Taxing Financial Transactions in Multiple Markets

Vincent Wolff

Abstract

What are the effects of taxing stock and derivative transactions on market liquidity and welfare? My theoretical model predicts asymmetric responses to equivalent tax rates across markets, resulting in welfare improvements upon taxation. Stock volume decreases significantly relative to options volume, and liquidity improves in the taxed market due to reduced adverse selection. I causally test the model’s predictions by leveraging three separate FTT introductions on stocks and derivatives. Empirical results show reduced trading in the taxed markets and migration of informed trading to the untaxed market. I reject the common conception that the synthetic replication of stocks is a practiced alternative to avoid the tax.

Version: October 30, 2023
JEL-Code: D40, D82, F38, H21
Keywords: Financial transaction tax, optimal taxation, liquidity, welfare

The impact of financial transaction taxes (FTT) on financial markets and its desirability for a country’s tax composition remains a crucial question for financial and public economists. Proponents of FTTs argue that the tax raises revenues and positively changes the trader composition in the market, which in turn improves market quality (Stiglitz, 1989). Critics argue that such a tax would be inefficient and impractical as it is easy to avoid, and the reduced participation impairs market quality. Although the question of tax avoidance and the resulting trader composition is at the heart of the discussion on the desirability of an FTT, the academic literature is silent about the effects of FTTs when traders are given the choice to operate in taxed or untaxed markets. This research gap is

I would like to thank Daron Acemoglu, Bruno Biais, Marc Chesney, Jean-Edouard Colliard, Sean Foley, and Jean-Charles Rochet for their thoughtful comments. This paper has also benefited from comments of the Workshop on Financial Transaction Taxes at Copenhagen University and seminar participants at the University of Amsterdam, Copenhagen, Zürich, Study Center Gerzensee Foundation of the Swiss National Bank, and Instituto Tecnológico Autónomo de México. I also thank the Swiss Finance Institute for the Best Paper Award. Vincent Wolff is at the University of Zurich (vincent.wolff@bf.uzh.ch)
particularly relevant considering the various FTT designs already in place across multiple countries and the increasing probability of a pan-European FTT.\footnote{The European Commission proposed an FTT at the European level in 2013. While it failed to obtain unanimous support from all EU member states, unilateral implementations have been undertaken by France, Italy, and Spain. Shortly before the pandemic outbreak, France and Germany proposed a pan-European FTT based on the French model (Directive, 2019). As of 2023, the following countries have some form of FTT in place: Belgium, China, Colombia, Finland, France, India, Italy, Spain, Peru, Poland, Singapore, Switzerland, Taiwan, and the United Kingdom.}

In this paper, I examine the effect of FTTs on market liquidity and aggregate welfare in a setting where alternative trading venues and financial products are present and traders endogenously choose to trade on the taxed or untaxed market.

In the first part of the paper, I develop a sequential trade model in which informed and uninformed traders choose to trade either in the stock or options market and where risk-neutral market makers face adverse selection in the price-setting problem. Subsequently, a tax on transactions is introduced in either one or both markets, demonstrating how liquidity and trading costs adjust in equilibrium. In the second part of the paper, I test the model’s predictions by utilizing tax introductions in Italy, France, and Spain with differing FTT designs. I employ a difference-in-difference analysis that allows for the causal estimation of the average treatment effect of FTTs on market quality measures.

For the theoretical part of my analysis, the approach taken in this paper is based on the idea that an increase in trading costs through a tax in one market generates an incentive to migrate to another market for the same security or its derivative instrument.\footnote{The results of this study apply to various scenarios of exogenous increases in trading costs, such as those related to exchange maker/taker fees and settlement costs, see Malinova and Park (2015).} For example, taxing on-exchange financial activity may encourage migration to OTC trading or synthetic replication of the stock through its equity derivative. To better understand these dynamics, I develop a multi-market sequential trade model that incorporates a stock and its options market. The model provides an explicit characterization of trading incentives given the ability to trade in the stock, its derivative, or both markets. The key element of my model is that it allows for trading migration conditional on either or both markets being subject to a transaction tax. Market makers face adverse selection in the price-setting problem in both markets due to the existence of informed traders. I determine the conditions under which, in equilibrium, traders use options, stocks, or a mixture of the two assets. Additionally, I extend the model to include the effects of taxation on market maker competition and resulting impacts on liquidity provision. The model allows to explicitly derive measures for both trading activity and market liquidity.

