Investor Taxes and Option Prices

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Abstract

In this paper, we examine how option prices reflect capital gains taxes, if at all. To our knowledge, existing empirical option pricing literature largely ignores the potential impact of taxes on option prices. To assess the effect of taxes on option prices, we exploit a unique setting where "index" options on the S&P 500 Index (SPX) and nearly identical "non-index" options on the exchange traded fund (ETF) tracking the S&P 500 Index (SPY) are subject to different tax regimes. We find evidence suggesting that investor taxes affect the demand for options and therefore the price (i.e., higher taxes reduce prices, representing the "capitalization theory" of taxes). We find consistent results when analyzing options in the period around the American Taxpayer Relief Act (ATRA) of 2012 and the unique year-end mark-to-market provisions of index (i.e., SPX) options. When we expand our analysis to options on the Russell 2000 Index and the Dow Jones Industrial Average, we also find evidence of the capitalization of taxes. Altogether, our findings provide new evidence of an additional factor - investor taxes - influencing option prices while also suggesting that taxes warrant consideration in broader options research.

I. INTRODUCTION

This study examines how option prices reflect capital gains taxes, if at all. Early theoretical work deriving option pricing formulas provides evidence that investor taxes can affect the price and quantity of options traded and suggests that empirical work account for these potential tax effects (Scholes, 1975). However, to our knowledge, recent options literature largely ignores the potential impact of taxes. Ignoring taxes is innocuous to the extent that all options and their underlying securities are subject to the same tax regimes (Scholes 1975, p. 323). In this paper, we explore an important case where certain options are subject to a tax regime that differs from the tax regime for other nearly identical options on the same underlying securities. We focus on how these tax differences affect option pricing. To our knowledge, despite the theoretical prediction that taxes affect option pricing (e.g., Scholes 1975), tax effects have not yet been documented empirically. As discussed below, there are several reasons to expect no tax effect on option pricing. However, finding empirical evidence that taxes affect option prices has implications for broader options research overall, further highlighting Scholes's (1975, p. 332) conclusion that tax effects should be incorporated into empirical options studies.

Options, like other traded securities, are likely affected by both the "lock-in" and "capitalization" theories of taxation. The lock-in theory of taxation suggests that capital gains taxes are transaction costs that affect an owner's willingness to sell assets (Constantinides and Scholes, 1980; Feldstein et al., 1980; Landsman and Shackelford, 1995; Klein, 2001; Ayers et al., 2002, 2003, 2007; Ivkovich et al., 2005). To induce owners to sell an asset, buyers must compensate owners for the expected tax to be paid upon a sale by paying a higher purchase price. Because the lock-in theory affects the decision of existing owners to sell assets, it is viewed as a supply-side effect. The lock-in effect suggests that as capital gains taxes increase, the supply of securities in the market (options, in our setting) decreases because the tax cost to sell is higher,

leading to an increase in securities' (e.g., options') prices. That is, the lock-in effect suggests that when tax rates are higher (lower), sellers demand more (less) compensation for tax costs, leading to higher (lower) asset prices.

Alternatively, the capitalization theory of taxation reflects a demand-side effect where asset purchasers consider future capital gains taxes when determining the price they are willing to pay to acquire an asset. This affects the demand for an asset and therefore the price (Brennan, 1970; Guenther and Willenborg, 1999; Lang and Shackelford, 2000; Ayers et al., 2002; Guenther and Sansing, 2006; Dai et al., 2008; Sialm, 2009; Edwards and Todtenhaupt 2018; Holcomb et al., 2018). The capitalization effect suggests that as capital gains taxes increase, asset purchasers' future tax costs also increase, making assets subject to capital gains taxes less attractive. Therefore, in the options setting, higher anticipated capital gains taxes likely decrease the demand for options, leading to lower option prices. That is, tax capitalization suggests that when tax rates are higher (lower), buyers impound higher (lower) tax liabilities into the price they are willing to pay for assets, leading to lower (higher) asset prices.

While these theories are in opposition to one another, they likely function simultaneously (Ayers et al., 2008; Dai et al., 2008). Because both effects are operative, we seek to identify if capitalization or lock-in affects option prices. However, if neither effect dominates then there will be no average effect of investor taxes on option prices. Further, because options trading is often performed by dealers, hedge funds, and other institutional traders that may not face or consider taxes in their trading decisions, it remains unclear whether investor taxes influence option prices. For example, Scholes (1975, p. 320) suggests that dealers price options as if they face no taxes. Therefore, we empirically examine whether investor taxes influence option prices.

To assess the effect of capital gains taxes on option prices, we exploit a unique setting

where options on nearly identical assets are subject to different tax regimes. Specifically, we analyze "index" options on the S&P 500 Index (SPX) and "non-index" options on the exchange traded fund (ETF) tracking the S&P 500 Index (SPY). In general, capital assets are subject to preferential long-term capital gains tax rates if they are held for more than one year at the time of the sale. Because options generally represent short-term contracts, under the general rule, most options are subject to tax at the short-term (i.e., ordinary) tax rates. While SPY non-index options are subject to these general tax rules, SPX index options face a different set of tax rules, despite being tied to the same underlying securities.[1] Specifically, SPX options are considered "Section 1256 contracts." Section 1256 contracts receive favorable tax treatment: 60% of any gain on the sale of a Section 1256 contract is subject to preferential long-term capital gains tax rates while the remaining 40% is subject to short-term capital gains (i.e., ordinary) tax rates, regardless of the actual holding period of the contract.[2] Comparing options on the SPX (index options) and SPY (non-index options) provides an ideal setting to examine how taxes affect option pricing because we hold the underlying security (and associated risks and macroeconomic effects) relatively constant, allowing us to clearly identify differences in prices due to differences in capital gains taxes.

To test the difference in prices between index and non-index options, we first analyze option implied volatility obtained from OptionMetrics' Ivy DB database. Examining implied volatility is the standard method for examining option prices in the option pricing literature (e.g., Bollen and Whaley, 2004). Option prices monotonically increase in volatility (Black and

[1] There are subtle differences between SPX options and SPY options including the time of day the options are closed, the style of option (American versus European), the treatment of dividends, and the way positions are closed. We take careful steps to mitigate these differences and discuss them in more detail in Section IV.
[2] For clarity, we refer to SPX options as "index options" or "1256 options" throughout the paper. We refer to SPY options as "non-index options" because the actual underlying is the S&P 500 ETF rather than the S&P 500 Index itself.

Scholes, 1973). We compare the implied volatility on index and non-index options and observe, on average, a significantly higher implied volatility for index options as compared to non-index options. In other words, investors are willing to pay more for index options due to their lower tax costs. Based on the Ivy DB Standardized Option Prices database, this is equivalent to a 24 cent (0.9%) difference in prices of at-the-money index options with a 30-day maturity as compared to similar non-index options. This suggests option prices reflect the capitalization theory of taxation, a demand-side tax effect.

