# Chapter 2
# Literature review and hypothesis development

Chapter one outlined that the main purpose of this dissertation is to estimate the impact of taxes on Australian stock index futures prices, evaluate the effectiveness of the information transmission mechanism between the cash and futures markets and assess the market impact and speed of adjustment in response to large trades in interest rate and stock index futures. This chapter provides an overview of the literature related to the three studies presented in this dissertation and identifies the unanswered questions in the extant literature that these studies aim to resolve.

## 2.1 Tax effects on the pricing of stock index futures

This section discusses previous research examining the value of the financing cost, dividends and imputation tax credits reflected in futures prices and the value of dividends and tax credits reflected in the ex-dividend day behaviour of share prices.

### 2.1.1 Impact of taxes on futures prices

The basis (that is, the difference between the futures price and the cash price) 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. The first study undertaken for this dissertation 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 capital 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.[2] The market may not value the franking credits in parity with cash dividends because foreign investors who hold a substantial proportion

[2] The franking credit is for the tax already paid on that income at the company level.

of the equity on issue in Australia have limited ability to access them.[3] It is as 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.[4] Theobald and Yallup (1996) investigate the impact of settlement features in the United Kingdom cash market and potential tax effects on the basis of FTSE 100 index futures, starting from a simple cost-of-carry formulation.[5] They find the interest rate, dividend and settlement related variable have the correct directional impact and are close to unity in the fiscal years 1990/91, 1991/92 and 1992/93, 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 on the ex-dividend day behaviour of German stocks. 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.

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 Australian tax laws designed to prevent short-term trading of imputation tax credits affected their economic value. The significant tightening of the tax laws included the imposition of a 45-day minimum holding period around the date of dividend entitlement for investors to qualify for the franking credits.[6] Cannavan, Finn and Gray find that (i) cash dividends

[3] 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).
[4] 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-paying stocks to estimate the expected relative ex-dividend stock price decline. They find that the decline is not meaningfully different from one.
[5] Under the account settlement system that operated in the United Kingdom cash market during most of their sample period, settlement of trades took place between ten and twenty-nine days after a trade date.
[6] 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

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 imposition 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 the introduction of tax rebates for unused franking credits from 1 July 2000.[7] This dissertation brings further evidence to bear on whether there is any positive value in the imputation credits after these more recent tax changes, using four years of intraday transaction data for the most actively traded equity derivative in Australia.

### 2.1.2 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 that it aims to achieve the same objective. A variety of theories involving the differential tax treatment of dividends and capital gains on stocks has been proposed to explain the expected share price adjustment on ex-dates. In ex-dividend day 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.[8] 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 for 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

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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.

[7] Prior to 1 July 2000, imputation credits could only be used to offset domestic personal tax obligations.

[8] 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.

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 franking credits. Beggs and Skeels (2006) examine 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 dissertation examines whether these recent estimates are substantiated in the futures market.

## 2.2 Index arbitrage and the relationship between spot and futures prices

This section discusses the findings of previous research examining the impact of unexpected information arrival on the mispricing of stock index futures and the risks and transaction costs faced by arbitrageurs acting to narrow price discrepancies between the cash and futures markets.

### 2.2.1 Information transfer

The second study undertaken for this dissertation further explores the impact on the mispricing series of the possibility that the stock and futures markets react to different information sets (the ‘differential information hypothesis’). In this context, the strength of the arbitrage pricing relationship for index futures reflects the efficiency with which information is transferred between stock and futures markets following its arrival in one of the markets. Hodgson, Masih and Masih (2006) provide evidence that substantial macroeconomic information flows from Australian stock index futures price changes and predicts subsequent movements in stock prices. It is likely that market-wide information is incorporated with greater speed in the futures market relative to the underlying stock market, if transactions costs are substantially lower and execution delays are shorter in the futures market. Consistent with the relative dominance of the futures market compared to the cash market in the price discovery process, Brailsford and Hodgson (1997) find that unexpected trading volume and the volatility of futures

prices have a positive impact on the mispricing spread of Australian stock index futures.[9] Conversely, individual stocks trading in the cash market are more likely to react to firm specific information (Chan, 1992).

The results of several studies demonstrate that the cost-of-carry relationship between spot and futures prices is disrupted by the arrival of significant information. Using daily data for cash and stock index futures markets in the United States, Merrick (1987) finds evidence of a strong causal flow from volatility to the cash/futures mispricing spread and Hill, Jain and Wood (1988) document a positive, contemporaneous relationship between mispricing changes and larger absolute index returns. Using executable prices for the index basket every thirty seconds in Hong Kong, Draper and Fung (2003) document a positive relationship between the mispricing of index futures and market volatility. These results imply that spot and futures prices respond to the arrival of new information at different speeds, causing the basis for the index futures contract to diverge temporarily away from the cost of carrying the index basket of stocks.

Kumar and Seppi (1994) develop an information-based model of arbitrage, where the order flow itself is informative about intermarket price discrepancies. An empirical implication of their model is that index arbitrage is associated with 'permanent' price revisions. Providing support for the model, Neal (1996) finds arbitrage trades narrow the deviation from fair value and most trades involve a simultaneous submission of the stock and futures portions of the trade. It follows that one component of unexpected trading volume in the underlying stocks represents arbitrage trading that serves to narrow intermarket price discrepancies. Another component of unexpected volume represents trading to exploit stock-specific information that serves to widen intermarket price discrepancies, whenever the futures market is slower to respond to the stock-specific information than the cash market (see Frino, Walter and West, 2000). The second study in this dissertation tests which component of unexpected trading volume in the underlying stocks dominates in its impact on the mispricing spread of the index futures contract. Unexpected trading volume in the underlying stocks is predicted to widen the deviation from fair value, if trading on stock-specific information dominates the presence of arbitrageurs in the composition of the unexpected volume. That is, by

[9] Garbade and Silber (1983) demonstrate that the price discovery function of futures markets hinges on whether price changes in futures markets lead price changes in cash markets more often than the reverse. In particular, if the futures market dominates the cash market, any deviations from the carrying cost relationship between cash and futures prices will be narrowed by cash prices moving further towards futures prices than futures prices move towards cash prices.

estimating its impact on the mispricing spread, evidence is provided of the source of information arrival in the cash market.

