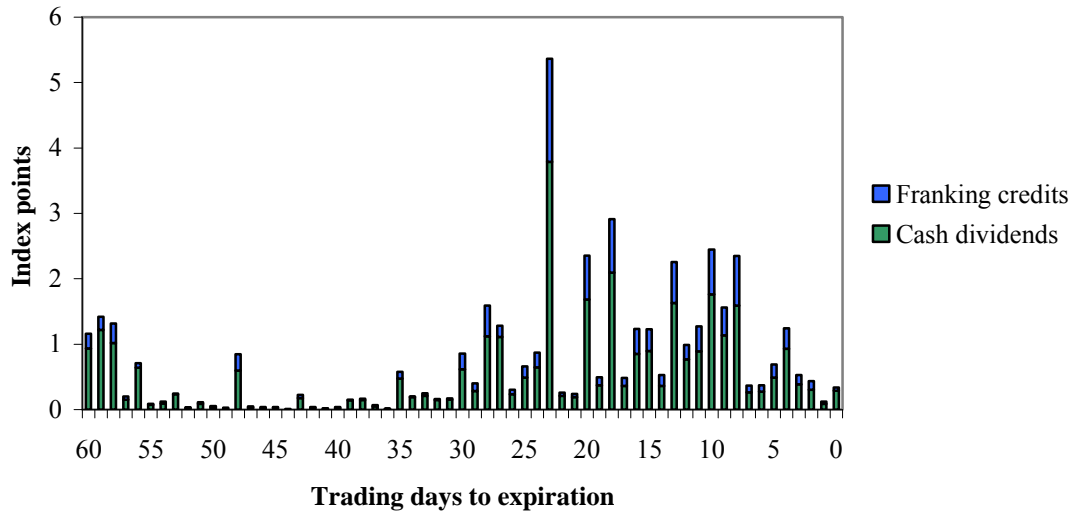
³³ MacKinlay and Ramaswamy (1988) find that S&P 500 futures price changes are slightly negatively autocorrelated at the first lag across fifteen minute time intervals while the underlying index changes are positively autocorrelated, consistent with the presence of stale prices in the available index quotes. However, the autocorrelation disappears as the interval length is increased and becomes close to zero for one hour differencing intervals.

³⁴ 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).

³⁵ Cornell and French (1983) and Harvey and Whaley (1992) show that dividend yields for the NYSE 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.

the basket stocks, which Harvey and Whaley (1992) show reduces pricing errors that occur when constant dividend yields are assumed.

Figure 3.1
Time-to-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.

3.3.2 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:³⁶

$$Interest_t = S_t (e^{r(T-t)} - 1) \quad (3.9)$$

³⁶ 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 3.2 are also settled at time $T + 3$ business days after futures expiry.

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 in the same way as Yadav and Pope (1994): (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 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:³⁷

$$Cash_t = \sum_{s=t+1}^T D_s e^{r(T-s)} \quad (3.10)$$

$$D_s = \sum_{i=1}^{200} (Dividend_{i,s} \times Shares_{i,s}) \times \frac{IndexLevel_s}{IndexMarketValue_s}$$

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 $t < s \leq T$.³⁸ In contrast to the cash dividends which accumulate interest until the maturity of the futures contract, it is assumed in the same way as 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:

$$Franking_t = \sum_{s=t+1}^T IC_s \quad (3.11)$$

$$IC_s = \sum_{i=1}^{200} (TaxCredit_{i,s} \times Shares_{i,s}) \times \frac{IndexLevel_s}{IndexMarketValue_s}$$

³⁷ 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 the 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.

³⁸ 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.

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:

$$GrossDiv_t = \sum_{s=t+1}^T D_s e^{r(T-s)} + \sum_{s=t+1}^T IC_s \quad (3.12)$$

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 3.1. The correlation between $Interest_t$ and $Cash_t$ 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 $Cash_t$ and $Franking_t$ are also highly collinear (with correlation of 0.877), reasonably narrow confidence intervals of the parameter estimates are obtained for the entire sample spanning four years.