The paper contributes to the literature by proposing a two-market microstructure model
that characterizes the migration of trading activity, the composition of market participants, and the consequent impact on market quality in the presence of asymmetric information, competition, and financial transaction taxes. Additionally, I estimate aggregate welfare by comparing the tax revenues to changes in market quality associated with the FTT. More generally, this paper provides theoretical and empirical insights into optimal tax design and welfare implications of financial transaction taxes.

There are four key findings of the theoretical model. First, the model predicts an asymmetric effect of taxes levied on stocks compared to options. Due to the payoff structure and leverage of options, traders in the model reduce trading quantities less forcefully in the derivative market relative to the stock market when confronted with the transaction tax. This translates into a smaller effect of any tax regime on options markets compared to stock markets. Relative to the options market, the stock trading volume reduces substantially upon taxation. This result is a combination of both a decrease in traded quantities as well as lower trading frequencies.

Second, my model predicts an improvement in market liquidity in terms of lower spreads for the taxed market and a deterioration in liquidity for the untaxed market. This result is driven by the migration of inform traders from the taxed to the relatively cheaper untaxed market, thereby alleviating the adverse selection cost in the first and increasing it in the second market. The improvement of lower adverse selection costs in the taxed market outweighs the increase in explicit costs introduced by the transactions tax.

Third, I extend the model to incorporate imperfect competition among market makers to study the impact of market maker exemptions. In response to increased costs, market makers scale back their liquidity provision, leading to a widening of the effective spread for two reasons. With diminished competition, the realized spread increases as market makers can exert greater market power, and the decline in competition amplifies each market maker’s exposure to informed trading, causing an increase in price impact.

Fourth, by calibrating the model to observable market shares of stocks and options, the model suggests an increase in welfare upon the introduction of the FTT. The improvement in stock market liquidity due to lower adverse selection, combined with the FTT revenue, outweighs the decline in liquidity in the options markets. This result is consistent regardless of whether only the stock market or both the stock and derivatives markets are taxed.3

For the empirical test of the theoretical model, I leverage three exogenous tax intro-

3The model suggests that a tax solely on the options market results in an overall decrease in welfare. In practice, the FTT is applied only to the stock markets (France and Spain), or it covers both the stock and derivatives markets (Italy). A detailed discussion can be found in Section 2.1.
ductions to estimate the causal effects of FTTs on stocks, derivatives, and OTC equity markets. Recent FTT introductions provide examples where either only stocks (France, Spain) or stocks and derivatives (Italy) are taxed. This study is unique in that it is the first to examine the FTT effects on stock options and futures. It is also the first to quantify the general FTT impact in Spain. The rich heterogeneity in tax designs, which includes various degrees of market maker exemptions, allows me to individually and explicitly test the model’s predictions. I leverage the FTT introductions of the following three scenarios:

1. stock transactions are taxed at the same rate both on-exchange and OTC,
2. stock transactions are taxed at a higher rate OTC than on-exchange, and
3. derivative transactions are taxed.

In the first scenario, I find that the FTT introduction significantly affects trading activity but not aggregate liquidity in stock markets. A 0.2% transaction tax decreases on-exchange trading volume by 10 - 21%. The trading activity of on-exchange derivatives is not significantly impacted. I reject the common conception that the synthetic construction of stocks is a practiced alternative to avoid the FTT. This is true for both stock options and futures. In the second scenario, I find spillover effects from OTC equity trading activity to on-exchange markets when different tax rates are implemented. A tax introduction of 0.1% on-exchange and 0.2% off-exchange has no effect on-exchange and causes a drop of 60% off-exchange. I explain the lack of response on-exchange with spillovers from the OTC markets. In the third case, the tax rate on derivatives, which follows a fixed sliding scale, does not influence trading activity or impact market quality.4

My empirical results confirm three of the theoretical model’s predictions while leaving a fourth one inconclusive. First, the effect of a transaction tax on stocks relative to their derivatives is asymmetric. Stock trading activity decreases significantly while option activity remains largely unaffected. Second, the FTT introduction incentivizes the migration of informed traders to the relatively cheaper untaxed market. However, I do not find an improvement in market liquidity in the taxed market due to the alleviation of the adverse selection problem. Third, FTT designs that reduce competition among marker makers due to stringent market maker exemptions experience a reduction in stock market liquidity. This empirical result suggests that in equilibrium, the decline in competition dominates the alleviation of the adverse selection costs. Fourth, I conduct a welfare analysis to more comprehensively understand the economic cost of the FTT. This involves comparing a

