Title: **One Session Options: Playing the announcement lottery?**

Abstract: One session options (OSO) are unique financial instruments that perfectly fit the criteria for a lottery-type asset; a low-price (average premium of 1 b.p.) coupled with a relatively small probability of a large payoff. Using intra-day data for over 12.8 million intra-day option contracts on the 3-Year Treasury Bond, we examine trading behaviour in the OSO market over the period 2002-2019. We find that trading volume is higher on days with a major macroeconomic announcement, and concentrated earlier in the trading session, prior to the data release. Trading volume tends to be higher when there is a difference of opinion surrounding the announcement outcome or when the level of economic policy uncertainty is higher. Trading in OSO has some predictive value for the surprise component of the macroeconomic announcement, but this does not translate into economic profits. While there is a positive option payoff on average, the average net profit is negative once premiums are accounted for. Our results are robust to different measures of uncertainty, market activity, and model form. It seems likely that OSO trading behaviour is best explained by 'differences of opinion'.

Keywords: Lottery-like assets; One Session Options; Trading Volume; Trading Behaviour

JEL Classification: G10, G12, G14

1. Introduction

Lottery-like assets offer a small likelihood of a large reward, and a large probability of a small loss, in exchange for a low cost (Kumar, 2009). By overweighting the tails of the return distribution, and the prospect of extreme positive returns in particular, investors over-value these assets leading to mispricing and low future returns (Barberis and Huang, 2008; Eraker and Ready, 2015). The payoff structure for an option contract, with its inherent leverage, mirrors that of a lottery, and there is evidence that investors overpay, particularly for short-dated and out-of-the-money options (Boyer and Vorknik, 2014; Byun and Kim, 2016; Felix et al., 2019). We focus on a novel type of option that accentuates these characteristics – One Session Options (OSOs).

OSOs are European-style options, offered on the Australian Securities Exchange (ASX), that are valid only in the session in which they are traded. We focus on the most actively traded OSOs; the intra-day options written on 3-Year Australian Treasury bond futures[1]. These options are typically priced at just 1 basis point. OSOs can be used to protect against, or speculate on, event risk and used as an alternative to stop-loss orders. The prospective lottery-like returns available via OSOs is exemplified by a trade occurring on 24th January 2007. On this date 1,870 OTM calls were bought prior to the announcement of CPI data. Weaker than expected inflation led to the underlying futures contract declining by 15 basis points. The OSOs generated a one-session profit of approximately AUD478,720 after paying a premium of AUD59,840 – a multiple of 8x.

We are interested in gaining a greater understanding for the trading, pricing, and potential payoffs of these unique, lottery-like securities. We ask whether market activity differs from other assets, including standard options. In particular, we concentrate on establishing the extent to which these characteristics are determined by macroeconomic announcements, which are known to significantly impact bonds (e.g. Ederington and Lee, 1993, 1995; Fleming and Remolona, 1999; Balduzzi et al., 2001), and Australian financial markets (Frino and Hill, 2001; Smales, 2013). This is worthy of investigation because the predisposition to buy OSOs should be more prominent in the period around announcements when there is greater investor attention and the potential for immediate payoffs (Liu et al., 2020). To-date, the only other paper to consider OSOs is provided by Zou et al. (2006). While they briefly examine volume and volatility patterns, their emphasis is on the bid-ask spread. They do not consider the pricing or profitability of these instruments. In addition, they focus on options traded during the overnight session (European / US trading hours), rather than the intra-day session (Australian / Asian trading hours), and thus are unable to measure the impact of domestic (Australian) economic news.

[1] 3-Year Australian Treasury bond futures are among the most liquid bond futures contracts in the world. In 2019, average daily volume was 257,106 contracts, equating to AUD 25.7bn.

Since Markowitz (1952) speculated that investors may be willing to "take large chances of a small loss for a small change of a large gain" much of the literature regarding lottery-like assets has focused on the stock market. The preference for securities with positively-skewed returns appears to be more pronounced among retail investors (Barberis and Huang, 2008; Barberis et al., 2016) and small under-diversified institutions (Kumar, 2005). However, this predilection is time-varying and tends to increase ahead of earnings announcements (Liu et al., 2020), and during economic downturns (Kumar, 2009) when the priced macroeconomic uncertainty factor peaks (Aramonte, 2014). Even institutional investors are more likely to buy lottery-like assets when sentiment is low (Alldredge, 2020). The "unusually dramatic lottery-like features" of options (Boyer and Vorknik, 2014; Byun and Kim, 2016) offer an ideal setting in which to understand demand for, and pricing of, lottery-like assets. Indeed, Boyer and Vorknik (2014) suggest the demand for lottery-like assets is a primary reason why out-of-the-money options are typically over-valued.

We also contribute to the growing literature on option trading patterns, and the potential information content arising from those patterns. Although trading volume on the market open may be lower (Stephan and Whaley, 1990; Berkman, 1993), standard options (non-OSOs) often exhibit an intra-day volume pattern that is similar to the U-shaped pattern found in most securities, even when the pattern of bid-ask spreads differs (Aggarwal and Gruca, 1993; Chan et al., 1995). Donders et al. (2000) show that there is an increase in implied volatility (option premiums) and trading volume in the period around earnings announcements. Zou et al. (2006) find that trading volume in overnight OSO's follows a "traditional reverse J-shape" whereby trading volume decreases during the first half of the night before increasing towards the end of the trading session.

One possibility is that the additional volume is a result of informed trading (Easley et al., 1998) which Black (1975) argues is due to option leverage allowing traders to more appreciably exploit their private information. There is empirical evidence to suggest that option trading volume contains information about stock prices (Pan and Poteshman, 2006), particularly in advance of earnings announcements (Amin and Lee, 1997), and takeover announcements (Cao et al., 2005; Augustin et al., 2019). Informed traders appear more likely to trade options ahead of negative news and the underlying asset ahead of positive news (Mazouz et al., 2015). However, Bauer et al. (2009) note that most retail investors incur substantial losses when trading options since they are primarily motivated to trade them for gambling and entertainment purposes.

Another possibility is that trading volume is driven by differences of opinion (Cao and Ou-Yang, 2009; Choy and Wei, 2012; Buraschi and Jiltsov, 2006). Several models provide theoretical explanations linking greater trading volume to differential interpretation of public information. For instance, Kim and Verrechia (1994) conjecture that announcements create information symmetry that can be exploited by traders with an information processing advantage. The models of Harris and Raviv

(1993) and Kandel and Pearson (1995) both assume that traders receive the same information but interpret it differently. As a result, disagreements arise and stimulate trading activity. Cao and Ou-Yang (2009) develop this notion further in the context of the option market. Their model is based on the idea that traders can disagree about the mean or precision of a public signal. Traders with lower precision (higher conditional volatility) about potential asset values will buy options, while those with higher precision (lower conditional volatility) will write options. They make two predictions that are largely borne out in our empirical study. First, they suggest that option trading volume should be bunched prior to, and during, important news events. Second, trading volume in both options and the underlying asset should be higher when there is greater disagreement about possible outcomes.

Our empirical results provide greater support for the 'differences of opinion' explanation, and the model of Cao and Ou-Yang (2009) in particular. First, we find that trading volume is higher on days when important macroeconomic news is released. Second, using dispersion of analyst forecasts as a proxy for differences of opinion, we show that trading volume is positively related to disagreement. Third, while there is some evidence that OSO trading offers some predictability for macroeconomic surprises, this does not translate into profitable trades. This suggests that trades are not informed on average. The contrast with the informativeness of option trading around corporate announcements makes intuitive sense given the lower possibility of information leakage ahead of macroeconomic news.