Table 3.1
Summary statistics on the value of the carry components (in index points)

	Panel A: Descriptive statistics			Panel B: Correlation matrix		
	Mean	Median	Std dev	$Interest_t$	$Cash_t$	$Franking_t$
$Interest_t$	22.2	21.0	13.9			
$Cash_t$	20.5	21.9	12.1	0.8188		
$Franking_t$	7.5	8.5	4.4	0.7409	0.8774	
$GrossDiv_t$	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 (3.4) 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:

$$f_{t,T}(z) = S_t + Interest_t \quad (3.13)$$

$$f_{t,T}(c) = S_t + Interest_t - Cash_t \quad (3.14)$$

$$f_{t,T}(g) = S_t + Interest_t - Cash_t - Franking_t \quad (3.15)$$

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 (3.8) 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:

$$f_{t,T}(p) = S_t + (1 - \tau_1)Interest_t - \gamma_1 Cash_t - \gamma_2 Franking_t \quad (3.16)$$

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.

3.4 Econometric method and results

3.4.1 Econometric method

In the 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:

$$M_t(b) = F_t - S_t \quad (3.17)$$

where F_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 (3.17) 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 3.2, 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 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 below the spot price implying that the dividend yield to maturity is larger than the interest rate from this

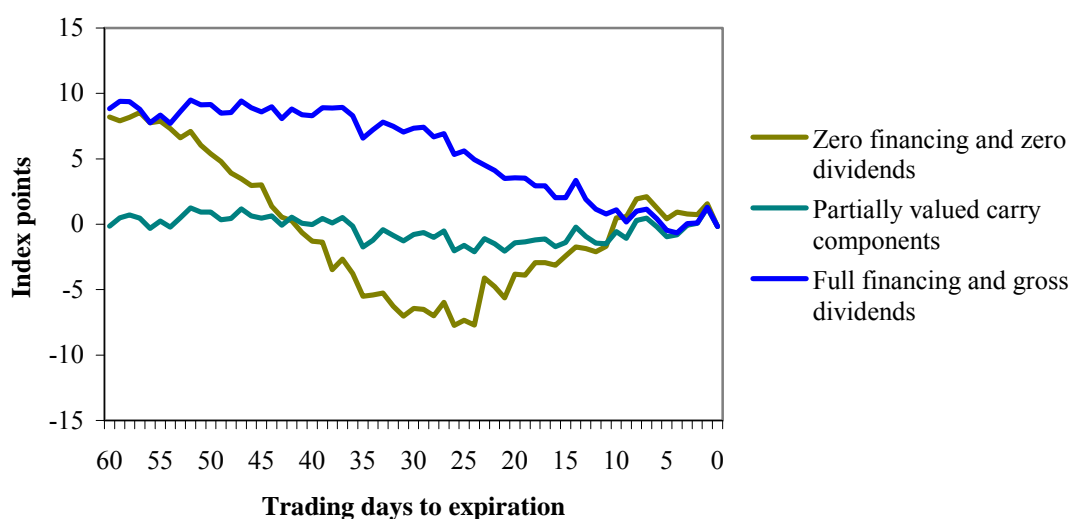
point forward. The latter observation reflects the considerably higher dividend yield of the index during the last six weeks prior to futures maturity.

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:

$$M_t(g) = F_t - f_{t,T}(g) \quad (3.18)$$

where $f_{t,T}(g)$ is the theoretical futures price specified in equation (3.15). Equation (3.18) 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 3.2 illustrates that the futures contract is consistently overpriced, especially for longer times to maturity, if 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 ($\gamma_2 = 1$) are accepted.

Figure 3.2
Time-to-expiry patterns in mispricing of near futures contracts



The formula that separates the cost-of-carry components of a forward contract in equation (3.8) is the foundation for the empirical tests. For each form of mispricing, parameters are estimated for the model

$$M_t = (1 - \tau_1)Interest_t + \gamma_1 Cash_t + \gamma_2 Franking_t + \sum_{i=1}^5 \delta_i D_i + \varepsilon_t \quad (3.19)$$

where

$$M_t = \sum_{j=1}^{N_t} M_t(j) / N_t$$

is the average intraday mispricing in index points of the near index futures contract on day t ;

$M_t(j)$ = mispricing at the j th 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.³⁹ 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 developed by Cannavan, Finn and Gray (2004: 186, 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.⁴⁰ In addition to the variable $Interest_t$ that allows for the value of the debt tax shield, day-of-the-week

³⁹ The theoretically valid restriction $(1 - \tau_1) = \gamma_1$ is not imposed on equation (3.19) because the dataset used in this study is sufficiently large to estimate these parameters separately.