---

4The FTT rate for derivative transactions in Italy varies and depends on the type of derivative and the total notional value of the contract. Equity options and futures are taxed on a sliding scale, starting with 0.125% for a notional value of the contract over 2,500 Euros up to 1% for a notional value over 1,000,000 Euros.
country’s tax revenues to the welfare loss associated with the FTT. In countries with lenient market maker exemptions, like France and Spain, the effect of the FTT on aggregate market liquidity and welfare loss is minimal, and the tax collects 0.26% - 0.62% of their yearly GDP. In contrast, for Italy, the welfare loss from the FTT is approximately double the revenue it generates, which stands at 0.25% of its GDP. Based on my model, I attribute this notable difference in welfare impact to Italy’s stricter market-maker exemption.

The key contribution of the paper’s empirical analysis is twofold. I examine the individual effects of the FTT introduction in three countries, as well as the comparison of the cross-country variation in policy design. Overall, my results highlight the importance of considering multi-market effects when designing optimal financial transaction taxes – those that both maximize governmental revenues and minimize distortionary deadweight losses.

My study contributes to the theoretical and empirical literature on FTTs, optimal tax design, and their impact on welfare. Prior research has examined FTTs only in single-market settings without consistent consensus on their effects. To the best of my knowledge, this study represents the first investigation into the effects of an FTT in a two-market setting and on derivatives. I draw upon the foundational work of Easley, Hara, and Srinivas (1998) and Biais and Hillion (1994), who developed closed-form models enabling informed traders to make investment decisions between the stock market and its corresponding options market.

Empirically, the literature is almost entirely focused on the taxation of stocks. In their seminal work, Colliard and Hoffmann (2017) find in the case of France that the introduction of the tax led to a decrease in trading volume while aggregate market liquidity remained unaffected. However, their research shows that the aggregate effect of the FTT on trading volume conceals heterogeneity among stocks. In line with my findings on lenient market maker exemptions, they find that stocks in a rebate scheme, promoting enhanced liquidity provision, were only mildly affected by the FTT. In contrast, stocks not covered by the scheme saw their trading volume drop by 20% and experienced a substantial deterioration in market quality. To my knowledge, there is only the work by Mixon (2021) on the transaction tax on futures during the 1920s and 1930s. It shows a decline in trading

---

5Subrahmanyam (1998) finds that a tax can both increase or decrease market liquidity, depending on whether informed traders act competitively or in a monopolistic way. Dupont and Lee (2007) find that the effect of a tax can be both negative or positive, depending on the level of informational asymmetry in the market. See also Dow and Rahi (2000) who study the effect of a tax on the profits of speculators and the risk-sharing opportunities for hedgers and find that the tax’s effect depends on the model’s informational parameters.

6See Matheson (2011) for a descriptive discussion of FTTs on other underlying. Feige (2001) and Ekeland, Rochet, and Wolff (2021) who propose a tax on payments.
volume due to reduced intra-day trading and that intermediaries passed through the tax to customers.

The remainder of this paper is organized as follows. Section 1 introduces the benchmark model, including taxation and imperfect competition among market makers, followed by the sequential model and its predictions. Section 2.2 describes the three financial transaction tax designs exploited in my empirical analysis and describes the data used. Section 3 shows the empirical results, followed by a discussion about the FTTs’ desirability with respect to their welfare considerations. The final section concludes.

1 The Two-Market Model

This section introduces the static adverse selection benchmark model and outlines the roles of market participants, their trading strategies, and the equilibrium outcomes. Section 1 introduces the two-market benchmark model with asymmetric information and imperfect competition. In section 1.1, the static baseline evolves into a sequential trading model, allowing for the simulation of trades and quotes and to examine the effects of FTTs on trading activity, market liquidity, and competition. The appendix A.1 - A.3 describes the model in great detail.\textsuperscript{7}

Benchmark model: In the benchmark model, there are three assets – a risk-free asset, one stock, and a set of options on the stock – as well as three market participants – liquidity and informed traders and market makers. The two types of traders in the market differ in their information sets. While informed traders (IT) perfectly anticipate the final value of the stock and trade to maximize their profits, uninformed liquidity traders (LT) experience liquidity shocks and accordingly trade to hedge their liquidity risk. Risk-neutral market makers observe the order flow and set prices according to their beliefs in both markets.