We also find that OSO's are more expensive (measured by moneyness) on days with major macroeconomic news, and when differences of opinion are larger. This is consistent with Buraschi et al. (2014) who note that more diverse opinions lead to a higher risk premium. The higher cost helps to explain why, on average, OSO purchases generate a positive payoff that becomes a negative profit once premiums are considered. The negative net returns to OSO buyers potentially reflects a willingness to overpay for lottery-like securities (Felix et al., 2019), and a reward to OSO writers for accepting undiversifiable event risk (Boyer and Vorkink, 2014). This finding aligns with Ilmanen's (2012) observation that "selling insurance and selling lottery tickets has delivered positive long-run rewards in a wide range of investment contexts".

We proceed as follows. Section 2 provides an overview of the data together with a description of the institutional setting for OSOs. Section 3 provides our empirical analysis and accompanying discussion. Section 4 provides concluding remarks.

2. Data

2.1 Macroeconomic Announcements

We focus on five major macroeconomic announcements. We commence our set of announcements with the monthly target cash rate decision by the Reserve Bank of Australia (RBA). The prior literature has shown that monetary policy announcements significantly impact fixed-income markets (e.g. Cook and Hahn, 1988; Kuttner, 2001; Demiralp and Jorda, 2004; Gürkaynak et al., 2005) including those in Australia (Gasbarro and Monroe, 2004; Smales, 2012). Greater central bank transparency, has meant that the minutes explaining those policy decisions also have an effect on markets (e.g. Reeves and Sawicki, 2007; Blinder et al., 2008; Rosa, 2013). Prior to December 2007, the RBA did not release minutes for its meetings. Instead, the market relied on the quarterly monetary policy statement for guidance with an accompanying meaningful response (Smales, 2012). We therefore add the release of this communication (*RBAMINS*) to our set of important announcements.

In setting monetary policy, the RBA is tasked with "the stability of the currency, full employment, and the economic prosperity and welfare of the Australian people[2]". Our final three macroeconomic announcements relate to these policy goals – the quarterly release of the consumer price index (*CPI*) and gross domestic product (*GDP*) in addition to the monthly release of the unemployment rate (*UER*). All three announcements have been identified as having a significant influence on Australian asset prices (Frino and Hill, 2001; Smales 2013).

The major macroeconomic announcements typically occur at 11:30AM (AEST) with the exception of the RBA policy decision[3]. In our empirical analysis, we are interested in the effect of differences of opinion on OSO market activity. We use the standard deviation (*SD*) of analyst forecasts for the respective announcement to proxy for disagreement. In addition, we consider whether OSO trading is useful in predicting the surprise component of the announcement (and so predict market response). We calculate the surprise component using the methodology of Balduzzi et al. (2001), where the surprise for announcement type *k* on day *t* is defined as:

$$S_{kt} = \frac{A_{kt} - E_{kt}}{\sigma_k} \qquad (1)$$

Where A_{kt} is the actual value, E_{kt} is the (Bloomberg) market survey expectation, and σ_k is the standard deviation of the news component ($A_{kt} - E_{kt}$). Thus, an announcement surprise equal to 1.0 implies a surprise that is one standard deviation greater than zero for that announcement type.

Table 1 reports provides information on the announcements included in our study, where the sample period runs from May 2002 to December 2019. Data is obtained from Bloomberg. 665 of the 4,474 days in our sample (14.9%) have at least one major macroeconomic announcement. Differences of opinion about the announcement outcome (*Analyst SD*) is greatest for *GDP* and slightest for *RBA*. The negative *surprises* suggest that analysts tend to overestimate Australian macroeconomic performance and seem better at predicting RBA decisions. Both the low level of disagreement and an improved forecasting performance around RBA decisions may be partly due to the lengthy period of monetary policy stability from 2016 – mid 2019.

[2] This role is established in an Act of Parliament; the Reserve Bank Act 1959.

[3] The RBA target rate decision is now announced at 02:30PM (AEST) and occurred at 09:30AM prior to 2008.

<Insert Table 1>

To enable some of our later discussion to be placed in context, we provide summary statistics for the daily change in yield for 3-Year Treasury bond futures (Reuters: YTT). The mean change is close to zero and "fat tails" are present (kurtosis). The standard deviation of yield changes is greater on days with macroeconomic announcements, and greatest when CPI is released. Yield changes tend to be negatively (positively) skewed on days with (without) macroeconomic announcements.

<Insert Table 2>

2.2 One Session Options

One Session Options (OSOs) are European style options that are valid only in the session in which they are listed. The Australian Securities Exchange (ASX) facilitates trading in OSOs for the Overnight and Intra-day sessions, and for both 3-Year and 10-Year Treasury bond futures. Trading volume for OSOs written on 10-Year futures has been very low since 2008 (a total of 20,835 contracts). For OSOs written on 3-Year futures, the trading volume of Intra-day Options (IDOs) has exceeded that of Overnight Options (ONOs) in every year since 2014. Figure 1 shows that the trading volume of both IDOs and ONOs has exceeded that of traditional quarterly exchange-traded options in almost every year since 2002[4].

<Insert Figure 1>

We focus on the Intra-day options written on 3-Year Treasury bond futures – the most actively traded OSOs in the latter half of our sample period. These options begin trading at the start of the day (8.30am), and cease trading prior to the close of the day session (4.10pm). The expiry settlement is calculated as the weighted average of trade prices in the underlying contract in a 10-minute period at the end of the session. Following this, OSOs are automatically exercised (if in-the-money) or abandoned (if at- or out-of-the-money). Exercise prices are set at intervals of 0.01 per cent per annum, with the option premium quoted in yield per cent per annum in multiples of 0.005 per cent. Over 99% of transactions in our sample occur at a premium of just 0.01.

Since so many transactions occur at a price of 0.01, the principal pricing tool is in effect the difference between the underlying spot and the strike price (i.e. the moneyness). When market participants are in less agreement about future price movements, or facing event risk, then that difference should increase (e.g. Boyer and Vorkink, 2014; Buraschi et al., 2014). This is illustrated by an average difference of 0.037 on announcement days, and 0.015 on non-announcement days

[4] Since 2014, the average annual volume is 672,425 IDOs, 588,650 ONOs, and 244,308 quarterly options. Source: https://www2.asx.com.au/content/dam/asx/markets/trade-our-derivatives-market/derivatives-market-overview/2019-annual-volumes.xls.xls

(significantly different with a *t*-value of 26.6). In essence, on announcement days, the underlying 3-Year future needs to change by a greater amount for the IDO to expire in-the-money. This provides some additional protection against event risk for the option seller, and also potentially signifies that the OSO buyer is over-paying.

Our sample period starts in May 2002 (shortly after IDOs were first listed) and ends in December 2019. Data is obtained from Refinitiv DataScope. During this sample of 4,474 trading days, a total of 12,850,666 IDOs[5] were traded across 51,272 transactions. Table 3 provides summary statistics for IDO trading. Trading volume (Panel A) for both calls and puts is significantly higher on days with a macroeconomic announcement, and is highest on the day that *CPI* is released. Indeed, we find that 32.9% of all trades occur on the 14.9% of days on which macro announcements occur. Panel B shows that the higher trading volume results from the transaction of both more and larger trades.