The trading hours of the Australian stock market do not overlap with the United States stock market, which allows the effect of overnight 'public information' arrival to be observed. Brailsford and Hodgson (1997) find that volatility of the overnight United States stock market has a consistent significant impact on the absolute pricing errors of Australian stock index futures at the opening of the local stock market. Higher mispricing at the opening is likely to be compounded by a microstructural feature of the Australian Stock Exchange (ASX); the opening price setting mechanism in the stock market entails staggered opening times for groups of stocks over the first nine minutes.[10]

### 2.2.2 Risks faced by index arbitrageurs

The positive association between the magnitudes of mispricing and time to maturity which has been documented in stock index futures markets is consistent with arbitrage being more risky further out from maturity (MacKinlay and Ramaswamy, 1988 in the United States; Yadav and Pope, 1990; 1994 in the United Kingdom). Arbitrageurs require greater compensation to act upon deviations from theoretical pricing levels when the risks they face are higher, permitting larger deviations to be sustained early in the futures expiry cycle. MacKinlay and Ramaswamy (1988) identify three of the risks that are greater with longer times until expiration: (i) the risk of unanticipated increases or decreases in dividends; (ii) unanticipated interest earnings or costs from financing the marking-to-market flows from futures positions; and (iii) attempts at arbitrage motivated trading that employ less than the full basket of stocks in the index must allow for a greater margin of error with longer times to expiration. The second study in this dissertation endeavours to disentangle which of the risks associated with index arbitrage activities have the most significant impact on futures contract mispricing.

Existing research does not explicitly quantify the risk premium required by arbitrageurs on account of dividend yield uncertainty, except by considering worst case scenarios (Yadav and Pope, 1994). The second study in this dissertation measures the uncertainty about the magnitude of dividends based on the dispersion of analysts' forecasts for

[10] See Comerton-Forde and Rydge (2006) for a detailed description of the opening price setting process on the ASX.

index constituent stocks.[11] The likelihood of incorrectly predicting ex-dividend dates is also higher for longer times until maturity. The risk pertaining to the unknown timing of ex-dividend dates is especially relevant to the pricing of futures contracts, in cases when either dividends are delayed that were expected to have ex-dividend dates before the expiration of the contract or dividends are brought forward that were expected to be deferred until after the expiration of the contract. Despite the presence of these forms of dividend uncertainty, Yadav and Pope (1994) are unable to attribute the magnitude of mispricing they observe in FTSE 100 futures to dividend forecast errors. Their measure of the uncertainty surrounding the timing of future dividends focuses on the difference between the ex-dividend date and the actual dividend payment date, which does not capture the pricing consequences of firms rescheduling ex-dividend dates relative to previous years. This issue is addressed in the second study by constructing an alternative measure of the time to expiration based on dividend announcements over the remaining life of the futures contract. The announcement of dividend amounts and ex-dividend dates over the period to contract maturity represents the source of uncertainty relating to both the magnitude and timing of dividends.

The application of the cost-of-carry model for forward prices to the pricing of futures contracts relies upon the assumption of non-stochastic interest rates (Cox, Ingersoll and Ross, 1981). As an alternative, Ramaswamy and Sundaresan (1985) develop a continuous time model in which the stock index follows a lognormal diffusion process and the interest rate follows a mean-reverting process. Cakici and Chatterjee (1991) compare the pricing models with stochastic and non-stochastic interest rates for United States S&P 500 futures and conclude that the stochastic model gives significantly better results when the spot interest rate is far away from the long-term mean or when the speed of adjustment toward this long-term mean is very high. However, simulations provided by Modest (1984) suggest that stochastic interest rates and marking to market are likely to have a minimal effect on equilibrium futures prices. Bailey (1989) and Brailsford and Hodgson (1997) examine the empirical performance of the Ramaswamy-Sundaresan model in the Japanese and Australian markets, respectively, and find that the pricing errors are not substantially different from those of a simple cost-of-carry model. These findings do not preclude interest rate volatility resulting in a widening of

[11] Typically, market participants estimate future dividends by applying a percentage growth factor to past dividends and use corresponding ex-dividend dates from previous years. Analyst forecasts for the sizes of dividends spanning the period to futures expiry are less reliable further out, dependent upon early guidance from a greater number of firms. Additionally, special dividends can constitute a substantial fraction of total dividends and are difficult to predict.

the arbitrage band for index futures prices, because arbitrageurs may require additional compensation to exploit pricing discrepancies between the cash and futures markets when they are exposed to interest rate risk.

Interest rate risk arises from futures positions because the marking to market feature of contracts necessitates the daily reinvestment or borrowing of cash. Index arbitrageurs are further exposed to interest rate risk if the borrowing or lending they undertake to support the cash leg of their transactions does not match the maturity of the futures.[12] The cost of continually rebalancing the maturities of cash and futures positions to neutralise this interest rate exposure may be prohibitive. Unanticipated changes in interest rates spanning the period to futures expiry are more likely to occur when starting further out. The second study in this dissertation investigates the dependence of absolute mispricing on the ex-ante estimate of interest rate volatility implied from interest rate option prices. Further, another alternative measure of the time to expiration is constructed based on the frequency of economic releases that influence interest rate expectations over the remaining life of the futures contract. Macroeconomic news releases over the period to contract maturity represent a source of uncertainty concerning short-term interest rate expectations (Connolly and Kohler, 2004).

MacKinlay and Ramaswamy (1988) provide evidence of countervailing forces that serve to establish a narrower trading band for index futures prices. Arbitrageurs' option to unwind their positions prematurely introduces path dependence into the mispricing series (refer also to Kempf, 1998). That is, its distribution in the future is dependent on its behaviour in the past. In particular, MacKinlay and Ramaswamy document that conditional on the mispricing of S&P 500 futures contracts having crossed one arbitrage bound, it is less likely to cross the opposite bound. This phenomenon is consistent with arbitrageurs unwinding positions established when the mispricing was outside one bound before it reaches the other bound. It is optimal to close out these positions before putting on new arbitrage trades in the reverse direction.