We next use a difference-in-difference analysis, following a capital gains tax rate increase, to identify the effect that a *change* in investor taxes has on option prices. More specifically, we analyze the change in implied volatility for index and non-index options following the passage of the American Taxpayer Relief Act of 2012 (ATRA), which increased the capital gains tax rate from 15% to 20% for taxpayers in the highest marginal tax bracket.[3] We find index options experienced a significant decline in implied volatility compared to non-index options following the capital gains tax rate increase. This is consistent with our earlier evidence supporting tax capitalization: when capital gains taxes increase, option prices decrease.

As with other studies using tax legislative events to identify tax effects, it is important to address the possibility that other confounding effects bias the results. To address this possibility and to better link our results to the change in investor taxes, we employ two separate falsification tests using pseudo-events before and after ATRA. As expected, we find no change in implied volatility for index options as compared to non-index options around these events. This supports

[3] We also analyze changes in implied volatility on *index* options surrounding the passage of the Taxpayer Relief Act of 1997 (TRA) and the Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA). TRA and JGTRRA both reduced capital gains tax rates. Because ETFs were not particularly common during the time TRA and JGTRRA were passed, we are restricted to examining only SPX (index) options in our TRA or JGTRRA tests (untabulated), limiting the conclusions we are able to draw. However, we find evidence consistent with the capitalization effect in that implied volatility on index options increases following the decrease in capital gains tax rates.

our main finding that investor taxes play a significant role in determining options prices.

Our results collectively show that index options, which receive favorable tax treatment, are in greater demand and thus more valuable than non-index options. However, it is possible that our findings are unique to the S&P 500 Index setting. To address this concern, we analyze options on two additional indices, the Russell 2000 Index and the Dow Jones Industrial Average (Dow), which also receive favorable tax treatment under Section 1256. Like the S&P 500 Index, both of these indices have corresponding ETFs which have active non-index options markets. Consistent with our baseline finding (i.e., tax capitalization), we observe index options on the Russell 2000 and Dow, which face lower investor taxes, have significantly higher implied volatilities compared to their corresponding non-index options. As a further test, we estimate our difference-in-difference analysis using these two additional settings. We find some evidence that an increase in the capital gains tax rate associated with ATRA led to a significant decrease in the implied volatility of index options as compared to non-index options. Altogether, these additional analyses provide support for tax capitalization in options prices and suggest that our findings generalize broadly across Section 1256 contracts.

Another unique aspect of Section 1256 contracts (i.e., index options) is the mark-to-market (MTM) requirement. That is, for tax purposes, 1256 contracts are treated as if they are sold at the end of the tax year and taxed at that time. This accelerates the recognition of gain (or loss) on these investments, in contrast to the deferral of capital gains (or losses) typically granted to investment assets. The MTM requirement for Section 1256 contracts allows us to further identify whether, and to what extent, index option prices reflect tax consequences. If the MTM is beneficial to buyers, then we expect to find a higher implied volatility for MTM index options as compared to other options. In contrast, if the MTM is viewed unfavorably at year-end, then we

expect that option implied volatility on MTM index options will be lower than that of other options. We find that index options that require MTM have lower implied volatility as compared to non-MTM index options and non-index options. These findings suggest an inherent tax cost associated with options requiring MTM under Section 1256.[4] This is consistent with anecdotal evidence suggesting that many traders try to close open positions on Section 1256 contracts before the end of the year to avoid MTM requirements (e.g., Green, 2016).

We contribute to literature in economics, finance, and accounting in multiple ways. First, we add to the literature on the effects of capital gains taxes on asset prices (see Hanlon and Heitzman (2010) and Shackelford and Shevlin (2001) for reviews). Specifically, we identify a capitalization effect of investor taxes in option prices. To our knowledge, we provide the first empirical evidence of the effect of taxes in option prices. Finding a tax effect in options prices also suggests that a non-trivial number of options investors are taxable (Blouin et al., 2017), in contrast to prior suggestions viewing institutions as largely non-taxable investors.[5]

Second, our paper expands our understanding of the determinants of option prices, adding to the mixed evidence in the literature on option mispricing (Broadie et al., 2009; Santa-Clara and Saretto, 2009; Chambers et al., 2014; Bai et al., 2017; Faias and Santa-Clara, 2017). While option mispricing has been attributed to a number of factors including default probabilities (Bai et al., 2017) and transaction costs (Santa-Clara and Saretto, 2009; Faias and Santa-Clara, 2017), we add another potential explanation for option mispricing: investor taxes. Our evidence suggests that ignoring capital gains taxes may lead to incorrect conclusions in the options

[4] We cannot specifically tie the effect of MTM to accelerated taxation of gains; the cost may relate to administrative burdens of MTM. However, the costs are driven by the tax laws requiring MTM, so we consider it a tax effect.
[5] We take no strong position on the "average" versus "marginal" investor perspective on taxes and asset prices. The average (marginal) investor perspective suggests that asset prices reflect the taxation of the average (next marginal price-setting) investor in the market. Hanlon and Heitzman (2010) argue that the marginal investor approach often faces limitations, except in the case where two securities with perfectly correlated returns differ only in tax treatment. Our setting is close to this situation, however, we cannot rule out the average investor perspective.

mispricing literature. Specifically, studies that compare options on the S&P 500 Index ETF (SPY), or an index replicated using portfolios of options on individual stocks, to a benchmark such as the S&P 500 Index (SPX) option (e.g. Broadie et al., 2009; Bai et al., 2017; Constantinides et al., 2017; Faias and Santa-Clara, 2017) ignore the distinct capital gains tax treatment of Section 1256 contracts, which may partially drive any observed differences.

In addition, our paper adds additional insight to the discussion of recent tax proposals supporting a full or partial MTM tax system (Weisbach, 1999; Hammer, 2013; Toder and Viard, 2016). Because of difficulties in implementing MTM regimes, few exist, and we are not aware of empirical evidence on their effects. Our evidence suggests the MTM of assets is costly to investors. However, our results apply to only a limited number of assets subject to MTM (i.e. index options) and may not apply to a broader MTM regime.

Our study also has implications for the widely used CBOE volatility index (VIX). The VIX is based on implied volatility of the Section 1256 index options analyzed in our study (i.e., S&P 500 Index (SPX) options), which are taxed differently than most other securities. To the extent that the government shares less of the risk in index options due to lower tax rates than other options (Sikes and Verrecchia, 2012) and tax rates affect the pricing of index options, the level of and changes in the VIX should be interpreted considering these tax effects. Our study suggests that future researchers and commentators carefully consider tax implications when evaluating the VIX.

Finally, our paper is particularly important and timely given the Tax Cuts and Jobs Act of 2017 (TCJA). TCJA imposed new restrictions on capital gains of certain institutions (e.g., hedge funds) that were viewed as unfairly benefiting from long-term capital gains tax rates on "carried interest." Although the TCJA extended the holding period required to obtain long-term capital

gains rates from one year to three years for these institutions, these institutions can still obtain favorable capital gains tax treatment on index options (Browning, 2018). Thus, understanding the effects of taxes on index options is increasingly important as the demand for index options potentially increases to allow certain institutions to circumvent TCJA's restrictions.