The game-theoretical trading mechanism is the following. The first two information events in the game are nature’s decisions regarding both the existence and type – good or bad – of information defining the state of the world. These can be thought of as events that happen prior to the opening of the markets.\textsuperscript{8} After the determination of the shock to

\textsuperscript{7}The section A.1 introduces the static trade model of asymmetric information and financial transaction tax with its equilibrium strategies and prices. Section A.2 outlines the competition among market makers for order flow. Section A.3 describes the sequential trading model, which characterizes the full-time series of quotes, prices, and traded volumes.

\textsuperscript{8}In a sequential trading model with a large number of trades within a day and multiple trading days, the information events can be thought of as occurrences taking place overnight. Appendix A.3, presents the sequential trading model.
fundamental value but before the market opens, market-makers set initial prices according to their beliefs. These beliefs include the existence and type of an information event as well as the presence and dispersion of informed versus liquidity traders. Next, a trader is randomly chosen from the population, and a trade outcome occurs. Figure 7 in appendix A.1 graphically illustrates the model’s probabilistic structure using a decision tree.

The equilibrium notion in the economy described above is a standard rational expectation equilibrium, characterized by a set of prices and trading strategies such that:

1. The liquidity traders choose market orders to maximize their expected utility
2. The insiders choose market orders to maximize their profits
3. The market makers set prices equal to their conditional expectations

Liquidity traders will trade in the markets to hedge their exposure to liquidity shocks. Specifically, LTs choose their strategies by maximizing their respective utility functions. For example, a liquidity trader who is exposed to a negative shock in the scenario where bad news hits the markets will be more inclined to either sell the stock or buy a put option. Similarly, an LT that experiences negative liquidity shocks in the case of good news will tend towards hedging strategies that involve either buying stocks or call options.

Informed traders, on the other hand, anticipate the impact of their strategies on prices and therefore need to limit their trades in order to avoid excessive information leakage (Meulbroek, 1992). In equilibrium, this will lead them to mimic the trading strategies followed by the liquidity traders (Biais and Hillion, 1994). The intuition is the following. Let us assume that we are in an up-state (e.g. good news). The insiders, having perfect prior information about the value of the asset, will prefer to buy the stock or a call option or sell the put option. Since the market maker has rational expectations and perfectly anticipates the strategies of the participants in the market, she will infer that any other strategy that is not a utility-maximizing strategy will necessarily come from the insider. In this case, she will set the price equal to the expected value, making the trades unprofitable for the insider. As such, informed traders’ optimal strategy is to replicate the trading amounts used by liquidity traders.

Lastly, equilibrium in the option and stock markets requires market makers to set prices equal to their conditional expectations. Due to the nature of the competition among market makers and the trading mechanism in the market structure, this will ultimately lead market

---

9Haselmann, Leuz, and Schreiber (2023) empirically illustrate that privately informed (insider) traders accumulate positive stock positions before positive news and short positions prior to negative news, with positions being liquidated shortly after the event. Lowry, Rossi, and Zhu (2019) provide empirical evidence of informed traders preferring the options to the stock market ahead of merger announcements to realize gains from private information.
makers to set equilibrium prices such that their expected profit is zero. The ask and bid prices in the stock market are, therefore, the expected value of the asset, conditional on the available information and the direction of the incoming order.

**Imperfect competition:** In the presence of imperfect competition between more than one market maker, the increase in costs due to the FTT potentially makes liquidity provision unprofitable for the marginal market maker. To better understand the impact of a financial transaction tax on market quality, I include the effects of competition on liquidity provision by adding additional friction in the model, namely imperfect competition (IC) among market makers. The detailed model is presented in Section A.2 of the Appendix. In the benchmark case described above, I considered a model where market makers, when chosen to trade, are allotted the entirety of the order flow. As is well-known, this mechanism leads to market makers slightly undercutting each other’s quotes until prices eventually reach their conditional expectations and expected profits are driven down to zero. In this section, in order to facilitate imperfect competition, I use the call auction trading mechanism. Dealers now submit a quote schedule consisting of quantities they are willing to trade at any given price. At every trading round, an auctioneer will then parcel out the full order flow among all the market makers at the market clearing price. Recall that market makers have rational expectations about the proportion of trader types and their trading strategies and set prices accordingly. With the call auction trading mechanism, market makers also need to take into consideration the behavior of the other market makers and, accordingly, how their own strategies impact equilibrium prices. Effectively this means that I consider a fixed number of strategic market makers, which will decide which price schedule to quote in which market based on their profit function.