The option to close out early and thereby make an additional arbitrage profit may also make it optimal to open a new arbitrage position even when the simple arbitrage profit is less than the cost incurred in opening and closing the position at maturity (Brennan and Schwartz, 1990). Empirical evidence provided by Finnerty and Park (1988) implies that most program traders are better off not to hold their positions and unwind them at

[12] In practice arbitrage firms typically finance their activity on an overnight basis.

the expiration of the futures contract but instead to keep trading their positions until expiration. Neal (1996) finds arbitrage positions are typically liquidated early and very few are held to expiration. The early unwind option potentially mitigates the greater risks involved in arbitrage strategies further out from maturity.[13] Arbitrageurs also obtain the option to roll their futures positions forward into the next available maturity. Merrick (1989) and Yadav and Pope (1990; 1994) find that early unwinding and rollovers are important determinants of arbitrage profits and explain why arbitrageurs can be active in the market even though prices are within conventionally-measured transaction cost bounds. Brailsford and Hodgson (1997) argue that the risk faced by arbitrageurs in a small volatile market like Australia may be lower than in larger and more liquid markets because the implicit option component of an arbitrage position increases in value with the volatility of the mispricing.

### 2.2.3 Transaction costs

Even before the risks faced by arbitrageurs are taken into account, the existence of transaction costs implies that the price of index futures can fluctuate within a band around its theoretical value without representing a profit opportunity for even the most favourably situated arbitrageurs (Modest and Sundaresan, 1983; Modest, 1984; Gould, 1988; Kawaller, 1987; 1991). Using minute-by-minute data, Dwyer, Locke and Yu (1996) estimate the parameters of a threshold error correction model for the S&P 500 futures and cash indexes that allows for non-linearity suggested by arbitrage with transaction costs. Their estimated thresholds are consistent with the transaction costs of index arbitrage and periods when futures prices move outside the no-arbitrage bands are associated with index arbitrage activity reported by NYSE member firms to the NYSE. In response to shocks from the futures market, their results indicate the basis converges towards its daily mean as much in five to seven minutes when arbitrage is profitable as it converges in fifteen minutes when arbitrage is unprofitable.

Also in the United States, Chung (1991) adapts the simple cost-of-carry model for index futures to incorporate transaction costs for different classes of investors, alternative execution lags and short-selling restrictions on the underlying stocks. His results show it is possible to significantly overestimate the size and frequency of profitable arbitrage opportunities in the index futures market by focusing on ex-post tests (without imposing

[13] In this regard, greater dividend yield uncertainty and interest rate volatility may increase the value of the early unwind option by increasing the volatility of the mispricing series.

execution lags) and by using the reported index level instead of transaction data. Furthermore, he finds the frequency of pricing violations declines significantly with the level of transaction costs and length of execution lags. In the United States and Korea respectively, Klemkosky and Lee (1991) and Gay and Jung (1999) find that member firms have more opportunity to engage in profitable index arbitrage than institutional investors who incur higher transaction costs. In Japan, Lim (1992) finds that arbitrage opportunities are very limited; no arbitrage profit could be made by those outside of the brokerage business that incurs the lowest possible transaction costs. In the United Kingdom, Butterworth and Holmes (2000) find that although mispricings tend to be larger and more persistent for the mid 250 contract than for the FTSE 100 contract, this is consistent with the larger transaction costs and difficulties associated with trading the illiquid constituent stocks of the mid 250 index.

The width of the no-arbitrage band around the theoretical fair value of the contract is determined by explicit costs such as fees paid to brokers, exchange levies and short selling costs, as well as by implicit costs including the bid-ask spreads and price impact costs of opening up positions in both the stock and futures markets. The second study in this dissertation extends the analysis of Brailsford and Hodgson (1997) by determining the influence on index futures mispricing of the minimum implicit round-trip transaction costs associated with bid-ask spreads in the stock and futures markets. In this way, the pricing relationship between the spot and futures markets is examined while controlling for fluctuations in the width of the arbitrage bounds due to medium-term, seasonal and intraday variations in transaction costs incurred when laying on index arbitrage trades. By allowing for varying degrees of effectiveness of the index arbitrage mechanism due to time-varying transaction costs, the study improves upon previous research that has assumed constant total transaction costs.

The second study in this dissertation investigates whether there are any maturity effects on the magnitude of mispricing of the futures contract related to the cost of borrowing stock. Borrowing costs are incurred by arbitrageurs who do not have capital in the form of treasury bills (for buy programs when the futures contract is overvalued relative to the underlying stocks) and index stocks (for sell programs when the futures contract is undervalued relative to the underlying stocks).[14] Short-sellers have to locate a willing

[14] In Australia, the borrower pays the lender a fee for the use of the borrowed securities ranging anywhere between 25 and 400 basis points per annum for ASX 200 equities and between 5 and 50 basis points per annum for Commonwealth Government securities (refer to King, 2005a). Pricing typically takes into

stock lender and pay a stock borrowing fee. Modest and Sundaresan (1983) demonstrate that if part of the proceeds from short sales in the spot market are unavailable for traders to earn interest, the no-arbitrage band dictated by transaction costs can be asymmetric around the theoretical fair value and the futures price can be below the spot index especially when the cost of shorting the spot index is large. The cost ranges from zero for those already owning the stock to a potentially high level. A dynamic equilibrium model developed by Kempf (1998) predicts that the absolute level of negative mispricing increases with time to maturity, since the holding costs associated with short arbitrage positions increase with time to maturity. If arbitrageurs have to borrow stocks to exploit negative index futures mispricing, the pricing of the near contract could deviate from its theoretical level more frequently when stock borrowing is relatively expensive. To test this expectation, it is determined whether borrowing costs in the Australian market have any incremental impact on the volatility of the mispricing series.

### 2.3 Price formation and liquidity surrounding large trades

This section reviews existing evidence on the price and liquidity effects of large trades in equity markets and the information content of large trades in futures markets.

#### 2.3.1 Price effects and speed of adjustment

The third study undertaken for this dissertation provides insights into the roles that the direction of trade initiation and trade size play in forming prices in futures markets. Easley and O'Hara (1987) show that trade size affects security prices because it is correlated with private information about the value of the security. Previous research provides empirical evidence of the price effects and speed of adjustment to large trades in equity markets. The empirical results from the United States and the United Kingdom are summarised in appendix 2.1 and the empirical results from Australia are summarised in appendix 2.2. Temporary price effects of large trades observed in equity markets have been ascribed to liquidity costs, whereas permanent price effects are often ascribed to either inelastic demand conditions or the arrival of new information. Holthausen, Leftwich and Mayers (1990) in the United States and Aitken and Frino

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account factors such as demand and supply for particular securities, the size of any manufactured dividend and the likelihood of the lender recalling the securities early (King, 2005a; b). There is no automated electronic platform for negotiating securities lending transactions in use in Australia and all transactions are entered into between the counterparties. Thus, whereas bid-ask spreads in both the stock and futures markets are able to be gauged, transaction costs associated with securities lending and repo transactions are not reported in Australia.