<Insert Table 3>

We also note that the vast majority (98%) of IDO trades on days with announcements occur prior to the data release; a clear indication that IDO trading is directly related to the announcement. Indeed, figure 2 illustrates that the bulk of trading transpires in the opening 90-mins of the session, well before the announcement. This is consistent with Zou et al. (2006) who demonstrate that trading of ONOs is concentrated in advance of the release of US economic news. However, Zou et al. (2006) also report that market activity increases again at the end of the trading session, this appears absent during the day session in our sample.

<Insert Figure 2>

3. Empirical Analysis

3.1 Determinants of IDO Trading Volume

In the first stage of our empirical analysis, we are interested in the determinants of IDO trading volume. To investigate this we employ a regression model of the form:

$$\log(IDO\_Volume_t) = \beta_c + \sum_i \beta_i ANN_{i,t} + \sum_j \beta_j ANN\_SD_{j,t} + \sum_k \beta_k CONTROL_{k,t} + \varepsilon_t \qquad (2)$$

Where the dependent variable is the log of the volume of IDO options[6] traded during interval *t*. *ANN* is a set of dummy variables indicating the occurrence of five macroeconomic announcements including the RBA target rate decision (*RBA*), RBA meeting minutes (*RBAMINS*), gross domestic product (*GDP*), consumer price index (*CPI*), and the unemployment rate (*UER*). The dummy variables

[5] This consists of 7,012,838 calls and 5,837,828 puts.
[6] We add 1 to the volume on each day to allow for days in which no IDOs are traded.

are assigned a value of 1 if the announcement occurs on day *t* and 0 otherwise. *ANN_SD* is a measure of disagreement regarding four of the economic releases – the standard deviation of analyst forecasts. We exclude *RBAMINS* as analysts do not provide a numerical forecast for this announcement.

CONTROL is a set of variables that we include to account for the prevailing state of the macro economy and the underlying Treasury futures market[7]. For the macro economy we include a measure of financial market uncertainty (*VIX*[8]) and Australian economic policy uncertainty (*EPU*) in addition to the prevalent levels of economic growth (*GDP_act*), inflation (*CPI_act*), and unemployment (*UER_act*)[9]. For the futures market we include the implied 3-Year Treasury yield (*YTT_YLD*) at the market open on day *t*, together with the logged level of open interest (*YTT_OI*), trading volume (*YTT_VO*), and absolute value of yield change (*YTT_PC*) on the prior day, *t-1*. We estimate the model with Newey-West standard errors (ε_t) to account for autocorrelation and heteroscedasticity.

Estimated coefficients for our model are reported in Table 4. The first three columns consider the whole trading day and the remaining columns considers only the pre-announcement period (for days without an announcement this is the whole day). We also disaggregate the trading volume into *calls* and *puts*. Confirming the result indicated in our summary statistics, trading volume is significantly higher on days which have a macroeconomic announcement. When there is more disagreement among analyst forecasts then the volume of call trading increases for all announcement types, but this is only statistically significant for *RBA* and *UER*. For three of the announcement types, put volume is negatively related to analyst dispersion but this relationship is not well-defined. For the fourth announcement type, *RBA*, the relationship is positive and significant. This means that higher levels of analyst disagreement have a significant impact on trading of both calls *and* puts, highlighting the importance of RBA decision-making to fixed-income markets. As a guide to the explanatory power for our set of announcement-related variables, the control variables alone account for less than 1% of variation in the dependent variable (i.e. Adjusted $R^2 < 0.01$). This set of results is consistent with the literature (e.g. Choy and Wei, 2012; Liu et al., 2020) and can be explained by the theoretical model of Cao and Ou-Yang (2009), and relate to the models of Harris and Raviv (1993) and Kandel and Pearson (1995).

<Insert Table 4>

[7] Data for macroeconomic control variables is obtained from Bloomberg except for Australian EPU which is obtained from www.policyuncertainty.com. Futures market data is obtained from DataStream.

[8] We include CBOE VIX, a US-centric measure, rather than the S&P/ASX 200 VIX (*AVIX*) as the latter is only available from 2008 onwards. VIX is widely used in the literature as a proxy for global financial market uncertainty. Re-running analysis for the shorter *AVIX* sample period produces qualitatively similar estimates, including for the *VIX* coefficient.

[9] Whereas the observations for *ANN* and *ANN_SD* are assigned 0 on days without a macroeconomic announcement, the macroeconomic control variables are assigned the most recent data release. This means, for instance, that *GDP_act* would be constant for a whole quarter.

The estimated coefficients for the control variables show that two types of uncertainty have contradictory signs, with financial market uncertainty (*VIX*) having a negative association with trading volume while economic policy uncertainty (*EPU*) has a positive association. One possible rationale for this could be that options are relatively more expensive (less likely to be exercised) when *VIX* is high than when *EPU* is high. For instance, when *VIX* is in the top quintile the difference between strike price and spot price at initiation is 0.032 (i.e. 3.2 basis points), and the difference is 0.024 when *EPU* is in the top quintile. Trading volume declines past a certain price point. The other economic state variables do not have any significant impact on trading volume. There is little explanatory power from the futures market variables and the only statistically significant variable is the prior day trading volume (*YTT_VO*). The positive sign possibly points to the use of IDOs as stop-losses, so that there is greater demand for IDOs when more of the underlying futures are traded.

We test the robustness of these results in several ways. First, rather than standard deviation, we utilise the range of analyst estimates as a measure of dispersion for announcement disagreement. Second, instead of total trading volume we use the number of trades as a measure of market activity. Third, we replace the ordinary least squares model with a Poisson distribution. Count distributions of this form are useful for modelling this type of problem, i.e. the number of IDOs traded within a day. The results, reported in Appendix A, are consistent with those in Table 4.

In subsequent analysis, for the sake of brevity, we only report results for the main variables of interest and not for the control variables.

If option cost provides an explanation for patterns in IDO trading activity, then we should expect a connection between cost and analyst disagreement. Table 5 shows that the cost of IDOs, measured by moneyness, is indeed higher when there is a divergence of opinion. This finding is consistent with Choy and Wei (2012).

<Insert Table 5>

This idea may be explored further by considering how trading volume changes during periods of the business cycle when differences of opinion are greater, such as during recession. The expected response of option trading to recession is not completely clear. For instance, Kumar (2009) suggests that investors are more likely to search for lottery-like assets when volatility is high (which tends to be during economic downturns) and Cao and Ou-Yang (2009) suggest option trading should concentrate around periods of heightened disagreement (which also tends to be during downturns). This suggests that *mor*e IDOs should be traded during recessionary periods. However, *less* IDO trading would be the likely outcome if the demand for lottery-like asset characteristics was stronger during periods of high investor sentiment (Byun and Kim, 2016) and this could be at least partially explained by the higher volatility risk premium (Buraschi et al., 2014).

Since Australia did not suffer a recession during our sample period, we proxy for a global recessionary environment using the US recession indicator defined by the National Bureau of Economic Research (*NBER_REC*). Measured by moneyness, IDOs are more expensive during recessionary periods both on announcement days (0.058 vs. 0.037 with *t*-statistic of -6.21) and non-announcement days (0.021 vs. 0.015 with *t*-statistic of -8.33). If our earlier supposition is correct, then we would expect trading volume to be lower when there are economic announcements during recessionary periods. This is consistent with the estimated coefficients reported in Table 6. Clearly, there is a point at which the option premium (or 'lottery ticket') is viewed as too expensive and so trading volume declines. This outweighs the greater propensity to gamble during recession noted by Kumar (2009). The remaining coefficients are comparable to those discussed earlier.