⁴⁰ Cannavan, Finn and Gray (2004) 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 analysed in this study are multiplied by the number of shares included in the index calculation and divided by the index divisor. Moreover, it follows from the theoretical analysis in section 3.2 that differential tax treatments impact upon absolute rather than relative amounts in the cost-of-carry model. Therefore it is natural to focus on absolute contract mispricing and absolute cost of carry components in the empirical analysis in this section.

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.⁴¹ 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 the sample T (Andrews, 1991). All t -statistics are adjusted accordingly.

3.4.2 Results

Table 3.2 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 (3.17) and hence the regression coefficients in this column can be interpreted as follows. If it is assumed 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 of a small tax saving from borrowing to fund the underlying stocks relative to the tax treatment of futures losses. If it is assumed 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 the model for the financing cost, the accumulated cash dividends and the franking credits are highly significant at conventional levels.

⁴¹ 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.

Table 3.2
Value of financing cost, cash dividends and imputation tax credits and day-of-the-week patterns in futures contract mispricing

	Zero financing and zero dividends ($1-\tau_1=\gamma_1=\gamma_2=0$)		Partially valued carry components ($1-\tau_1=0.93, \gamma_1=0.80$ and $\gamma_2=0.52$)		Full financing and gross dividends ($1-\tau_1=\gamma_1=\gamma_2=1$)	
	$M_t(b)$	$ t $	$M_t(p)$	$ t $	$M_t(g)$	$ t $
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						
$Interest_t$	0.93	29.60*	-0.00	0.00	-0.07	2.07*
$Cash_t$	-0.80	15.74*	0.00	0.00	0.20	3.83*
$Franking_t$	-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 summary statistics for the average intraday mispricing of the near futures contract (M_t).

Panel B presents the results of the regression equation $M_t = (1-\tau_1)Interest_t + \gamma_1 Cash_t + \gamma_2 Franking_t + \sum \delta_i D_i + \varepsilon_t$ where $Interest_t$ is the cost of borrowing for the financing of the set of shares of the underlying index, $Cash_t$ is the value of cash dividends paid out by the stocks over the remaining life of the contract, $Franking_t$ is the value of franking credits paid out by the stocks over the remaining life of the contract and D_i is a day-of-the-week dummy variable. *Denotes significance at the 5% level.

The third column in table 3.2 describes the difference between the market price of the index futures contract and its theoretical price with fully valued cost of carry components, specified in equation (3.18). The regression coefficients in the third column of panel B can be interpreted as follows. If it is assumed 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.⁴² If it is assumed 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.

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:

$$M_t(p) = F_t - f_{i,T}(p) \quad (3.20)$$

where $f_{i,T}(p)$ is the theoretical futures price specified in equation (3.16) 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 3.2 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 3.2.⁴³ Consistent with the specification for this regression which is effectively a linear transformation of the earlier regressions, the coefficients in the second column of table 3.2 panel B for the financing cost, the values of accumulated cash dividends and franking credits as well as the corresponding

⁴² 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.

⁴³ 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.

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 widen on Mondays and narrow on Tuesdays.⁴⁴ Negative residual mispricing of less than one index point on Wednesdays, Thursdays and Fridays (shown in table 3.2 panel B) is statistically insignificant on each of these days.

3.4.3 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:

$$M_t(z) = F_t - f_{t,T}(z) \quad (3.21)$$

where $f_{t,T}(z)$ is the theoretical futures price specified in equation (3.13). Descriptive statistics are shown in the first column of table 3.3 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:

⁴⁴ 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.

$$M_t = \beta_1 \text{GrossDiv}_t + \sum_{i=1}^5 \delta_i D_i + \varepsilon_t \quad (3.22)$$

The results are reported in the first column of table 3.3 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. The result is verified by regressing the mispricing incorporating the fully valued carry components (equation 3.18) against the gross dividends to produce the estimates in the third column of table 3.3 panel B. Further, the mispricing incorporating the partially valued carry components with $1 - \tau_1 = 1$ and $\gamma_1 = \gamma_2 = 0.78$ (equation 3.20) 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.