(1996) in Australia find that permanent price effects dominate temporary price effects for both block purchases and block sales in equity markets and these results hold across sub-samples of block size and alternative measures of price impact.[15] This dissertation examines the impact of trades of various sizes to provide equivalent evidence for financial futures markets.

The inherent leverage and lower transaction costs of futures are likely to attract informed traders. Fleming, Ostdiek and Whaley (1996) show that trading S&P 500 futures, for example, costs about 3 percent of the cost of trading an equivalent stock portfolio. As a result, they find that S&P 500 futures prices appear to lead the S&P 500 stock index, even after controlling for the effects of infrequent trading on the index. For market-wide information, price discovery occurs in the index futures market where trading costs are considerably less than the cost of trading the basket stocks in the index.[16] The structure of trading costs suggests that large futures trades should have permanent price effects because informed traders prefer to exploit their information advantages in the futures market rather than in the cash market. Informed buyers believe the futures contract is underpriced and informed sellers believe the futures contract is overpriced. The trade size could represent the quality of the information contained in their trades (Chan and Lakonishok, 1993).

Several prior studies based on equity markets establish an asymmetry between purchases and sales in the price reaction following large transactions (Kraus and Stoll, 1972; Holthausen, Leftwich and Mayers, 1987; 1990; Chan and Lakonishok, 1993; and Gemmill, 1996 in appendix 2.1; and Aitken and Frino, 1996 in appendix 2.2). These studies show that prices remain high after block purchases whereas they tend to revert back towards pre-trade levels after block sales. The different price reactions between purchases and sales could reflect the reluctance of brokers to accommodate clients' purchases by undertaking short positions. Alternatively, purchases might convey a stronger signal of favourable information, whereas there are numerous liquidity-motivated reasons to dispose of stock (Chan and Lakonishok, 1993). Futures markets differ from equity markets at least to the extent that there are no additional costs for

[15] Holthausen, Leftwich and Mayers (1990) define blocks as the largest fifty trades by number of shares traded for each stock by tick type. Similarly, Aitken and Frino (1996) define blocks as the largest one percent of on-market trades for each stock over their sample period.

[16] Berkman, Brailsford and Frino (2005) confirm that the execution costs paid by the initiators of large trades in the FTSE 100 stock index futures contract are substantially lower than for large on-market trades in index-constituent equities on the London Stock Exchange (LSE). Similarly, Frino and Oetomo (2005) demonstrate that the slippage costs incurred in executing packages of trades that are likely to belong to the same original orders are significantly lower in futures markets than in equity markets.

traders taking short positions compared to long positions. Without the constraints on short sales experienced in equity markets, there are potentially as many informed sellers as informed buyers. In these conditions, there should be no asymmetry in the price reaction between purchases and sales.

There is little empirical evidence of the price effects of large trades in futures markets. Using the FTSE 100 stock index futures contract traded on the London International Financial Futures and Options Exchange (LIFFE), Berkman, Brailsford and Frino (2005) find there is only a small permanent price impact associated with trades in index futures. Their results reveal that much of the initial price reaction is reversed, especially for large trades. Furthermore, they find no evidence of asymmetry in the price reaction following large trades in stock index futures, suggesting that the asymmetry documented in previous studies is specific to equity markets. This dissertation examines whether the price recovery documented for London equity index futures is evident in the price changes surrounding large trades for a suite of Australian interest rate and equity index futures. In doing so, previous research documenting that large trades contribute to the information dissemination process is extended to a broader range of financial futures contracts.

This dissertation analyses how quickly prices adjust to a new equilibrium after a large block trade to determine whether incentives exist for liquidity providers to restrict the size of sequential price changes in futures markets. Dann, Mayers and Raab (1977) present early evidence of the speed of adjustment of stock prices to large block transactions on the NYSE. They find that although the adjustment is rapid, the prices do not appear to be unbiased estimates of closing prices until more than ten minutes after the occurrence of a block trade. They suggest the anomaly could be due to transactions observed in the immediate post-block period that are part of the compensation offered to NYSE members to absorb the block (the ‘compensation’ hypothesis) or to obligations on specialists to restrict the size of sequential price changes (the ‘orderly market’ hypothesis). Faster adjustment times are expected in futures markets, where there are no affirmative obligations of market-makers to maintain smooth and orderly price changes.

Holthausen, Leftwich and Mayers (1990) find that prices rebound quickly after a block trade on the NYSE (see appendix 2.1). For buyer-initiated trades, the price reversal takes one trade at most. For seller-initiated trades, most of the recovery occurs within one trade of the block and the recovery is complete within three trades. Holthausen,

Leftwich and Mayers' results indicate that the speed of response depends on block size: the larger the block, the slower the adjustment. They argue this will be the case if larger blocks induce traders to offer price concessions on subsequent sales to avoid inventory holding costs and if traders reduce their inventory immediately after the block.[17] The price adjustment to large futures trades is observed to determine whether there is any support for the compensation hypothesis, the orderly market hypothesis or an inventory management explanation in futures markets.

### 2.3.2 Liquidity effects and speed of adjustment

In view of the distinctive price effects of large futures trades, the market response to large-trade activity is further probed by examining changes in liquidity surrounding large-trade execution, as well as the time taken for liquidity to return to normal. Moulton (1998) describes a "decrease in liquidity after a large trade that returns quickly to pre-trade levels" as a sign of market resiliency (see also Bernstein, 1987). Evidence presented by Moulton indicates liquidity drops after large equity trades on the NYSE then returns to pre-large trade levels quickly, both in terms of quote update time (within roughly three quotations) and clock time (within roughly fifteen minutes).[18] He also finds that the return of liquidity to normal levels is significantly related to whether limit orders or specialist orders provide counterparty volume to the large trade and to security-specific attributes such as trading activity and bid-ask spread widths, rather than whether it is a purchase or a sale and the relative size of the trade. Given the alternative structure of electronic limit-order driven futures markets where any potential counterparties are required to post visible quotes, the third study in this dissertation endeavours to establish equivalent benchmarks for market resiliency and test whether the speed of liquidity recovery is essentially a product of contract-specific attributes. The proxy suggested by Moulton, the time taken for both spreads and depths to return to pre-trade levels, is adopted as a measure of the resiliency of interest rate and equity index futures markets to the impact of large trades. Thus, a more comprehensive analysis of market resiliency is obtained.