II. INSTITUTIONAL SETTING AND HYPOTHESIS DEVELOPMENT

2.1 Section 1256 Contracts

Internal Revenue Code (IRC) Section 1256 governs option contracts on "any nonequity option," which specifically includes options on "broad-based" stock indices. One example of a broad-based stock index is the S&P 500 Index. Under Section 1256, options on broad-based indices like the S&P 500 Index receive favorable tax treatment where 60% of any gain from the sale of the option is treated as a long-term capital gain taxed at preferential tax rates (IRC §1256(a)(3)). The remaining 40% of the gain is taxed at the investors' ordinary tax rate.[6]

Another unique aspect of Section 1256 contracts (i.e., index options) is the mark-to-market (MTM) requirement where, for tax purposes, the assets are treated as if they are sold at the end of the tax year and subject to tax at that time (IRC §1256(a)(1)). This MTM creates a taxable event for investors with open index option positions at the end of the year. This contrasts with the general treatment of capital assets, where taxation is deferred until the asset is sold. Anecdotal evidence suggests that many traders try to close open positions on Section 1256 contracts before the end of the year to avoid MTM requirements (e.g., Green, 2016).

[6] While Section 1256 capital losses also receive the same 60/40 split, all capital losses for non-corporate taxpayers are deductible against ordinary income up to $3,000, regardless of the asset type. Thus, the majority of the *difference* in the taxation of 1256 contracts and other options arises from gains as opposed to losses. Section 1256 losses also have the unique feature of being permitted a three-year carryback period to offset prior Section 1256 gains (Green 2016). This represents an additional potential tax benefit of Section 1256 options over other options.

Unlike index options, non-index options, such as options on ETFs or other equity securities, are not considered Section 1256 contracts and thus do not receive favorable capital gains tax treatment (e.g., Green 2016). That is, even though the SPY ETF tracks the S&P 500 Index, the ETF itself is a security, and options on a single security are generally not eligible for Section 1256 treatment.[7] This unique setting allows a comparison of index options, which benefit from favorable Section 1256 capital gains treatment, to non-index options tracking the same underlying security, but without favorable capital gains treatment, allowing us to identify the effect of capital gains taxes on option prices.

There are several other important tax details related to options trading relevant for our study. First, corporations do not receive preferential tax rates on capital gains. To the extent that options investors are corporations, they receive little benefit from Section 1256. Second, options held by certain *dealers* are also covered by Section 1256 (e.g., Soled et al 2014).[8] Thus, Section 1256 affects a subset of options investors that potentially engage in a substantial amount of options trading.[9] Finally, we note that special rules for options writing (i.e., short sales of

[7] We acknowledge that there is some debate as to whether options on the SPY ETF qualify as Section 1256 options (see, e.g., CXO_Advisory_Group 2010). To our knowledge, the general consensus is that they do not. Relatedly, some non-index options are held for long term periods, making them 100% eligible for capital gains tax rates, an advantage over Section 1256 options. Thus, to the extent that some investors treat SPY (non-index) options as 1256 (index) options or hold non-index options periods long enough to gain preferential tax treatment,it adds noise to our measures and biases against results. We expect any such bias should be small because most options are short term contracts.

[8] Certain Section 1256 contracts specifically designated as hedges are not subject to the mark-to-market rules but generally receive the 60/40 long-term/short-term capital gain treatment. The application of this provision appears to be limited and unlikely to affect our setting.

[9] Of course, a dealer that is a corporation would not receive any benefit from Section 1256 because corporations are not eligible for preferential rates. Although dealers are subject to IRC Section 1236, which generally requires that gains and losses on otherwise capital assets be a) marked-to-market and b) treated as ordinary income or loss, Section 1256 still applies to certain dealers' Section 1256 assets. Relatedly, certain dealers and traders have the option to make a mark-to-market election under IRC Section 475, which results in treating all gains or losses on capital assets as ordinary income. A Section 475 election overrides Section 1256 treatment. See Harmon and Kulsrud (2010) and Soled, Goldhirsch, and Tierney (2014) for details.

options) generally treat the related gains or losses as short term. However, option writers are also subject to Section 1256, allowing for preferential tax treatment for writing options contracts.

2.2 Hypothesis Development

Black and Scholes (1973), the seminal paper on option pricing, derived a now well-known theoretical model of option prices. This model has been referred to extensively in subsequent options research yet notably excludes investor taxes. Subsequent work in Black (1975) discusses this point and suggests that investor taxes are partially responsible for observed patterns in option trading. Scholes (1975) extends the Black-Scholes model theoretically to include investor taxes and shows that option values are lower after considering taxes than the values derived using the original Black-Scholes model. While this early theoretical work accounted for investor taxes, empirical literature has largely ignored the affect that investor taxes can have on option prices (e.g. (Broadie et al., 2009; Bai et al., 2017; Constantinides et al., 2017; Faias and Santa-Clara, 2017). We advance the existing literature by empirically examining the effect investor taxes have on option prices.

Aside from options, the literature on investor taxes and asset prices is expansive, extending back to early work in Brennan (1970) showing that firm valuation is impacted by taxes on capital gains and dividend income. Poterba and Summers (1985) show that from an investor's perspective, investor taxes influence the expected after-tax and pre-tax rates of return and therefore investors' demand for assets. This finding represents the capitalization theory of taxation, which suggests that higher capital gains tax rates increase an investor's required pre-tax rate of return, reducing the demand for and price of an asset. Recent empirical work in Dai et al. (2008) and Sialm (2009) provides evidence consistent with the capitalization theory of taxation by showing an inverse relation between stock prices and capital gains tax liability. Lang and

Shackelford (2000) and Holcomb et al. (2018) also find evidence consistent with the capitalization theory of taxation in the context of corporate acquisitions. If capitalization applies to options, we would expect a negative association between option prices and investor taxes.

An alternative theory of taxation, known as the lock-in theory, suggests investor taxes are a transaction cost affecting an existing owner's willingness to sell an asset (Constantinides, 1983, 1984). More specifically, as capital gains taxes increase, the lock-in theory suggests current asset owners will be increasingly reluctant to sell assets due to the required payment of capital gains tax due upon exit (e.g., Klein, 1998, 1999, 2001; Ayers et al., 2003). As a result, existing asset owners require a higher price from a potential buyer to compensate the seller for the capital gains taxes due. Thus, the lock-in theory of taxation is a supply-side effect suggesting a positive relation between taxes on capital gains and asset prices (e.g., Feldstein et al., 1980; Ayers et al., 2008; Dai et al., 2008). Theoretically, Constantinides and Scholes (1980) show a lock-in effect in the context of option pricing by showing that investor taxes affect investors' optimal option trading behavior. As a result, we would expect option prices to be positively associated with capital gains taxes. Importantly, the capitalization and the lock-in effect of taxation affect asset prices simultaneously (Ayers et al., 2008; Dai et al., 2008). Thus, it remains unclear whether we expect to observe a dominant capitalization or lock-in effect in option pricing. Therefore, we state our first formal hypothesis in the null form as follows:

H1: There is no effect of investor taxes on option prices.