<Insert Table 6>

Having identified that analyst disagreement helps to explain a proportion of trading volume on announcement days, we investigate whether there are specific circumstances that indicate how IDOs are used by market participants. We replace the analyst disagreement variables in our prior model (Eq. 2) with a set of dummy variables indicating whether the standard deviation is in the bottom quintile or not, indicating whether the analyst's forecasts are in *close* agreement. Table 7 reports the estimated coefficients. All announcement variables remain positive and significant. However, when *GDP* forecasts are largely in agreement there is an increase in IDO volume. In contrast, low dispersion of analyst forecasts for *RBA* decisions reduces IDO trading. The incongruity may occur because the RBA typically provides extensive policy guidance, so when analysts agree about the prospective outcome there is less likely to be a policy surprise, and it is less worthwhile purchasing a 'lottery ticket'. However, there is no such guidance for other macroeconomic announcements leading to a greater potential surprise and making IDO purchase more worthwhile. This is similar to the effect documented by Byun et al. (2020) when investors refrain from buying lottery-like stocks if they believe there will be no further positive surprises.

<Insert Table 7>

3.2 Informativeness and Profitability of IDO Trading

So far, we have demonstrated that macroeconomic announcements lead to an increase in IDO trading volume. Now, we proceed to test whether this trading behaviour can be used in some way to profitably predict the outcome of the economic data release. If IDO trading is informative then we would expect trading to predict the surprise component of the related announcement. That is, if the surprise component is negative, indicating the economy is weaker than forecast (i.e. CPI, GDP, or RBA rates are lower than expected and UER is higher), then a lower (greater) number of puts (calls) would be purchased prior to the announcement (yields will go lower, pushing futures prices higher[10]).

We perform a series of regressions where the dependent variable is the surprise component on day t, computed using Eq. (1). The explanatory variables of interest are the ratio of put volume to call volume (*P/C ratio*), or the abnormal call and put volume (adjusted for average volume on days with the specific economic release)[11], occurring prior to the data release. We also include the economic state and futures market control variables described for Eq. (2).

<Insert Table 8>

In Table 8, we find that the signs of the abnormal volume coefficients are in the right direction to predict economic surprises but they are not statistically significant. However, the put/call ratio does seem to provide some explanatory power for the economic release; when put purchases increase relative to call purchases (*P/C ratio* increases) the predicted surprise component is more negative.

The next question is whether the identified IDO trading behaviour translates into profitability. Since IDOs cannot be exercised early and are automatically exercised (or abandoned) at the end of each session we can calculate the payoff and profit for *every* trade occurring in our sample. From the perspective of the IDO buyer, this is calculated in the typical way for each transaction at the end of the trading session:

$$Call\ Payoff = N \cdot max(S - X, 0) \quad Put\ Payoff = N \cdot max\ (X - S, 0) \qquad (3)$$

Where N is the number of IDO contracts traded, X is the strike price, and S is the settlement price[12] for the underlying futures contract. Profit is then calculated as the payoff minus the option premium paid. We convert this into a dollar amount by multiplying by AUD32[13] and tabulate averages by transaction in Table 9.

<Insert Table 9>

The table highlights the potential lottery-like payoffs from IDO trading. 155 individual transactions generated profits greater than AUD100,000, with the most profitable single transaction

[10] The significance of macroeconomic surprises for 3-Year Treasury bond futures is documented in Smales (2012) and Appendix B illustrates this for our updated sample period.

[11] We also repeat the analysis using nominal volume and find that the results are qualitatively similar.

[12] We use the settlement price for RIC: 2YTT since this applies to the day session.

[13] One implication arising from the quotation style of 3-Year Treasury bond futures (100 minus the yield to maturity) is that the tick value is not constant – it increases (decreases) as interest rates fall (rise) – but 1 basis point is worth a minimum of AUD32.

occurring on 24-Jan-2007. In this instance, 1,870 calls were bought ahead of a weaker than forecast CPI announcement. In contrast, 80% of IDOs finish the session at-the-money or out-of-the money are so are abandoned.

It is possible that some traders are more skilled, and so trade more profitably by targeting specific announcements (lotteries). However, we find a clear pattern across trading days. On average, IDO purchases generate a positive payoff but, once premiums are considered, this produces a negative profit[14]. This holds for announcement and non-announcement days, and across all announcement types. The highest payoffs for calls are generated on days when *CPI* is released, and for puts it is when *GDP* is released. This is consistent with the relatively large (small) surprise factors for *CPI* (*GDP*) shown in Table 1.

Therefore, on average, any perceived explanatory power regarding economic surprises does not induce trading profitability for IDO buyers. Instead, the payoff/profitability pattern demonstrated here suggests that option writers are proficient at pricing event risk for economic announcements, or that IDO buyer over-pay for lottery-like assets.

4. Concluding Remarks

One session options are unique financial instruments that offer a lottery-like payoff. Their distinctive characteristics suggest that their trading patterns may not follow the typical intra-day U-shape found in other assets. To some extent this is true in that we find that trading volume is heavily concentrated in the first hour of the trading session, prior to the release of macroeconomic announcements. However, in a similar vein to other assets, we also find that trading is concentrated on days when there is likely to be more disagreement among market participants – that is, days with macroeconomic announcements. We also find that OSO's are more expensive, and generate negative profits for buyers, on these days. Although OSO's are distinctive instruments, our empirical results relating to determinants of market activity can be largely explained by the 'differences of opinion' model used to explain trading in other assets.

Gaining a better understanding of trading activity, pricing, and profitability is important for at least two types of market participants. First, there are implications for exchange operators considering the introduction of new derivative products. Second, there are investors that are considering the utilisation of lottery-like assets to hedge against, or speculate on, event risk stemming from macroeconomic announcements.

<Insert Appendix A>

<Insert Appendix B>

[14] Similar to the "losses disguised as wins" phenomenon found within gambling (e.g. Griffiths, 1990; Barton et al., 2017).