[17] Inventory costs are small in futures markets. Manaster and Mann (1996) show that the median S&P 500 index futures trader reduces inventory by almost fifty percent in one trade, whereas Hasbrouck and Sofianos (1993) and Madhavan and Smidt (1993) find that it takes an equity specialist a matter of weeks to reduce an inventory imbalance to the same extent.

[18] To investigate the systematic changes in quoted liquidity around large trades on the NYSE, Moulton (1998) develops a quoted liquidity metric to indicate the number of shares that can be traded per unit cost (the inverse of the slope of the equity specialist's demand curve).

The liquidity supply response to large futures trades is analysed to determine whether liquidity providers in futures markets make the same strategic choices to those in equity markets. Specialists and other liquidity providers in equity markets actively manage adverse selection risk by adjusting both bid-ask spreads and depth. Kavajecz (1999) demonstrates that depths are used as a strategic choice variable by NYSE specialists, documenting changes in quoted depth consistent with specialists managing their inventory positions as well as having knowledge of the future price of the stock. Koski and Michaely (2000) document that spreads increase significantly and depths decrease significantly after large trades on the NYSE, though not after small trades. They also show that excess spreads above a pre-trade benchmark after large purchases are relatively greater during dividend announcement periods, when information asymmetry is higher, than during ex-dividend periods.

A subset of studies provides further evidence consistent with an increase in adverse selection risk after large trades. For NYSE-listed equities, Lee, Mucklow and Ready (1993) document that bid-ask spreads widen and depths drop after volume shocks; liquidity suppliers use increased volume to infer the presence of informed traders. Hasbrouck (1991) shows, by estimating vector autoregressive (VAR) models for trades and quote revisions, that large trades induce an increase in the spread and trades which occur in the face of a relatively wide spread have a greater price impact than those which occur when spreads are narrow. The results of these studies are consistent with the Easley and O'Hara (1992a) prediction that volume shocks are associated with higher information risk and lower market liquidity.

In futures markets, any increase in adverse selection risk after large trades is likely to originate from *systematic* factors. Subrahmanyam (1991) and Gorton and Pennacchi (1993) show that adverse selection costs can be expected to be lower in equity index futures markets than in the underlying equity markets because the individual equity-specific component of adverse selection tends to be diversified away in contracts written over a basket of securities.[19] Suppliers of liquidity are less exposed to the risk of private information pertaining to individual equities.[20] Subrahmanyam shows that the

[19] The absence of 'upstairs trading' in an off-market block trade facility for interest rate futures contributes to the low adverse selection component of execution costs in the downstairs market, because liquidity-motivated traders do not have the option to use the services of an upstairs broker to obtain lower trading costs (Bessembinder and Venkataraman, 2003).

[20] The low risk of private information in futures markets does not imply that futures trades are bereft of any information content. Futures markets are shown to be driven by public information in the form of macroeconomic news, as discussed in the next section. Hasbrouck (1991) points out that the requirement

diversification of systematic information further reduces adverse selection in the index futures market relative to the underlying equity markets, even when there are traders who are informed about the systematic component of equity values, if the sensitivities to systematic risk differ in sign across the individual equities. The analysis of the liquidity impact of large trades presented in this dissertation reveals what systematic component of adverse selection risk remains for interest rate and equity index futures when these diversification benefits are realised.

With regard to the speed of recovery of the limit order book, Biais, Hillion and Spatt (1995) analyse the interrelated dynamics of the order flow and order book for equities traded on the Paris Bourse. They find investors place limit orders when bid-ask spreads are wide or the order book is thin, providing liquidity when it is valuable to the marketplace. Following market orders, the market response to restore the prior state of the book is rapid (taking less than ninety seconds), which Biais, Hillion and Spatt attribute to intense competition in supplying liquidity. Limit order traders monitor the order book and wait for favourable order placement opportunities. Similarly, Aitken, Frino and Sayers (1994) do not detect any significant disruption to spreads surrounding block trades in Australian equities. The third study in this dissertation seeks to ascertain how quickly limit order placement opportunities re-emerge as liquidity providers adjust their price expectations and safeguard against the adverse selection problem following large trades in futures markets.

The third study in this dissertation tests the predictions of information models that incorporate quoted depth. Recognising that the size of quotes posted by market makers have received scant research attention relative to the price of quotes, Mann and Ramanlal (1996) model the adverse selection component of the bid-ask spread and the corresponding component of the size of quotes in a competitive dealership market. They argue that the quote size is a more informative indicator of market liquidity, defined as the relative market power of liquidity traders versus informed traders, than the adverse selection component of the spread.[21] Dealers lower their quote sizes as a first response to a decrease in market liquidity, and only when the quote sizes are at a minimum do

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in analyses which relate trading and price movements that public information is not useful in predicting the trade innovation is most likely to be violated when there are market features which impair the quote revision process and thereby constrain the quote revisions from fully reflecting public information.

[21] Mann and Ramanlal (1996) show that the rate at which the size of quotes become increasingly asymmetric reflects the rate at which private information is impounded in prices. Block trades could improve the informational efficiency of futures markets, to the extent that they instantly make the size of quotes asymmetric.

they resort to wider spreads. This dissertation tests two implications of the theoretical model developed by Mann and Ramanlal: (i) the extent to which liquidity providers maintain lower quote sizes as a first response to the disruption to market liquidity caused by a large trade; and (ii) the extent to which the quote sizes are slower to recover than the spreads.