Table 3.3
Value of gross dividends and day-of-the-week patterns in futures contract mispricing incorporating the full financing cost

	Zero dividends ($1-\tau_1=1$ and $\gamma_1=\gamma_2=0$)		Partially valued gross dividends ($1-\tau_1=1$ and $\gamma_1=\gamma_2=0.78$)		Gross dividends ($1-\tau_1=\gamma_1=\gamma_2=1$)	
	$M_t(z)$	t	$M_t(p)$	t	$M_t(g)$	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						
$GrossDiv_t$	-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 summary statistics for the average intraday mispricing of the near futures contract (M_t). Panel B presents the results of the regression equation $M_t = \beta_1 \text{GrossDiv}_t + \sum \delta_i D_i + \varepsilon_t$ where $GrossDiv_t$ is the value of gross dividends paid out by the stocks over the remaining life of the contract and D_i is a day-of-the-week dummy variable. *Denotes significance at the 5% level.

The model expressed in equation (3.22) assumes that cash dividends and their accompanying franking credits can be combined into a single gross dividend variable. However, there are reasons 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 (3.8), the value the investor places on the credits is expected 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:

$$M_t = \gamma_1 \text{Cash}_t + \gamma_2 \text{Franking}_t + \sum_{i=1}^5 \delta_i D_i + \varepsilon_t \quad (3.23)$$

The results are reported in the first column of table 3.4. 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 2004.⁴⁵ The result accommodating the differential market valuations is verified by regressing the mispricing incorporating the fully valued carry components (equation 3.18) against the accumulated cash dividends and franking credits to produce the estimates in the third column of table 3.4. Finally, the mispricing incorporating the partially valued carry components with $1 - \tau_1 = 1$, $\gamma_1 = 0.86$ and $\gamma_2 = 0.54$ (equation 3.20) is assigned as the dependent variable to net out the variation attributed to the representative market valuations in the second column.

⁴⁵ The 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.

Table 3.4
Value of cash dividends and imputation tax credits and day-of-the-week patterns in futures contract mispricing incorporating the full financing cost

	Zero dividends ($1-\tau_1=1$ and $\gamma_1=\gamma_2=0$)		Partially valued cash and franking credits ($1-\tau_1=1$, $\gamma_1=0.86$ and $\gamma_2=0.54$)		Gross dividends ($1-\tau_1=\gamma_1=\gamma_2=1$)	
	$M_t(z)$	t	$M_t(p)$	t	$M_t(g)$	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						
$Cash_t$	-0.86	20.12*	-0.00	0.00	0.14	3.28*
$Franking_t$	-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 summary statistics for the average intraday mispricing of the near futures contract (M_t). Panel B presents the results of the regression equation $M_t = \gamma_1 Cash_t + \gamma_2 Franking_t + \sum \delta_i D_i + \varepsilon_t$ where $Cash_t$ is the value of cash dividends paid out by the stocks over the remaining life of the contract, $Franking_t$ is the value of franking credits paid out by the stocks over the remaining life of the contract 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 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 the results reported in this chapter 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).

3.5 Summary

Taxes are shown to be irrelevant to the value of the basis for index futures (the difference between the futures price and the spot price) when investors face the same marginal tax rate on all forms of income. In this case, the basis simply reflects the cost of borrowing for the financing of the basket stocks in the index, the accumulated cash dividends and the market value of the imputation credits flowing from the index. The actual marginal tax rates become relevant to the value of the basis where different tax rates apply to interest payments and dividend income versus capital gains on stocks. In the same way that 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, the analysis in this chapter demonstrates that the relative tax rates on these two types of income are also reflected in the pricing of index futures relative to the underlying index.

The observed basis of Australian stock index futures is used to infer the values of the debt tax shield, accumulated cash dividends and franking credits for the underlying stocks. Results from the main regression model without any constraints placed upon the values of the carry components indicate that 93 percent of the financing cost is embedded in the futures price. Further, the futures price is reduced by 80 percent of the accumulated cash dividends and 52 percent of the franking credits. There is not any evidence of systematic biases associated with days of the week after controlling for the market valuation of the carry components.