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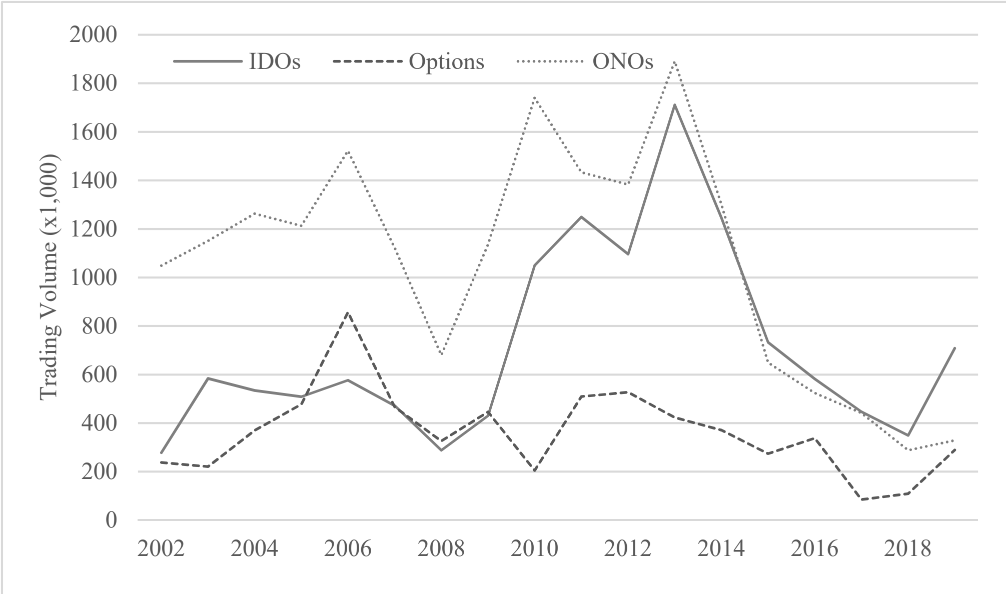

Fig.1. Annual Option Volume

Note: This figure depicts annual option trading volume for single session intra-day

Source: Australian Securities Exchange (ASX)

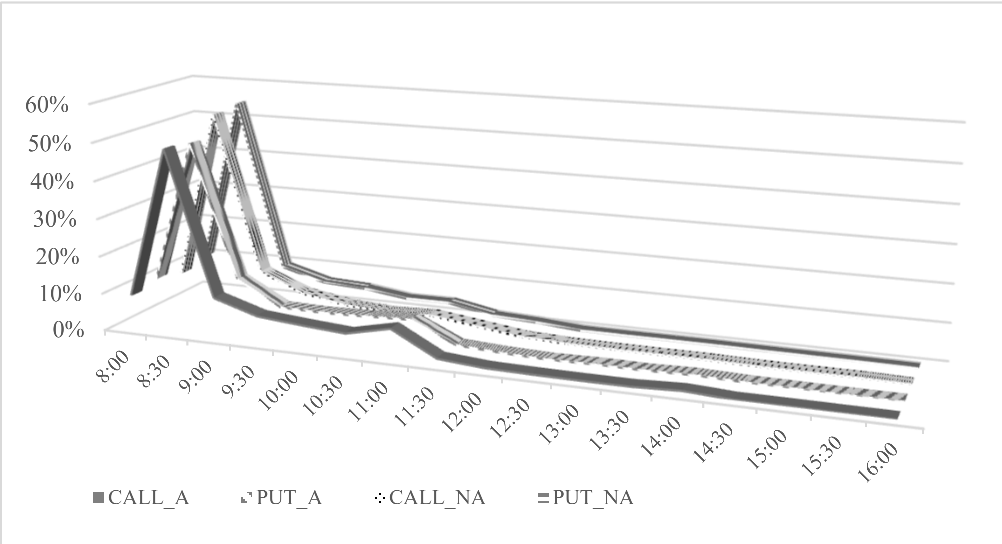

Fig.2. Proportion of Daily IDO Trading Volume in 30-min Intervals

Note: This figure depicts the proportion of daily trading volume of calls and puts occurring in each 30-min interval. Days are classified as having a major macroeconomic announcement (A) or not (NA).

Table 1
Major Macroeconomic Announcements

Announcement	Mnemonic	Frequency	Release Time	Analyst SD	Surprise	N
Consumer Price Index (QoQ)	CPI	Quarterly	11:30	0.134	-0.136	70
Real GDP (QoQ)	GDP	Quarterly	11:30	0.176	-0.043	71
RBA Monetary Policy Announcement	RBA	Monthly	14:30*	0.035	-0.034	195
RBA Minutes	^RBAMINS	Monthly	11:30	N/A	N/A	156
Unemployment Rate	UER	Monthly	11:30	0.072	-0.313	212

Note: This table includes summary data for the Australian major macroeconomic annoucements utilised in this study. The Reserve Bank of Australia (RBA) monetary policy announcement and associated meeting minutes are provided by the RBA. All other announcements are issued by the Australian Bureau of Statistics (ABS). ^Since December 2007, RBA minutes have been released two weeks after the associated RBA monetary policy meeting. Prior to this the quarterly RBA monetary policy statement is utilised to indicate RBA policy direction. *Prior to 2008 the RBA policy announcement occurred at 09:30. A measure of disagreement is provided by *Analyst SD* - the standard deviation of analyst forecasts for the macroeconomic announcement at time t. *Surprise* is the difference between the actual data release and the expected (median forecast) data release at time t, standardised by the standard deviation of this difference. Sample period: 01 May 2002 - 31 Dec 2019

Table 2
Daily Yield Changes in 3-Year Treasury Note Future (*ΔYTT*)

	Mean	**Std. Dev.**	**Min.**	**Max.**	**Skewness**	**Kurtosis**
A	0.002	0.059	-0.210	0.195	-0.116	3.98
NA	-0.001	0.036	-0.250	0.305	0.131	7.81
CPI	-0.005	0.070	-0.150	0.140	0.008	2.74
GDP	0.003	0.054	-0.170	0.140	-0.052	3.85
RBA	-0.004	0.063	-0.210	0.180	-0.335	4.14
RBAMINS	-0.004	0.045	-0.165	0.195	0.296	5.92
UER	0.011	0.057	-0.150	0.180	0.028	3.46

Note: This table provides summary statistics for daily changes in the implied yield of 3-Year Treasury Note futures (*ΔYTT*). The sample is disaggregated into days with major macroeconomic announcements (A) or not (NA), as well as by specific macroeconomic announcement type.
Sample period: 01 May 2002 - 31 Dec 2019.

Table 3
Summary Statistics for IDO Trading

Panel A: Trading Volume	Whole Day			Pre-Announcement Only			% Pre-Announcement
	Calls	**Puts**	**Total**	**Calls**	**Puts**	**Total**	
A	3299.3	3063.5	6362.8	3222.4	3014.8	6237.2	98.0%
NA	1265.1	997.8	2262.9				
t-value	22.8***	27.2***	29.7***				
CPI	5077.6	4983.4	10061.1	5045.9	4959.1	10005.1	99.4%
GDP	3447.9	2745.1	6193.0	3295.8	2663.4	5959.3	96.2%
RBA	3018.3	2914.4	5932.7	2902.0	2846.9	5749.0	96.9%
RBAMINS	1881.8	1612.4	3494.2	1583.9	1363.1	2947.0	84.3%
UER	3798.8	3476.2	7275.0	3742.0	3448.2	7190.2	98.8%

Panel B: No. Trades & Trade Size	No. Trades			Ave. Trade Size		
	Calls	**Puts**	**Total**	**Calls**	**Puts**	**Total**
A	12.8	11.7	24.6	234.7	235.4	252.0
NA	5.0	4.2	9.2	173.7	151.2	206.1
t-value	25.6***	28.7***	32.1***	9.2***	11.7***	7.8***
CPI	18.6	17.6	36.2	255.0	272.7	268.4
GDP	13.5	10.9	24.4	225.0	216.7	228.8
RBA	11.8	11.3	23.0	219.9	233.1	239.9
RBAMINS	6.7	6.0	12.7	239.7	217.2	267.8
UER	16.1	14.1	30.2	226.4	229.7	238.1

Note: This table provides summary statistics for daily trading in Intra-Day Options (IDOs) on 3-Year Treasury Note futures. Panel A relates to average trading volume. The first three columns disaggregate average trading volume for the whole trading day into days in which major macroeconomic announcement occur (A) or not (NA), in addition to disaggregation by specific announcement type. The next three columns note the volume occuring prior to the specific macroeconomic announcement (i.e. pre-announcement). The final column show the proportion of daily trading volume occurring prior to the macroeconomic announcement. Panel B indicates average number of trades and average trade size for days with and without macroeconomic announcements. *** indicates statistical significance at the 0.01% level.
Sample period: 01 May 2002 - 31 Dec 2019.