There are also several reasons to expect taxes to have no effect on options prices. First, prior literature often assumes that dealers and institutions likely to invest in options do not or should not consider taxes in their trades. However, we note that certain dealers are specifically allowed Section 1256 treatment for a broader set of options than other traders (e.g., equity

options, IRC § 1256(b)(1)(D)), suggesting that they likely pay attention to tax consequences, although this is not necessarily true for other institutions (e.g., hedge funds focused on pre-tax returns when calculating their fees). Second, if options are mainly used as a hedge, taxes may not affect pricing decisions. However, Scholes (1975) argues that, even in hedging transactions, taxes likely matter in determining the quantity of options required to complete the hedge. Third, if many options traders elect under Section 475 to MTM capital assets and treat income and losses as ordinary then we will find no effect of Section 1256 on option prices.[10] Finally, many investors in this setting may be corporations, who do not benefit from preferential tax rates.

III. EMPIRICAL METHODOLOGY

To assess the capital gains tax effect on option prices, we first identify options traded on a broad-based index, focusing on options on the S&P 500 Index (SPX), which receives favorable tax treatment under Section 1256 as discussed in the previous section. We next identify non-index options, focusing on options on State Street Global Advisors' SPY ETF, which tracks the S&P 500 Index. These non-index options are similar to index options in terms of the underlying securities, the S&P 500 Index, yet do not receive favorable tax treatment. This allows us to compare options with similar characteristics yet different tax treatment.[11] We focus on options related to the S&P 500 because these are relatively widely traded options.

[10] Dealers are in the trade or business of purchasing securities as inventory and selling them to customers (IRC §475). Except for Section 1256 contracts held by certain dealers, income and expenses of dealers are generally treated as ordinary. Traders are in engaged in a trade or business, but generally do not have customers (e.g., day traders). Traders may benefit from making a mark-to-market election because this allows them to deduct losses as ordinary (Soled et al. 2014). Further, as noted earlier, dealers (but not traders) are generally required to MTM all securities held as inventory (Section 1236 and 1256). However, the 1256 60/40 split of long/short term gains still applies to index options for certain dealers. Traders (and certain dealers) that elect Section 475 must MTM and lose all benefits under Section 1256 – all gains and losses are treated as ordinary (Soled et al. 2014).

[11] Options are generally short-term in nature, meaning they often do not qualify for preferential long-term capital gains tax treatment; as such, gains realized from SPY options are generally taxed at ordinary income tax rates.

We compare the implied volatilities of these index and non-index options to identify differences due to capital gains tax rates using a regression framework as follows:[12]

$$Impl\_Vol_{it} = \beta_1 SPX_{it} + \delta_t + \epsilon_{it} \qquad (1)$$

where *SPX* is an indicator variable taking the value of 1 if the option is an index option and 0 if the option is a non-index option. δ represents either day-year, month-year, or quarter-year time fixed effects. This methodology allows us to identify the capital gains tax effect on option implied volatility while simultaneously considering macroeconomic factors that influence the S&P 500 and overall option values regardless of whether the option is on an index or non-index option. Because the options cover the same underlying securities, we do not need to explicitly control for the performance of the S&P 500 index.[13]

To further identify the capital gains tax effect on option prices, we use a difference-in-difference empirical design surrounding recent tax legislation. Using this methodology, we are able to isolate how a change in investor taxes influences option prices. For our tax legislative event, we use the passage of the American Taxpayer Relief Act of 2012 (ATRA). ATRA increased both the capital gains tax rate as well as the dividend income tax rate. The capital gains tax rate and the dividend income tax rate both increased from 15% to 20% for individuals in the top marginal tax bracket. In addition, ATRA also increased the ordinary income tax rate from 35% to 39.6% for taxpayers in the highest marginal income tax bracket. Therefore, analyzing index and non-index option prices before and after the passage of ATRA allows us to identify how an increase in investor taxes affects index and non-index options differently.

[12] Importantly, the SPY ETF trades at approximately 1/10th of the price of the S&P 500 Index. As a result, comparing prices of SPY ETF options to SPX options would lead to incorrect conclusions. Therefore, consistent with existing option pricing literature, we use implied volatility to capture the effect of capital gains taxes on value.
[13] We find consistent results when we estimate a 'doubly robust' empirical model that includes control variables for the daily level and return of the S&P 500.

Using ATRA, we estimate the following difference-in-difference model:

$$Impl\_Vol_{it} = \beta_1 ATRA_t * SPX_{it} + \beta_2 SPX_{it} + \beta_3 ATRA_t + \beta X_t + \varepsilon_{it} \quad (2)$$

where *Post* takes the value of 1 if the option trade occurs in the 365 days after the day ATRA was signed into law and 0 if the trade occurs in the 365 days prior to the signing of the legislation.[14] *SPX* takes the value of 1 if the option traded is an index option and 0 if the option traded is a non-index option. *X* represents a vector of control variables which includes the S&P 500 daily return for day *t* as well as the S&P 500 value for day *t*. We account for heteroskedasticity by clustering the standard errors by month-year.

IV. SAMPLE SELECTION AND DESCRIPTIVE STATISTICS

Our sample is derived from the Ivy DB database from OptionMetrics. We use the standardized pricing file from the Ivy DB database and gather all options traded on the SPY (non-index options) and SPX (index options).[15] This database provides option prices and implied volatilities based on a 'standardized' or interpolated price and volatility for at-the-money forward options with a particular length of maturity. Because we are interested in comparing option volatility for similar index and non-index options, the standardized option data allows us to compare options with similar moneyness and strike price, which is difficult when analyzing non-standardized option pricing data.

We restrict our sample to include only option trades in 2005 or later because options on the SPY do not trade before this time (Chicago Board Options Exchange, n.d.). We further restrict our sample to include only options with a 30-day maturity to ensure we capture options that are liquid (Goyal and Saretto, 2009). We also include only call options and exclude option

[14] ATRA was signed into law by President Obama on January 2, 2013.
[15] According to OptionMetrics, using the ticker of the underlying security to identify options on the SPY and SPX may be incorrect. Thus, we ensure correct identification of options on the SPY and SPX by restricting the sample to options where the security ID, SECID, is either 108105 for SPX options or 109820 for options on the SPY ETF.

trades that occur 30 days before the ex-dividend date. We do so because the SPY ETF pays quarterly dividends and the SPX index does not. According to the Black-Scholes model, dividends significantly affects the timing of option trades and therefore the price. Another important distinction between options on the SPX and SPY is that SPX options are European options, which cannot be exercised early, whereas SPY options are American options, which can be exercised early. As such, we exclude all put options in our analyses. Excluding puts and focusing on calls helps eliminate the early exercise premium that exists between American and European options, especially for put options (Dueker and Miller, 2003). Finally, because options on the SPX are defined as Section 1256 contracts and require a MTM at the end of the tax year, we exclude options that trade in one year and expire in another.[16]

Following this selection process, we are left with 1,773 and 1,768 observations for SPX and SPY options, respectively. Panel A of Table 1 presents the data by year and by month for both types of options. We observe a consistent number of observations across years. The option trades by month show most of the observations occur in the first month of a quarter. This is a result of our exclusion of observations that are within 30 days of the ex-dividend date, which is the 3rd Friday of the last month in the quarter. Panel B of Table 1 shows the results comparing the implied volatility on SPX to that on the SPY ETF. Because the SPY ETF trades at approximately 1/10th the price of SPX, we cannot strictly compare option prices and thus rely on option implied volatilities. We observe implied volatility on the SPX is higher than that of the SPY ETF by roughly 0.002 although the difference is statistically insignificant. However, this implied volatility comparison is simply a univariate comparison, as such we defer our main inferences to our multivariate and difference-in-differences analyses in Section V.