With reference to the liquidity adjustment surrounding large trades, this dissertation examines how the trading costs incurred by limit order traders as suppliers of liquidity are passed through to the consumers of liquidity in futures markets. Market liquidity is modelled by Grossman and Miller (1988) as being determined by the demand and supply of immediacy to trade now rather than wait to trade later. Demsetz (1968: 35-6) describes the bid-ask spread as "the markup that is paid for predictable immediacy of exchange in organized markets". In the context of a competitive futures market, the demand for immediacy is elastic due to the availability of liquidity in substitute securities and the supply of immediacy is also elastic due to the low risk of trading with better informed investors. Two consequences of these demand and supply conditions for the market adjustment to large trades are expected: (i) to the extent that liquidity suppliers anticipate an intra-day increase in the demand for immediacy, unquoted latent depth will be converted to an increase in quoted depth and higher volumes traded per unit of time while spreads remain close to the minimum tick and; (ii) when a large trade creates a temporary disruption to the supply of immediacy, the disruption is expected to be realised primarily in the form of a reduction in quoted depth (lower size quotes) rather than through substantially wider spreads. In particular, the liquidity cost of a large trade will be a pecuniary externality borne by other traders by impairing their continued ability to trade in large quantities over the interim period.

### 2.3.3 Information content of futures trades

The information disseminated through futures trading has two features that distinguish it from other kinds of information affecting market prices. The first feature relates to the source of the information. Futures market price volatility and volume are shown to be driven by public information released in the form of macroeconomic news, for interest rate and foreign exchange futures (Ederington and Lee, 1993) and equity index futures

(Tse, 1999).[22] In making an investment decision based on public information, investors gain an advantage from superior information processing skills rather than from having seen the numbers first.[23] The futures price adjustment is observed in the third study in this dissertation to infer the unexpected informational content of large trades derived through macroeconomic analysis and the interpretation of market-wide events. In particular, the objective is to isolate the portion of information that is delivered to futures markets through large trades, to distinguish it from information that is delivered through other forms of information media.[24]

The second feature of the information contained in futures trades is that its timing is unpredictable relative to scheduled economic announcements. Despite the low inventory costs in futures markets, locals are less able to protect themselves against unwanted inventory derived from unexpectedly large trades than that derived from the unexpected components of macroeconomic data releases. Seeing that macroeconomic news may alter futures prices immediately and significantly, traders will quote a higher ask or lower bid at the release time, to avoid unwanted inventory (as shown by Tse, 1999 in the United Kingdom). In contrast to the regularity of macroeconomic data, there is no equivalent forewarning of large trades in a continuous auction system of trading. The information contained in large trades may reach the market at any time during the trading day, including the periods after the market opening and following the official release of macroeconomic data. The only cue to locals of an impending large trade is through systematic interdependency in the order flow.

The distinct source and uncertain timing of the information revealed in large futures trades necessitates that the efficiency of futures markets in responding to these trades be evaluated, relative to their efficiency in responding to macroeconomic announcements analysed in prior research. Ederington and Lee (1995) find that the major adjustment of United States interest rate and foreign exchange futures prices to a scheduled macroeconomic news release is complete within 40 seconds of the release and zero drift is observed after three minutes. Not all studies are unequivocal about the rapid reaction of futures prices to macroeconomic announcements. Becker, Finnerty and Kopecky

[22] Similarly, Fleming and Remolona (1997) find that the largest price shocks and the greatest surges in trading activity in the United States Treasury securities market stem from the arrival of public information, especially when taking account of the surprise component of a given announcement.
[23] Strictly defined, public information is that which affects prices before anyone can trade on it (French and Roll, 1986: 9). This definition ignores any heterogeneity in information processing ability among market participants.
[24] Large trades can have permanent price effects and appear to contain original information, simply because they transmit information from the underlying cash market to the futures market.

(1996) find that the reaction of Eurodollar and Treasury bond futures prices to unexpected news about the merchandise trade balance appears to be delayed; while in the case of consumer price index and non-farm payroll news shocks, prices tend to under-react initially. They attribute this anomalous price behaviour to some unspecified bias in using Money Market Services (MMS) forecasts to derive the unexpected components of macroeconomic data releases or, alternatively, market inefficiency.

The news effects of Australian scheduled macroeconomic announcements including the consumer price index inflation rate, the gross domestic product growth rate and the retail sales growth rate on Australian 10 year government bond futures traded on the Sydney Futures Exchange (SFE) are investigated by Kim and Sheen (2001). Their results indicate that most of the price adjustment and volatility response are concluded within the first minute of trading after the 11.30 a.m. announcement. In comparison, the third study in this dissertation determines whether the speed of adjustment in response to large trades is as rapid as previous evidence suggests it is in response to new information relevant for bond pricing contained in scheduled economic information releases.

Block trades may provoke subsequent trading activity in much the same way that has been shown for macroeconomic news. Enlightening in this respect, Fleming and Remolona's (1999) exposition on inter-dealer trading in the United States five-year Treasury note market around the release times of major macroeconomic announcements reflects the primary motivation for trading in markets dominated by public information. They discover a two-stage adjustment to such public information. In a brief first stage, the release induces a sharp and nearly instantaneous price change accompanied by dramatically wider bid-ask spreads and a reduction in trading volume. Market makers evidently widen or withdraw their quotes to manage the inventory risk of sharp price changes. In a prolonged second stage, trading volume surges and persists along with high price volatility and moderately wide bid-ask spreads. Fleming and Remolona attribute the extended second phase of the adjustment process to residual disagreement among investors about what the just-released information means for prices.[25]

[25] Alternative explanations for the delayed rise and slow decline in trading volume after announcements include portfolio rebalancing after significant price changes and the unwinding of speculative positions established during the few minutes prior to announcements. Fleming and Remolona (1999) point out that these activities may be expected to lead to a surge in volume, but not persistently high volatility.

For futures markets, this dissertation contends that the market response to large trades will resemble the two-phase response to news releases described by Fleming and Remolona (1999), because both the initial inventory risk and the motivation for frenetic follow-up trades are similarly based on a public information event (albeit an impromptu event). A large on-market trade instantly transmits information from the private domain into the public domain. The information signal in the trade is inclined to excite the market. Traders then seek to re-establish a consensus on the meaning of the large trade for prices, until they consider that it is no longer profitable for them to contribute to the debate. The increased trading activity prompts a rapid recovery in the bid-ask spread, as liquidity suppliers respond to the increased demand for immediacy. This argument predicts that a block trade produces an increase in risk (reflected in higher volatility after the trade) that stimulates an increase in trading activity, as traders rush to express differences of opinion about the price implication of the block.