Table 4
Regression: Determinants of IDO Trading Volume

	Whole Day						Pre-Announcement					
	Call Volume		Put Volume		Total Volume		Call Volume		Put Volume		Total Volume	
C	8.312	***	8.774	***	10.363	***	0.126		-0.010		-0.028	
	(0.628)		(0.630)		(0.603)		(0.140)		(0.124)		(0.132)	
CPI	4.090	***	3.805	***	3.033	***	8.721	***	8.428	***	9.146	***
	(0.742)		(0.576)		(0.504)		(0.769)		(0.455)		(0.450)	
GDP	1.414		3.011	***	1.991	***	4.990	***	6.315	***	6.632	***
	(0.970)		(0.612)		(0.500)		(1.271)		(1.035)		(1.169)	
RBA	1.561	***	2.160	***	1.673	***	5.534	***	5.900	***	6.950	***
	(0.276)		(0.243)		(0.201)		(0.301)		(0.277)		(0.250)	
RBAMINS	1.194	***	1.290	***	1.212	***	5.004	***	4.802	***	6.075	***
	(0.247)		(0.234)		(0.190)		(0.282)		(0.275)		(0.270)	
UER	1.759	***	3.413	***	2.229	***	6.722	***	7.756	***	8.347	***
	(0.470)		(0.565)		(0.431)		(0.437)		(0.423)		(0.311)	
CPI_SD	4.477		-0.724		0.134		4.576		-1.786		1.442	
	(6.148)		(4.256)		(3.827)		(6.294)		(3.537)		(3.537)	
GDP_SD	3.265		-2.980		-0.382		4.296		-1.649		0.836	
	(5.127)		(3.321)		(2.705)		(6.842)		(5.615)		(6.427)	
RBA_SD	7.542	*	6.439		2.663		11.885	**	10.787	**	10.782	**
	(4.389)		(4.165)		(3.893)		(4.953)		(4.605)		(4.596)	
UER_SD	11.497	**	-6.563		0.062		9.701	**	-4.816		0.162	
	(5.100)		(7.129)		(5.131)		(4.731)		(5.132)		(3.236)	
VIX	-0.093	***	-0.087	***	-0.099	***	-0.013	***	-0.009	***	-0.007	**
	(0.013)		(0.011)		(0.013)		(0.003)		(0.003)		(0.003)	
EPU	0.008	***	0.008	***	0.008	***	0.001	**	0.001	***	0.001	***
	(0.002)		(0.002)		(0.001)		(0.000)		(0.000)		(0.000)	
CPI_Act	0.951		6.957		3.595		0.032		3.015		1.568	
	(20.793)		(19.383)		(18.450)		(4.396)		(3.919)		(3.617)	
GDP_Act	17.940		30.770	*	22.940		-2.769		0.832		-0.002	
	(19.474)		(18.380)		(18.150)		(3.933)		(3.783)		(3.679)	
UER_Act	11.431		9.767		12.740		3.165		-0.511		-1.303	
	(14.736)		(14.798)		(13.810)		(3.776)		(3.677)		(3.630)	
YTT_OPEN	-0.020		-0.056		-0.025		-0.004		-0.012		-0.013	
	(0.061)		(0.058)		(0.058)		(0.014)		(0.013)		(0.013)	
YTT_OI_{t-1}	-0.010	*	-0.008	*	-0.002		-0.003		-0.006		-0.006	
	(0.005)		(0.004)		(0.004)		(0.013)		(0.012)		(0.012)	
YTT_VOLUME_{t-1}	0.006	***	0.005	***	0.005	***	0.006	**	0.003	***	0.005	***
	(0.002)		(0.001)		(0.002)		(0.003)		(0.001)		(0.002)	
$\lvert YTT\_DELTA_{t-1}\rvert$	0.845		1.791	*	0.175		0.317		0.071		0.016	
	(1.131)		(1.072)		(0.963)		(0.499)		(0.400)		(0.414)	
Adjusted R^2	0.119		0.142		0.143		0.828		0.854		0.896	
F-statistic	38.88		47.30		47.69		1344.15		1630.50		2404.65	
No. Obs.	4472		4472		4472		4472		4472		4472	

Note: This table reports the estimated coefficients for a regression where the dependent variable is the daily trading volume in Intra-day options (IDOs) for 3-Year Treasury bond futures. IDO trading activity is also disaggregated into *calls* and *puts*. The key explanatory variables are event indicator variables and measures of analyst forecast disagreement (standard deviation) for several macroeconomic announcements. The announcements include inflation (*CPI*), growth (*GDP*), monetary policy decisions (*RBA*), their associated minutes (*RBAMINS*), and unemployment (*UER*). Control variables account for the prevailing economic state (*VIX*, *EPU*, current levels of economic growth, inflation, and unemployment) and conditions in the underlying Treasury futures market (implied yield at opening, prior day change in implied yield open interest, and trading volume). In the first three columns daily (*whole day*) trading volume is considered. In the latter three columns only trading that occurs *prior* to the announcement is included. Newey-West standard errors are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels respectively.
Sample period: 01 May 2002 - 31 Dec 2019

Table 5
Regression: Announcement Effect on Moneyness

C	0.015	***
	(0.001)	
CPI	0.019	*
	(0.011)	
GDP	-0.004	
	(0.008)	
RBA	0.011	***
	(0.002)	
RBAMINSMPS	0.008	***
	(0.002)	
UER	0.003	
	(0.007)	
CPI_SD	0.129	*
	(0.077)	
GDP_SD	0.075	*
	(0.045)	
RBA_SD	0.396	***
	(0.057)	
UER_SD	0.286	***
	(0.106)	
Controls	YES	
Adjusted R^2	0.199	
F-Statistic	124.36	
No. Obs.	4474	

Note: This table reports the estimated coefficients for a regression where the dependent variable is the absolute difference between the strike price and underlying spot price (moneyness) at inception for Intra-day options (IDOs) on 3-Year Treasury bond futures. The key explanatory variables are event indicator variables and measures of analyst forecast disagreement (standard deviation) for several macroeconomic announcements. The announcements include inflation (*CPI*), growth (*GDP*), monetary policy decisions (*RBA*), their associated minutes (*RBAMINS*), and unemployment (*UER*). Control variables accounting for the prevailing economic state and conditions in the underlying Treasury futures market are not reported. Newey-West standard errors are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels respectively.
Sample period: 01 May 2002 - 31 Dec 2019