[16] Our additional analyses relax some of these restrictions, as discussed in later sections.

INSERT TABLE 1 HERE

V. RESULTS

5.1 Main Results

To account for potential unobserved characteristics and time trends in option volatility, we implement our regression estimation using a series of time fixed effects. Table 2 presents results from our main analysis estimating equation (1). We find that, on average, index option implied volatility is significantly higher than non-index options. This suggests a capitalization, or demand-side, tax effect in option prices. In other words, investors are willing to pay more for index options due to the lower tax costs. Our findings are equivalent to a 24 cent (0.9%) difference in prices of at-the-money options with a 30-day maturity.[17]

INSERT TABLE 2 HERE

Table 3 presents results from our difference-in-difference estimation of equation (2) surrounding a tax legislative event, ATRA. We find that following ATRA, the implied volatility of index options declined significantly as compared to non-index options. In other words, following a capital gains tax rate increase, investors have a significantly lower demand for index options subject to the capital gains tax rate (p-values = 0.032) following the rate increase. This finding is consistent with the capitalization theory of taxation. We also note that this table presents evidence consistent with our main tests showing index options, which face lower taxes have, on average, higher implied volatility compared to non-index options.[18] Altogether, our

[17] This is measured using a comparative price for non-index options, which is calculated by taking the stated trade prices for SPY options and multiplying it by 10 to achieve a close approximation of an SPX option.

[18] We also analyze changes in implied volatility on *index* options surrounding the passage of the Taxpayer Relief Act of 1997 (TRA) and the Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA). TRA reduced the capital gains tax rate from 28% to 20% and JGTRRA further reduced the capital gains tax rate from 20% to 15%. In addition, JGTRRA reduced the tax rate on dividend income from the highest ordinary income tax rate of 38.6% to 15%. Because ETFs were not particularly common during the time TRA and JGTRRA were passed, there were no SPY (non-index) traded options at this time. Thus, we are restricted to examining only SPX (index) options in our TRA or JGTRRA tests (untabulated), limiting the conclusions we are able to draw from such analyses. However, we

results provide strong support for the tax capitalization effect in option prices and has broad implications for options research overall.

INSERT TABLE 3 HERE

5.2 Falsification Test

Our results to this point provide compelling evidence of a capitalization effect of investor taxes in option prices. Using the capital gains tax rate increase associated with ATRA, we find lower option implied volatility for index options as compared to non-index options following the capital gains tax rate increase. However, a concern when using an event study surrounding a tax legislation event such as ATRA is the possibility that results are attributable to other confounding effects such as time trends or macroeconomic factors within the time period corresponding to the tax rate change.

To mitigate this concern, we employ two separate falsification tests using similar time periods as ATRA, yet without a tax legislation event (i.e., pseudo-events). We identify one time period before ATRA, the period between 2010 and 2012, as well as the post-ATRA period between 2014 and 2016 where there were no capital gains tax rate changes. We perform a falsification test before the ATRA (Roberts and Whited, 2013) as well as after the event to reduce concerns that some other event or omitted variable drives our results around ATRA. We expect any change in index and non-index option implied volatility from before to after these pseudo-events to be indistinguishable from zero (i.e., no change).

To estimate our difference-in-difference model we establish pseudo-event dates of January 2, 2011 and January 2, 2015, which are similar dates to the date ATRA was passed

find evidence consistent with the capitalization effect in that implied volatility on index options increases following the decrease in capital gains tax rates. The fact that we find consistent evidence of capitalization around both tax rate increases and decreases provides comfort that we identify a capitalization effect not unique to the specific circumstances surrounding the tax rate change.

except they are two years before or two years after ATRA's passage. Using these pseudo-event dates, we estimate equation (2) separately exchanging *Post_ATRA* with *Post_Pseudo*, which takes the value of 1 for option trades that occur in the 365 days following each pseudo-event date and 0 for option trades that occur in the 365 days before the pseudo-event dates. The results from these estimations are presented in Table 4.

INSERT TABLE 4 HERE

We find that the changes in option implied volatility for index options surrounding these event dates are similar to the changes in the implied volatility of non-index options (i.e., no change around the pseudo-event). This suggests that, absent a capital gains tax rate change, the difference in pricing for index options and non-index options remains the same. We note some evidence of a trend in implied volatility for all options during these time periods, confirming the importance of using difference-in-difference analyses in the previous section and the falsification tests presented here. In addition, we again find evidence consistent with our main results showing index options have higher implied volatility, on average, due to the favorable tax treatment as compared to non-index options although the result is only marginally statistically significant in columns 3 and 4.

5.3 Additional Section 1256 Contracts

To this point we focused our main analyses on index and non-index options that track the S&P 500 Index. We do so because options on the S&P 500 Index are arguably the most liquid and most important options because "the options track the world's leading benchmark" (Chicago Board Options Exchange, n.d.). However, there are a number of other indices with traded options eligible for Section 1256 tax treatment. Two such indices are the Russell 2000 Index and the Dow Jones Industrial Average (Dow). Like the S&P 500, these indices are commonly used by

investors and have relatively liquid options markets. The Russell 2000 is a benchmark index for small capitalization firms and is traded under the ticker RUT. The Dow, on the other hand, covers 30 of the largest publicly traded firms based in the United States and is traded under the ticker DJI. Analyzing options on these alternative indices provides additional generalizability of our results and provides additional evidence that we identify a tax effect rather than an unrelated, unique characteristic of options that track the S&P 500.

Important to this analysis, as with our previous tests, is that both the Russell 2000 and the Dow both have ETFs with active non-index options markets. The Russell 2000 Index has a corresponding ETF managed by iShares called iShares Russell 2000 ETF (ticker IWM). The Dow has a corresponding ETF managed by State Street Capital under the name SPDR Dow Jones Industrial Average ETF, sometimes referred to as 'Diamonds' (ticker DIA). As in our baseline model, we compare index options on RUT and DJI to the corresponding non-index options on IWM and DIA to determine whether the implied volatility, or price, of index options that receive favorable Section 1256 tax treatment is significantly different than the implied volatility of non-index options. Based on our earlier findings of tax capitalization in S&P 500 index options – that is, lower taxes increase demand and therefore prices – we expect that the implied volatility of each index option will exceed that of the corresponding non-index option.

We estimate equation (1) using options on RUT and DJI separately in place of *SPX*. The results from the estimation using RUT (DJI) are presented in Table 5 Panel A (B). We find that options on the Russell 2000 Index and the Dow have significantly higher implied volatility than options on their corresponding ETFs. This evidence supports the tax capitalization effect, consistent with our previous results, suggesting index options that receive favorable tax treatment under Section 1256 have higher values due to a greater demand for such options as

compared to similar options on the same underlying security but without the same favorable tax treatment.