In relation to the price formation process, the market response may indicate the extent to which block trades have the capacity to change the average reservation price across traders and, separately, to provoke greater disagreement among traders when they revise their reservation prices for the futures contract. Traders exchange a futures contract because they interpret the same piece of information differently, reaching different conclusions about the probabilities of future events. With traders disagreeing on the interpretations of private signals, Hindy (1994) analyses the doubled-sided auction price formation mechanism in a purely speculative futures market in the absence of liquidity traders and a designated market maker. He shows that trading volume and changes in prices are related to two different properties of the information flow pattern; volume is related to the reversals or fluctuations over time of a typical trader's private signal around the average signal, while changes in prices are related to changes in the median of signals. Similarly, Tauchen and Pitts (1983) derive and estimate a model of the 90-day United States Treasury bills futures market, where the market clearing price is the average reservation price across traders and the trading volume is proportional to the average absolute deviation of the reservation price changes about their mean. In this sense, the average trade represents a swing in views.

## 2.4 Summary

The overview of the related literature in this chapter identifies the unanswered research questions addressed by this dissertation. The methodology used to answer these questions and the results of the analysis are reported in the next three chapters.

There is conflicting evidence in the literature regarding the value of cash dividends and imputation tax credits distributed to Australian shareholders. Using the relative prices of futures contracts and the individual stocks on which they are based, Cannavan, Finn and Gray (2004) find that cash dividends are fully valued relative to futures payoffs and franking credits are effectively worthless to the marginal investor after the 1997 tightening of Australian tax laws designed to prevent the transfer of franking credits. Using a conventional dividend drop-off approach, Beggs and Skeels (2006) find that cash dividends are less than fully valued and franking credits provide substantial value to marginal investors after the year 2000 tax change that allowed for a rebate of unused franking credits.

The first study undertaken for this dissertation addresses research questions that are left unresolved in the existing literature:

*Q1: What is the value of cash dividends reflected in the market prices of Australian stock index futures after the 1999 tax change that reduced the capital gains tax rate for individuals and superannuation funds?*

*Q2: What is the value of imputation tax credits reflected in the market prices of Australian stock index futures after the 2000 tax change that allowed for a tax rebate of unused franking credits?*

*Q3: What is the value of the debt tax shield reflected in the market prices of Australian stock index futures after the 1999 tax change that reduced the capital gains tax rate for individuals and superannuation funds?*

The results of several studies in the literature establish that the price linkage between stock index futures and the portfolio of shares in the underlying index is disrupted by the arrival of significant information (Merrick, 1987; Hill, Jain and Wood, 1988; Draper and Fung, 2003). These results imply that spot and futures prices respond to the arrival of new information at different speeds, causing the basis for the index futures contract

to diverge temporarily away from the cost of carrying the index basket of stocks. Greater absolute magnitudes of mispricing for longer times to maturity documented in index futures markets are consistent with arbitrage being more risky further out from maturity (MacKinlay and Ramaswamy, 1988; Yadav and Pope, 1990; 1994). Even before the risks faced by arbitrageurs are taken into account, the existence of transaction costs implies that the price of index futures can fluctuate within a band around its theoretical value without representing a profit opportunity for even the most favourably situated arbitrageurs (Modest and Sundaresan, 1983; Modest, 1984; Gould, 1988; Kawaller, 1987; 1991). Modest and Sundaresan demonstrate that the no-arbitrage band dictated by transaction costs can be asymmetric around the theoretical fair value when the cost of shorting the spot index is large.

The second study undertaken for this dissertation addresses research questions that are left unresolved in the existing literature:

*Q4: What is the incremental impact on the mispricing spread of stock index futures of unexpected trading volume in the cash market relative to unexpected trading volume in the futures market?*

*Q5: Which of the risks faced by index arbitrageurs have the most significant impact on futures contract mispricing further out from maturity?*

*Q6: How much does the efficiency of the information transmission mechanism between the spot and futures markets fluctuate as a result of intraday variations in transaction costs incurred when laying on arbitrage trades?*

*Q7: Are there any maturity effects on the mispricing of the index futures contract related to the cost of borrowing stock to implement sell programs when the futures contract is undervalued?*

There is little empirical evidence in the literature of the price effects of large trades in futures markets. Berkman, Brailsford and Frino (2005) find there is only a small permanent price impact associated with trades in United Kingdom stock index futures. Their results are surprising given that the inherent leverage and lower transaction costs of futures are likely to attract informed traders (Fleming, Ostdiek and Whaley, 1996). Previous research provides empirical evidence of the price effects and speed of adjustment to large block trades in equity markets (Holthausen, Leftwich and Mayers,

1990; Aitken and Frino, 1996; Gemmill, 1996). Holthausen, Leftwich and Mayers find that the speed of price adjustment after seller-initiated trades depends on block size: the larger the block, the slower the adjustment. They argue this will be the case if larger blocks induce traders to offer price concessions on subsequent sales to avoid inventory holding costs. Koski and Michaely (2000) document that spreads increase significantly and depths decrease significantly after large trades on the NYSE, though not after small trades. The results of other studies are consistent with an increase in adverse selection risk after large trades in equity markets (Hasbrouck, 1991; Lee, Mucklow and Ready, 1993). Evidence provided by Moulton (1998) indicates that liquidity drops after large trades on the NYSE and then returns to pre-trade levels within roughly fifteen minutes. He finds that the return of liquidity to normal levels is significantly related to whether limit orders or specialist orders provide counterparty volume in filling the large trade and to security-specific attributes such as trading activity and bid-ask spread widths.