Table 6

Regression: Determinants of IDO Trading Volume During Recession

	Call Volume		Put Volume		Total Volume	
C	-0.003		-0.115		-0.127	
	(0.157)		(0.145)		(0.137)	
CPI	8.687	***	8.394	***	9.109	***
	(0.521)		(0.482)		(0.453)	
GDP	5.398	***	6.338	***	6.741	***
	(0.423)		(0.391)		(0.368)	
RBA	5.631	***	5.966	***	7.033	***
	(0.100)		(0.093)		(0.087)	
RBAMINS	5.056	***	4.799	***	6.060	***
	(0.095)		(0.088)		(0.082)	
UER	6.732	***	7.771	***	8.358	***
	(0.265)		(0.245)		(0.231)	
NBER_REC	0.132	*	0.067		0.057	
	(0.080)		(0.074)		(0.070)	
CPI*NBER_REC	-2.150	***	-1.189	***	-1.400	***
	(0.472)		(0.437)		(0.411)	
GDP*NBER_REC	-2.425	***	0.284		-0.238	***
	(0.471)		(0.436)		(0.410)	
RBA*NBER_REC	-1.821	***	-1.247	***	-1.608	***
	(0.296)		(0.274)		(0.258)	
RBAMINS*NBER_REC	-0.525	*	0.018		0.145	
	(0.294)		(0.272)		(0.256)	
UER*NBER_REC	-1.425	***	-1.934	***	-1.175	***
	(0.277)		(0.256)		(0.241)	
CPI_SD	2.958		-0.768		0.272	
	(3.770)		(3.489)		(3.284)	
GDP_SD	3.155		-1.934		0.311	
	(2.269)		(2.098)		(1.975)	
RBA_SD	13.308	***	11.856	***	8.175	***
	(1.653)		(1.529)		(1.439)	
UER_SD	11.173	***	-2.756		1.381	
	(3.552)		(3.280)		(3.091)	
Controls	YES		YES		YES	
Adjusted R^2	0.832		0.856		0.897	
F-statistic	1006.57		1210.16		1778.99	
No. Obs.	4472		4472		4472	

Note: This table reports the estimated coefficients for a regression where the dependent variable is the daily trading volume in Intra-day options (IDOs) for 3-Year Treasury bond futures. IDO trading activity is also disaggregated into *calls* and *puts*. The key explanatory variables are event indicator variables and measures of analyst forecast disagreement (standard deviation) for several macroeconomic announcements. The announcements include inflation (*CPI*), growth (*GDP*), monetary policy decisions (*RBA*), their associated minutes (*RBAMINS*), and unemployment (*UER*). *NBER_REC* is a dummy variable indicating whether there is a NBER-defined US recession (1) or not (0). Control variables, not reported, account for the prevailing economic state (*VIX*, *EPU*, current levels of economic growth, inflation, and unemployment) and conditions in the underlying Treasury futures market (implied yield at opening, prior day change in implied yield open interest, and trading volume). Newey-West standard errors are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels respectively.

Sample period: 01 May 2002 - 31 Dec 2019

Table 7

Regression: Impact of Analyst Agreement on IDO Trading Volume

	Call Volume		Put Volume		Total Volume	
C	0.139		-0.004		-0.017	
	(0.143)		(0.132)		(0.124)	
CPI	8.118	***	8.200	***	8.969	***
	(0.154)		(0.142)		(0.133)	
GDP	5.538	***	5.717	***	6.535	***
	(0.157)		(0.144)		(0.136)	
RBA	6.707	***	6.919	***	7.604	***
	(0.125)		(0.115)		(0.108)	
RBAMINSMPS	5.006	***	4.802	***	6.077	***
	(0.091)		(0.084)		(0.079)	
UER	7.458	***	7.362	***	8.307	***
	(0.085)		(0.078)		(0.073)	
CPI_LO	0.048		-0.040		0.006	
	(0.301)		(0.277)		(0.261)	
GDP_LO	0.653	**	1.003	***	0.812	***
	(0.291)		(0.268)		(0.252)	
RBA_LO	-1.262	***	-1.062	***	-0.688	***
	(0.161)		(0.148)		(0.139)	
UER_LO	0.290		0.303		0.323	*
	(0.209)		(0.193)		(0.181)	
Controls	YES		YES		YES	
Adjusted R^2	0.828		0.854		0.896	
F-statistic	1346.25		1630.50		2404.65	
No. Obs.	4472		4472		4472	

Note: This table reports the estimated coefficients for a regression where the dependent variable is the daily trading volume in Intra-day options (IDOs) for 3-Year Treasury bond futures. IDO trading activity is also disaggregated into *calls* and *puts*. The key explanatory variables are event indicator variables and measures of analyst forecast disagreement for several macroeconomic announcements. The announcements include inflation (*CPI*), growth (*GDP*), monetary policy decisions (*RBA*), their associated minutes (*RBAMINS*), and unemployment (*UER*). In this case, the measure of forecast disagreement is a dummy variable indicating whether there is *analyst agreement* (the standard deviation of forecasts is in the bottom quintile) or not. Control variables, not reported, account for the prevailing economic state (*VIX*, *EPU*, current levels of economic growth, inflation, and unemployment) and conditions in the underlying Treasury futures market (implied yield at opening, prior day change in implied yield open interest, and trading volume). Newey-West standard errors are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels respectively.

Sample period: 01 May 2002 - 31 Dec 2019

Table 8

Regression: Predicting Macroeconomic Surprise

	CPI	**CPI**	**GDP**	**GDP**	**RBA**	**RBA**	**UER**	**UER**
C	-0.096	-0.914	-0.037	-2.030	-0.877	1.038	-0.331 ***	0.194
	(0.120)	(0.928)	(0.117)	(0.430)	7.358	(0.700)	(0.068)	(0.274)
P/C Ratio	-0.011 ***		-0.010 ***		-0.019 *		0.018 ***	
	(0.001)		(0.003)		(0.011)		(0.004)	
Abnormal Put Volume		0.215		0.089		0.009		0.000
		(0.221)		(0.111)		(0.119)		(0.085)
Abnormal Call Volume		-0.176		-0.099		-0.033		-0.001
		(0.200)		(0.097)		(0.082)		(0.098)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted R^2	0.023	0.007	0.002	0.002	0.020	0.029	0.011	-0.018
F-statistic	2.62	0.59	2.12	1.02	4.92	1.63	3.40	0.56
No. Obs.	70	70	71	71	195	195	212	212

Note: This table reports the estimated coefficients for an OLS regression where the dependent variable is the *surprise* component for one of several macroeconomic announcements. The surprise component is the difference between actual and forecast economic data, standardised by the standard deviation of surprises over the sample period. The announcements include inflation (*CPI*), growth (*GDP*), monetary policy decisions (*RBA*), and unemployment (*UER*). The key explanatory variable is either the ratio of put to call purchases (*P/C Ratio*) or *abnormal trading volume* (Volume adjusted for average trading on days with that announcement type). Control variables, not reported, include open interest and trading volume in the 3-Year Treasury bond futures contract, VIX, EPU, and economic state variables. Newey-West standard errors are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels respectively.