INSERT TABLE 5 HERE

To provide further evidence of tax capitalization, we use these samples of options to estimate our difference-in-difference model, equation (2), using the passage of ATRA for identification. Table 6 Panel A presents results from this estimation using options on the Russell 2000 Index (RUT) and iShares Russell 2000 ETF (IWM). We find that following the passage of ATRA, which increased capital gains tax rates, the implied volatility of index options declined significantly as compared to the implied volatility of non-index options. This provides further support for the tax capitalization effect, where the increase in the capital gains tax rate leads to a lower demand for index options likely to be subject to the capital gains rate. Panel B of Table 6 presents the results from this estimation using options on the Dow (DJI) and the SPDR Dow ETF (DIA). The results from this estimation show no significant reduction in implied volatility for index options on the Dow following ATRA. We conjecture that this lack of strong evidence in options on the Dow following ATRA is due to fact that Dow options have fallen out of favor in recent years, reducing their liquidity and investor interest.[19] These reductions may make it harder for us to capture any tax effect. Alternatively, the remaining traders in Dow options may include mainly tax-exempt or tax indifferent investors. Collectively, these factors may reduce the sensitivity to tax rate changes in index options on the Dow.

5.4 Mark-to-Market

In addition to the favorable tax treatment of gains on Section 1256 contracts, e.g. index options, Section 1256 requires a mark-to-market (MTM) for open option positions at the end of

[19] We thank Jules van Binsbergen for this insight. Note that recent data shows that Dow options are not in the top 15 most active options, while S&P 500 and Russell 2000 are in the top 5 (Roy 2017).

the taxpayers' tax year. This MTM gives rise to a realized gain or loss (40% treated as short-term and 60% treated as long-term) that is recognized in taxpayers' taxable income as if the option contract was sold at year-end, in contrast to most investment assets where gain is deferred until the asset is actually sold. We expect that the demand for index options that require a MTM at year-end will increase, along with the price, if investors favorably view the acceleration of losses, which provide a tax benefit. In contrast, we expect the demand for MTM options to be lower if investors prefer to defer long-term and short-term capital gains recognition, or if MTM adds complexity because it differs from the usual treatment of investment assets. Analyzing the implied volatilities of option contracts subject to the MTM provision of Section 1256 in comparison to similar assets not requiring MTM provides yet another strategy to identify the investor tax effect on option prices.[20]

Using the standardized option pricing file from the Ivy DB database, we restrict our sample to include options on the SPX and SPY with a 60-day maturity that trade in either November or December. This leaves us with 914 observations for both SPX options and SPY options. We then identify options that expire in the following year and those options that expire in the current year.[21] We have 239 observations each for both SPX and SPY options that trade and expire in the current year, and 675 observations each for SPX and SPY options that trade in November or December yet expire in the following year. For SPX (index) options, the

[20] Under Section 475(e), options held by certain securities dealers are required to be marked to market regardless of whether the options are subject to Section 1256. To the extent non-index SPY options are held by these securities dealers, we would not expect to observe significant differences between MTM index SPX options, non-MTM index SPX options (i.e., index options that do not cross year-end), and similar non-index SPY options.

[21] We use December 31 as the cutoff for determining whether an option expires in the next year or the current year. It is possible that some option investors have an alternative tax year-end and thus would not be affected by a calendar year-end mark-to-market. To the extent this occurs frequently, we would not expect a significant difference between MTM SPX options, non-MTM SPX options, and similar SPY options.

observations crossing the year-end are subject to MTM. Table 7 Panel A provides detail of our sample by year and by expiration date for SPX and SPY options.

INSERT TABLE 7 HERE

We then compare the implied volatility for index options subject to MTM to index options not subject to MTM, as well as to non-index options. We present results in Panel B of Table 7. We find lower implied volatility for MTM SPX index options compared to SPX index options not subject to MTM (column 2), although the difference is statistically insignificant. This is also the case when we compare implied volatilities for non-index options for current versus next year expiration dates (column 4). Finally, we examine the difference in these differences. Consistent with the prior results, the univariate difference-in-differences indicate that the MTM on SPX options results in lower implied volatilities, although these results are not statistically significant. Because these comparisons are univariate only, we use a regression framework to further analyze the differences.

Following a similar empirical methodology as before, we estimate an OLS regression to compare implied volatility for index and non-index options as follows:

$$Impl\_Vol_{it} = \beta_1 Next\ Year\ Expiration_{it} * SPX_{it} + \beta_2 SPX_{it} + \beta_3 Next\ Year\ Expiration_{it} + \delta_t + \varepsilon_{it} \quad (3)$$

where *Next Year Expiration* takes the value of 1 if the option expires in the following year and 0 otherwise. The interaction term, *Next Year Expiration * SPX* identifies an option that expires next year and is an option on the SPX and thus requires a mark-to-market. δ represents either day-year or month-year time fixed effects. We also cluster standard errors by month-year to account for heteroskedasticity. Results presented in Table 7 Panel C show that after accounting for time trends in option prices, index options requiring a MTM at year-end have lower implied

volatility (i.e. lower prices) as compared to similar non-index options and those options not expiring in the following year. This suggests that investors have lower demand for options that require a mark-to-market. This could indicate that acceleration of tax gains results in higher tax costs, and therefore lower prices (i.e., the capitalization effect of taxation) for MTM options. However, this could also indicate additional administrative costs associated with the tax rules requiring MTM. While we cannot distinguish between these two possibilities, we view both as tax effects. We also note that the main effect on index options is consistent with our main results showing higher implied volatility for index options that face lower capital gains tax rates.

VI. CONCLUSION

In this paper we fill the void in the existing empirical literature regarding the effects that investor taxes have on option prices. Using the unique setting of Section 1256 contracts, which are options on broad-based indices that obtain favorable capital gains treatment, we find evidence consistent with the capitalization theory of taxation. Specifically, our results suggest lower capital gains taxes increase investors' demand for options resulting in higher prices.

We confirm this finding using a difference-in-difference analysis surrounding the passage of the American Taxpayer Relief Act of 2012, which increased the capital gains tax rate. Using this setting we find that, following the capital gains tax rate increase, implied volatility significantly declined for index options subject to capital gains tax rates as compared to non-index options. A decrease in price following an increase in taxes is consistent with a capitalization effect of taxes in option prices. In addition, we mitigate concerns of identification, omitted variables, and generalizability by performing two falsification tests, analyzing the unique MTM requirement of Section 1256 contracts, and examining Section 1256 options covering several different underlying securities. We find evidence consistent with higher capital gain taxes

reducing the price an investor is willing to pay for options (i.e., tax capitalization). Altogether, our evidence suggests that investor taxes influence option prices, consistent with early theoretical work (Scholes (1975)). This suggests that existing and future option research should consider the impact that investor taxes have on option prices, especially when evaluating option mispricing.