The third study undertaken for this dissertation addresses research questions that are left unresolved in the existing literature:

*Q8: How large is the price adjustment to large trades in interest rate and equity index futures markets?*

*Q9: How quickly do prices adjust to a new equilibrium after large trades in interest rate and equity index futures markets?*

*Q10: How much do bid-ask spreads widen after large trades in interest rate and equity index futures markets?*

*Q11: How long does it take for bid-ask spreads to return to normal after large trades in interest rate and equity index futures markets?*

*Q12: How much does market depth decrease after large trades in interest rate and equity index futures markets?*

*Q13: How long does it take for market depth to return to normal after large trades in interest rate and equity index futures markets?*

## Appendix 2.1

## Price effects of large trades in world equity markets

| Study | Sample data and period | Methodology | Price impact | Speed of adjustment |
|---|---|---|---|---|
| Kraus and Stoll (1972) | Block trades on the NYSE from July 1968 to September 1969 | Measure the effect of a block trade on closing market prices | Permanent price effects for plus tick blocks and temporary and permanent price effects for minus tick blocks | New price level is established rather quickly and there is little drift after day ten following blocks |
| Scholes (1972) | Secondary distributions for NYSE stocks from January 1947 to December 1965 | Isolate the effects of the sales of a large block of securities on the price of the security using the market model | Permanent average two percent loss associated with the sale of a secondary distribution | Total adjustment to the sale of a secondary distribution takes approximately six days |
| Mikkelson and Partch (1985) | Secondary distributions of common stock listed on the NYSE or AMEX from 1972 to 1981 | Estimate daily excess returns around the announcement date of the sale | Significant negative average stock returns at the earliest public announcement of large block sales | No evidence of a price recovery in the first few days following the distribution date |
| Holthausen, Leftwich and Mayers (1987) | Block transactions on the NYSE in 1982 | Employ cross-sectional regressions to examine the determinants of variation in price effects | Price effects are mainly temporary for seller-initiated transactions and permanent for buyer-initiated transactions | |
| Hasbrouck (1988) | Trades and quote revisions for NYSE-listed stocks in March and April 1985 | Model the impact of trades on quote revisions | Contemporaneous and persistent effects of both trade direction and size are almost invariably positive | Pattern of reversal (negative lagged direction and size coefficients) is rarely statistically significant |
| Aggarwal and Chen (1990) | Block trades on the NYSE in 1977 | Examine the adjustment of stock returns to block trading information | Most block trades do not result in either excess returns or volatility | Period of increased volatility is longest for minus ticks and shortest for plus ticks |
| Holthausen, Leftwich and Mayers (1990) | Block transactions of NYSE-listed companies from December 1982 to January 1984 | Examine trade-to-trade excess returns surrounding blocks | Both temporary and permanent price effects are associated with large blocks, with the predominant effect being permanent | Price recovers to a new equilibrium level within three trades after downtick blocks and one trade at most after uptick blocks |

| Study | Sample data and period | Methodology | Price impact | Speed of adjustment |
|---|---|---|---|---|
| Hasbrouck (1991) | Trades and quote revisions from the NYSE and AMEX in the first quarter of 1989 | Estimate general vector autoregressive models for trade and quote variables | As a function of trade innovation size, the ultimate impact of the innovation on the quote is nonlinear, positive and increasing, but concave | Full impact of a trade on the security price is not felt instantaneously but with a protracted lag |
| Madhavan and Smidt (1991) | Transactions of a NYSE specialist firm from February to December 1987 | Develop and test a model of intraday price formation | Large trades have a greater price impact than small trades, but the relationship is not proportional to trade size | |
| Seppi (1992) | Block trades on the NYSE in 1982 | Investigate the extent to which block price changes are explained by unexpected earnings | Prices on large blocks shortly before earnings announcements are positively correlated with earnings forecast errors | |
| Barclay and Warner (1993) | All NYSE firms that were tender-offer targets from 1981 to 1984 | Estimate the proportion of the cumulative stock-price change that occurs in each trade-size category | Most of the preannouncement cumulative stock price change occurs on medium-size trades | |
| Chan and Lakonishok (1993) | Large and small trades by 37 large institutional money managers on the NYSE and AMEX from July 1986 to December 1988 | Track the intraday behaviour of prices around institutional trades | Price continues to rise after purchases whereas it tends to correct itself after sales | |
| Madhavan and Smidt (1993) | All transactions of a NYSE specialist firm in its assigned stocks from February to December 1987 | Develop and test an inter-temporal model of market maker behaviour | Large-block trades appear to convey little information to the specialist | |
| Gemmill (1996) | Block trades on the LSE for the month of May in each of the years 1987 to 1992 | Examine the patterns of individual returns around block trades under different publication rules | Block purchases have significant permanent impacts, but blocks sales have small impacts that only border on significance | Prices fully adjust after three to five trades, except for a slow upward drift following purchases (which is not statistically significant) |

| Study | Sample data and period | Methodology | Price impact | Speed of adjustment |
|---|---|---|---|---|
| Madhavan and Cheng (1997) | Block trades in NYSE stocks from 7 December 1993 to 28 January 1994 | Analyse the price movements surrounding large-block trades in the upstairs and downstairs markets | Relative importance of the permanent component increases with size in both markets | |
| Koski and Michaely (2000) | Trades on the NYSE in 1988 | Examine trades of different sizes during periods which differ with respect to asymmetric information | Price and liquidity effects are strongly related to information asymmetries as measured by the information environment and trade size | Quotes revised within one minute after large block trades during announcement periods |
| Chakravarty (2001) | NYSE stocks that displayed a significant price increase from November 1990 to January 1991 | Analyse the cumulative price change attributable to trades in each size category | Medium-size trades are associated with the largest cumulative stock price change | |

This table summarises the findings of studies about the price effects and speed of price adjustment to large trades on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX) and London Stock Exchange (LSE).

## Appendix 2.2

## Price effects of large trades in Australian equity markets

| Study | Sample data and period | Methodology | Price impact | Speed of adjustment |
|---|---|---|---|---|
| Ball and Finn (1989) | Blocks traded on the floor of the SSE from July 1974 to June 1977 | Estimate the relation between block trades and excess returns on a daily basis | Block trades are associated with permanent price changes | No systematic reversal for either plus or minus ticks in the 30-day post-block trading period |
| Aitken, Frino and Sayers (1994) | Block trades on the ASX from July 1991 to June 1992 | Estimate trade-to-trade excess returns surrounding blocks | Continued price increases following block purchases and continued price decreases following block sales | Significant returns only in the transaction interval in which the block took place |
| Aitken and Frino (1996) | Block trades on the ASX from July 1991 to June 1993 | Estimate abnormal returns surrounding blocks | Price continuation following block purchases and price reversal following block sales | Abnormal returns significant for up to three trades following block purchases and the first trade following the block sales |

This table summarises the findings of studies about the price effects and speed of price adjustment to large trades on the Australian Stock Exchange (ASX) and the former Sydney Stock Exchange (SSE).