Sample period: 01 May 2002 - 31 Dec 2019

Table 9
Profitability of IDO Trading

	CALLS		PUTS		ALL			
	Payoff	**Profit**	**Payoff**	**Profit**	**Payoff**	**Profit**	**Max. Payoff**	**Max. Profit**
TOTAL	2543.4	-2837.5	1837.3	-3177.3	2865.4	-3399.6	181154	171000
A	4473.5	-2437.2	3581.6	-3367.1	4322.4	-3109.2	181154	171000
NA	2207.6	-2907.1	1533.8	-3144.3	2612.0	-3450.1	127500	108750
CPI	7365.3	-78.1	4155.1	-3798.7	6211.5	-1618.1	58855	48312
GDP	4595.1	-2061.9	4964.7	-1949.6	5262.1	-2108.4	45643	32250
RBA	3377.1	-3111.0	2278.4	-4627.8	3156.0	-3945.1	57520	45842
RBAMINS	6888.2	-163.3	2801.7	-3625.6	5392.0	-2516.9	181154	171000
UER	2504.5	-4160.2	4123.5	-2631.9	3176.7	-3829.4	36214	31143

Note: This table shows the average daily payoff and profitability from buying IDOs on 3-Yr Treasury Note futures.Trading profit for IDO purchases is disaggregated into days on which a major macroeconomic announcement occurs (A) or does not occur (NA). *Payoff* is computed as N x max(S-X,0) x V for call options, and as N x max(X-S,0) x V for put options. Where N is the number of contracts traded, X is the strike price, S is the spot rate of the futures contract at the end of the session (expiry), and V is the tick-value of a contract. The tick-value varies according to the implied yield to maturity on the underlying futures contract but is generally close to AUD32. *Profit* is equal to the payoff minus the option premium (P). The final two columns show the maximum daily payoff and profit.
Sample period: 01 May 2002 - 31 Dec 2019

Appendix A

Robustness Tests: Determinants of IDO Trading Volume

Panel A: Using RANGE for analyst dispersion	Call Volume		Put Volume		Total Volume	
C	-0.359		-0.829		-1.237	*
	(0.747)		(0.692)		(0.715)	
CPI	8.116	***	8.400	***	8.980	***
	(0.299)		(0.356)		(0.262)	
GDP	5.283	***	6.622	***	6.978	***
	(1.369)		(1.114)		(1.301)	
RBA	5.896	***	6.204	***	7.130	***
	(0.231)		(0.211)		(0.195)	
RBAMINSMPS	5.009	***	4.811	***	6.076	***
	(0.282)		(0.275)		(0.270)	
UER	6.688	***	7.507	***	8.176	***
	(0.447)		(0.415)		(0.351)	
CPI_RANGE	-1.796		-37.655		-4.438	
	(54.042)		(69.390)		(49.107)	
GDP_RANGE	63.335		-84.041		-27.653	
	(184.620)		(151.055)		(178.872)	
RBA_RANGE	7.138	***	9.990	***	7.280	***
	(1.805)		(1.473)		(1.446)	
UER_RANGE	261.51	**	-37.82		65.34	
	(129.42)		(123.16)		(97.67)	
Controls	YES		YES		YES	
Adjusted R^2	0.826		0.853		0.896	
F-statistic	1331.92		1626.30		2406.25	
No. Obs.	4472		4472		4472	

Panel B: Using TRADES for market activity	Call Trades		Put Trades		Total Trades	
C	0.165		0.123		0.021	
	(0.262)		(0.232)		(0.265)	
CPI	3.027	***	3.079	***	3.768	***
	(0.403)		(0.285)		(0.290)	
GDP	1.515	***	2.028	***	2.338	***
	(0.485)		(0.383)		(0.489)	
RBA	1.685	***	1.747	***	2.361	***
	(0.105)		(0.098)		(0.106)	
RBAMINSMPS	1.345	***	1.256	***	1.856	***
	(0.087)		(0.084)		(0.097)	
UER	2.078	***	2.546	***	2.990	***
	(0.198)		(0.173)		(0.165)	
CPI_SD	-1.763		-2.330		-2.072	
	(3.081)		(2.263)		(2.328)	
GDP_SD	2.036		-1.019		0.646	
	(2.722)		(2.120)		(2.768)	
RBA_SD	4.937	***	5.407	***	5.200	***
	(1.821)		(1.689)		(1.941)	
UER_SD	5.740	**	-1.740		2.273	
	(2.266)		(2.144)		(1.844)	
Controls	YES		YES		YES	
Adjusted R^2	0.795		0.816		0.868	
F-statistic	1084.89		1236.74		1838.28	
No. Obs.	4472		4472		4472	

Panel C: Using a POISSON model

	Call Volume		Put Volume		Total Volume	
C	-5.680	***	-6.694	***	-5.726	***
	(2.067)		(2.327)		(2.029)	
CPI	5.028	***	5.161	***	5.082	***
	(0.393)		(0.374)		(0.323)	
GDP	0.516		2.586	**	1.251	
	(1.068)		(1.129)		(1.296)	
RBA	3.608	***	3.779	***	3.677	***
	(0.285)		(0.242)		(0.247)	
RBAMINSMPS	3.604	***	3.587	***	3.582	***
	(0.178)		(0.191)		(0.170)	
UER	4.217	***	4.527	***	4.335	***
	(0.257)		(0.288)		(0.246)	
CPI_SD	-1.657		-1.698		-1.678	
	(2.860)		(2.592)		(2.251)	
GDP_SD	8.774		-2.546		4.985	
	(5.406)		(6.344)		(7.073)	
RBA_SD	6.475	***	6.895	***	6.681	***
	(2.430)		(1.810)		(1.971)	
UER_SD	3.670		-0.288		2.091	
	(2.568)		(3.057)		(2.411)	
Controls	YES		YES		YES	
Adjusted R^2	0.317		0.402		0.405	
No. Obs.	4472		4472		4472	

Note: This table reports the estimated coefficients for a regression where the dependent variable is the daily trading activity in Intra-day options (IDOs) for 3-Year Treasury bond futures. IDO trading activity is also disaggregated into *calls* and *puts*. The key explanatory variables are event indicator variables and measures of analyst forecast dispersion for several macroeconomic announcements. The announcements include inflation (*CPI*), growth (*GDP*), monetary policy decisions (*RBA*), their associated minutes (*RBAMINS*), and unemployment (*UER*). Control variables, not reported, account for the prevailing economic state (*VIX*, *EPU*, current levels of economic growth, inflation, and unemployment) and conditions in the underlying Treasury futures market (implied yield at opening, prior day change in implied yield open interest, and trading volume). In Panel A the range of analyst forecasts is used instead of the standard deviation measure used elsewhere. In Panel B the dependent variable is the logged number of trades rather than the logged trading volume measure used elsewhere. In Panel C a Poisson model specification is used in place of the OLS specification used elsewhere. Newey-West standard errors are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Sample period: 01 May 2002 - 31 Dec 2019

Appendix B

Regress: Macroeconomic News and Yield Changes

	ΔYTT	
C	-0.001	*
	(0.001)	
CPI_SURPRISE	0.044	***
	(0.005)	
GDP_SURPRISE	0.035	***
	(0.005)	
RBA_SURPRISE	0.030	***
	(0.003)	
UER_SURPRISE	-0.029	***
	(0.003)	
Controls	YES	
Adjusted R^2	0.080	
F-statistic	98.03	
No. Obs.	4474	

Note: This table reports the estimated coefficients for an OLS regression where the dependent variable is the daily change in yield for 3-Year Treasury futures (*ΔYTT*). The key explanatory variables are the *surprise* component for several macroeconomic announcements. The surprise component is the difference between actual and forecast economic data, standardised by the standard deviation of surprises over the sample period. The announcements include inflation (*CPI*), growth (*GDP*), monetary policy decisions (*RBA*), and unemployment (*UER*). Control variables, not reported, include open interest and trading volume in the 3-Year Treasury bond futures contract, VIX, EPU, and economic state variables. Newey-West standard errors are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels respectively.

Sample period: 01 May 2002 - 31 Dec 2019