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Table 1: Descriptive Statistics

Panel A: Option trades on SPX and SPY by year and month

Year	SPY	SPX	Month	SPY	SPX
2005	150	155	1	236	241
2006	154	154	2	125	125
2007	158	158	3	98	98
2008	157	157	4	249	249
2009	155	155	5	139	139
2010	154	154	6	87	87
2011	155	155	7	233	233
2012	157	157	8	141	141
2013	158	158	9	85	85
2014	156	156	10	242	242
2015	155	155	11	133	133
2016	59	59	12	n/a	n/a
	1,768	1,773		1,768	1,773

Panel B: Option implied volatility on SPX and SPY

Variable	Obs	Mean	Std. Dev.	Min	Max
SPX	1,773	0.175	0.086	0.082	0.705
SPY	1,768	0.173	0.087	0.081	0.789
	3,541				
Difference (SPX-SPY)		0.002			
p-value		(0.571)			

This table presents descriptive statistics for the sample of call options on the SPX and SPY with a maturity of 30 days, excluding those trades that occur within 30 days of the ex-dividend date. Panel A presents the option trades by year and then by month. Panel B shows the option implied volatility for SPY and SPX options. P-values are presented in parenthesis.

Table 2
Regression of Option Implied Volatility on Underlying Index

DV=	(1) Impl_Vol	(2) Impl_Vol	(3) Impl_Vol
SPX	0.002**	0.002*	0.002***
	(0.018)	(0.089)	(0.000)
Constant	0.117***	0.112***	0.132***
	(0.000)	(0.000)	(0.000)
Observations	3,541	3,541	3,541
R-squared	0.934	0.866	0.998
FE (Month-Year)	Yes	No	No
FE (Quarter-Year)	No	Yes	No
FE (Day-Year)	No	No	Yes

This table presents regression estimates for our empirical model. The dependent variable, *Impl_Vol*, is equal to the option implied volatility from the standardized option price database from OptionMetrics' Ivy DB database. Column 1, 2, and 3 employ the estimation using fixed effects at the month-year, quarter-year, and day-year levels, respectively. SPX takes the value of 1 if the option has the underlying of the S&P 500 and 0 if the option is on the SPY ETF. Two-tailed p-values are in parenthesis with ***, **, and * indicating significance at the one percent, five percent, and ten percent levels, respectively.

Table 3

Difference-in-Difference Regression of Option Implied Volatility on Tax Legislation

	(1)	(2)
DV =	Impl_Vol	Impl_Vol
Post_ATRA*SPX	-0.002**	-0.002**
	(0.032)	(0.032)
Post_ATRA	-0.033***	-0.013
	(0.000)	(0.306)
SPX	0.003	0.003***
	(0.135)	(0.000)
S&P 500		-0.000
		(0.101)
S&P 500 Ret		-0.607***
		(0.000)
Constant	0.155***	0.255***
	(0.000)	(0.000)
Observations	632	632
R-squared	0.446	0.522
Cluster SE's (Month-Year)	Yes	Yes

This table presents regression estimates for our difference-in-difference empirical model surrounding the passage of the American Taxpayer Relief Act of 2012. The dependent variable, *Impl_Vol*, is equal to the option implied volatility from the standardized option price database from OptionMetrics' Ivy DB database. Column 1 presents results using a simple difference-in-difference surrounding American Taxpayer Relief Act of 2012 with Column 2 presented results for ATRA with additional macroeconomic controls. Post_ATRA takes the value of 1 if the option trade falls within 1 year after the passage of ATRA and 0 if the trade occurs in the year preceding the passage of ATRA. SPX takes the value of 1 if the option has the underlying of the S&P 500 and 0 if the option is on the SPY ETF. Two-tailed p-values are in parenthesis with ***, **, and * indicating significance at the one percent, five percent, and ten percent levels, respectively. Standard errors are clustered by month and year.

Table 4

A Falsification Test using a Difference-in-Difference Regression of Option Implied Volatility on Pseudo-Event Date

	(1)	(2)	(3)	(4)
DV =	Impl_Vol	Impl_Vol	Impl_Vol	Impl_Vol
Post_Pseudo*SPX	-0.000	-0.000	0.000	0.000
	(0.965)	(0.965)	(0.972)	(0.972)
Post_Pseudo	0.007	0.133***	0.016*	0.053***
	(0.785)	(0.000)	(0.098)	(0.001)
SPX	0.002**	0.002**	0.001	0.001
	(0.048)	(0.049)	(0.138)	(0.138)
S&P 500		-0.001***		-0.000***
		(0.000)		(0.001)
S&P 500 Ret		-0.338**		-0.542***
		(0.011)		(0.000)
Constant	0.196***	1.243***	0.124***	0.577***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	618	618	622	622
R-squared	0.003	0.773	0.085	0.421
Cluster SE's (Month-Year)	Yes	Yes	Yes	Yes

This table presents regression estimates for our difference-in-difference empirical model surrounding a pseudo-event date as a falsification test. The dependent variable, *Impl_Vol*, is equal to the option implied volatility from the standardized option price database from OptionMetrics' Ivy DB database. Columns 1 and 2 present results using a pseudo date, January 2, 2011, which is similar to the date the American Taxpayer Relief Act of 2012 was passed yet does not have a corresponding investor tax rate change. Similarly, Columns 3 and 4 present results using a pseudo date, January 2, 2015, which again is similar to the date the American Taxpayer Relief Act of 2012 was passed yet does not have a corresponding investor tax rate change. Two-tailed p-values are in parenthesis with ***, **, and * indicating significance at the one percent, five percent, and ten percent levels, respectively. Standard errors are clustered by month and year.

Table 5
Regression of Option Implied Volatility on Various Underlying Indices

Panel A: Regression of Option Implied Volatility on Underlying Index – Russell 2000 Index

	(1)	(2)	(3)
DV=	Impl_Vol	Impl_Vol	Impl_Vol
RUT	0.003***	0.003***	0.003***
	(0.000)	(0.001)	(0.000)
Constant	0.312***	0.308***	0.403***
	(0.000)	(0.000)	(0.000)
Observations	5,192	5,192	5,192
R-squared	0.921	0.845	0.996
FE (Month-Year)	Yes	No	No
FE (Quarter-Year)	No	Yes	No
FE (Day-Year)	No	No	Yes

Panel B: Regression of Option Implied Volatility on Underlying Index – Dow Jones Industrial Average

	(1)	(2)	(3)
DV=	Impl_Vol	Impl_Vol	Impl_Vol
DJI	0.004***	0.004***	0.004***
	(0.000)	(0.000)	(0.000)
Constant	0.236***	0.278***	0.246***
	(0.000)	(0.000)	(0.000)
Observations	3,890	3,890	3,890
R-squared	0.928	0.846	0.997
FE (Month-Year)	Yes	No	No
FE (Quarter-Year)	No	Yes	No
FE (Day-Year)	No	No	Yes

This table presents regression estimates for our empirical model. Panel A estimates differences in implied volatility using options on the Russell 2000 Index and the iShares Russell 2000 ETF. Panel B estimates differences in implied volatility using options on the Dow Jones Industrial Average and the SPDR Dow Jones Industrial Average ETF. The dependent variable, *Impl_Vol*, is equal to the option implied volatility from the standardized option price database from OptionMetrics' Ivy DB database. Column 1, 2, and 3 employ the estimation using fixed effects at the month-year, quarter-year, and day-year levels, respectively. RUT takes the value of 1 if the option has the underlying of the Russell 2000 Index and 0 if the option is on the iShares Russell 2000 ETF. DJI takes the value of 1 if the option has the underlying of the Dow Jones Industrial Average Index and 0 if the option is on the SPDR Dow Jones Industrial Average ETF. Two-tailed p-values are in parenthesis with ***, **, and * indicating significance at the one percent, five percent, and ten percent levels, respectively.

Table 6

Difference-in-Difference Regression of Option Implied Volatility on Tax Legislation Various Underlying Indices

Panel A: Difference-in-Difference using options on Russell 2000

	(1)	(2)
DV =	Impl_Vol	Impl_Vol
Post_ATRA*RUT	-0.002**	-0.002**
	(0.012)	(0.012)
Post_ATRA	-0.048***	-0.036*
	(0.000)	(0.066)
RUT	0.007***	0.007***
	(0.000)	(0.000)
Russell 2000		-0.000
		(0.426)
Russell 2000 Ret		-0.409***
		(0.006)
Constant	0.214***	0.261***
	(0.000)	(0.000)
Observations	688	688
R-squared	0.477	0.500
Cluster SE's (Month-Year)	Yes	Yes

Table 6 (continued)

Panel B: Difference-in-Difference using options on Dow Jones Industrial Average

	(1)	(2)
DV =	Impl_Vol	Impl_Vol
Post_ATRA*DJI	-0.000	-0.000
	(0.868)	(0.868)
Post_ATRA	-0.022**	0.008
	(0.022)	(0.641)
DJI	0.005***	0.005***
	(0.003)	(0.003)
Dow Jones		-0.000*
		(0.056)
Dow Jones Ret		-0.568***
		(0.000)
Constant	0.143***	0.348***
	(0.000)	(0.003)
Observations	582	582
R-squared	0.208	0.348
Cluster SE's (Month-Year)	Yes	Yes

This table presents regression estimates for our difference-in-difference empirical model surrounding the passage of the American Taxpayer Relief Act of 2012. Panel A estimates the difference-in-difference model using options on the Russell 2000 Index and the iShares Russell 2000 ETF. Panel B estimates the difference-in-difference model using options on the Dow Jones Industrial Average and the SPDR Dow Jones Industrial Average ETF. The dependent variable, *Impl_Vol*, is equal to the option implied volatility from the standardized option price database from OptionMetrics' Ivy DB database. Column 1 presents results using a simple difference-in-difference surrounding American Taxpayer Relief Act of 2012 with Column 2 presented results for ATRA with additional macroeconomic controls. *Post_ATRA* takes the value of 1 if the option trade falls within 1 year after the passage of ATRA and 0 if the trade occurs in the year preceding the passage of ATRA. RUT takes the value of 1 if the option has the underlying of the Russell 2000 Index and 0 if the option is on the iShares Russell 2000 ETF. DJI takes the value of 1 if the option has the underlying of the Dow Jones Industrial Average Index and 0 if the option is on the SPDR Dow Jones Industrial Average ETF. *Russell 2000* and *Dow Jones* represent the daily value of each respective index. *Russell 2000 Ret* and *Dow Jones Ret* represent the daily return on each respective index. Two-tailed p-values are in parenthesis with ***, **, and * indicating significance at the one percent, five percent, and ten percent levels, respectively. Standard errors are clustered by month and year.

Table 7: Analysis of Option Implied Volatility and Mark-to-Market Requirements.

Panel A: SPX and SPY Options coupled with MTM requirements

	SPX		SPY	
	(1)	(2)	(3)	(4)
Year	No-MTM	MTM	Current Year Expiration (No-MTM)	Next Year Expiration (MTM)
2005	23	61	23	61
2006	23	59	23	59
2007	23	60	22	60
2008	20	62	20	62
2009	21	63	21	63
2010	23	63	23	63
2011	23	61	23	61
2012	22	60	22	60
2013	21	61	21	61
2014	20	62	20	62
2015	21	63	21	63
	239	675	239	675

Panel B: Average Option Implied Volatility Comparison for MTM options

	SPX		SPY			
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Obs	Mean	Obs	Mean	Diff (SPX-SPY)	p-value
Current Year Expiration	239	0.199	239	0.194	0.005	(0.668)
Next Year Expiration (MTM for SPX)	675	0.195	675	0.193	0.003	(0.652)
	914		914			
Difference (Next Year-Current Year)		-0.004		-0.001	-0.002	
p-value		(0.665)		(0.880)	(0.845)	

Table 7 (continued)

Panel C: Regression Comparison for SPX and SPY Options

DV=	(1) Impl_Vol	(2) Impl_Vol	(3) Impl_Vol
Next Year Expiration * SPX (i.e., MTM)	-0.002**	-0.002**	-0.002**
	(0.011)	(0.025)	(0.011)
SPX	0.005***	0.005***	0.005***
	(0.000)	(0.000)	(0.000)
Next Year Expiration	-0.001	0.005	0.003
	(0.967)	(0.121)	(0.273)
Constant	0.194***	0.125***	0.107***
	(0.000)	(0.000)	(0.000)
Observations	1,828	1,828	1,828
R-squared	0.000	0.996	0.943
Clustered SE's (Month-Year)	Yes	Yes	Yes
Fixed Effects (Day-Year)	No	Yes	No
Fixed Effects (Month-Year)	No	No	Yes

This table presents summary statistics and estimation results for options prices on call options on the SPY and SPX that trade in November and December and expire in the following year, requiring a mark-to-market in some instances. The dependent variable, *Impl_Vol*, is equal to the option implied volatility from the standardized option price database from OptionMetrics' Ivy DB database. Panel A presents summary statistics for options that trade and expire in the current period and those that trade in the current year and expire in the following year. *MTM* is an indicator variable taking the value of 1 if the option is an index option and if the option has an expiration in the next year thus requiring a year-end mark-to-market. *SPX* is an indicator variable taking the value of 1 if the option is on the SPX index and 0 otherwise. *Next Year Expiration* signifies the option crosses the year-end and takes the value of 1 if the option expires in the next year and 0 if the option expires in the current period. For SPX, those options that trade and expire in the current period are referred to as *Non-MTM* options. We also refer to SPY options as *Non-MTM*, or not having an expiration date that crosses into the next year. For ease of exposition we refer to both as *Non-MTM* options. SPX options that require a year-end mark-to-market and expire in the next year are labeled as *MTM* options. Similar SPY options that expire in the following year are also labeled as *MTM* in Panels A and B to signify the crossing over a year-end yet do not have the same tax implications of Section 1256 contracts. Panel B provides univariate analysis of option premiums by underlying security, mark-to-market requirements, and those that expire in the following tax year. Panel C presents regression results. Two-tailed p-values are in parenthesis with ***, **, and * indicating significance at the one percent, five percent, and ten percent levels, respectively.