The equilibrium in this economy is a rational expectation equilibrium with profit-maximizing market makers. It is characterized by a set of schedules consisting of quantities and respective price mappings, describing how prices correspond to these quantities. Each market maker correctly anticipates the clearing price and forms expectations accordingly. Then markets clear.\(^{10}\) The next section visualizes the results of financial transaction taxes with imperfect competition among market makers.

### 1.1 Comparative Statics and Model’s Predictions

The theoretical tax scenarios mirror the two real-world implementations of financial transaction taxes in Europe: a tax solely on stocks and a tax applied to both stocks and their

\(^{10}\)The equilibria are formally defined in propositions 1 and 2 in Appendix A.1 and A.2.
derivative contracts. An FTT on stocks is introduced only in the stock market as a percentage cost of the value of the transaction (ad valorem tax). Therefore, when buying or selling a stock or an option, the agent will pay $A(1 + t)$ and receive $B(1 - t)$, where $A$ and $B$ are the ask and bid in the respective market and $t$ is the transaction tax.\footnote{The double tax is introduced as a percentage cost on the value of the transaction of the stock or the option. The traders pay (receive) $A_c(1 + t)$ ($B_c(1 - t)$) when they trade in the stock market as well as pay (receive) $A_p(1 + t)$ or $A_p(1 + t)$ and ($B_c(1 - t)$ or $B_p(1 - t)$) if they buy call or put options respectively.}

Figure 1 shows the effect of both tax regimes on the trading volume in stock and options markets. We can see that introducing a tax in the stock market significantly reduces its

\footnote{I simulate one year of trading data with 252 days and 30 trading rounds per day. Figures 1 to 3 show the average results of 1000 simulations for volume and liquidity in different scenarios. Furthermore, the options available for trading are European-type options with four months (80 days) until expiration, which are rolled over every three months.}

The static model can be extended to a sequential trading model by allowing the market makers to update their beliefs (see Appendix A.3). Updating is achieved by assessing the probability of informed trading based on the observed order flow and adjusting their quotes/prices accordingly. This approach enables the generation of the full-time series of quotes, prices, and traded volume and the explicit derivation of standard liquidity measures. This is particularly crucial as it facilitates a direct comparison between the model’s predictions on market liquidity and the empirical causal results derived from the difference-in-difference analysis in Section 3. In the following part of this section, I present the impact of both FTT scenarios through a simulation study using the sequential adaptation of the static model.\footnote{I simulate one year of trading data with 252 days and 30 trading rounds per day. Figures 1 to 3 show the average results of 1000 simulations for volume and liquidity in different scenarios. Furthermore, the options available for trading are European-type options with four months (80 days) until expiration, which are rolled over every three months.}
trading volume. The large impact on trading volume arises from significant reductions in both trading quantities and trading frequency (see Figure 8, Appendix A.3). On the other hand, introducing an option tax in addition to the stock tax does not significantly affect trading volumes in the stock market or the options market. This result, which is pervasive throughout my analysis, is due to the inherent leverage contained in options when compared to stocks. Recall that I introduce taxation both in the stock and options market as a percentage cost of the transacted value. As the transacted value in options is much smaller compared to their potential payoff (or loss), taxing options and stocks with the same tax rate and tax function leads to this asymmetric effect.

Next, I consider the impact of different tax regimes on market liquidity. In order to do so, I construct four different spread measures, namely quoted spread, effective spread, realized spread, and price impact in the stock market. The red dotted line represents the introduction of the tax. "Benchmark" is the scenario without a tax, "Stock Tax" is the scenario with an FTT in the stock market, and "Double Tax" represents the scenario with FTTs in both the stock and options market.

Figure 2: The Figure shows the effect of the different tax regimes on the quoted spread, effective spread, realized spread, and price impact in the stock market. The red dotted line represents the introduction of the tax. "Benchmark" is the scenario without a tax, "Stock Tax" is the scenario with an FTT in the stock market, and "Double Tax" represents the scenario with FTTs in both the stock and options market.

---

13Patel, Putniš, Michayluk, and Foley (2020) empirically confirm my finding showing that insiders prefer to trade using options because of this inherent leverage.
realized spread, and price impact. The quoted spread represents a market maker’s marginal cost of liquidity provision. The effective spread measures the cost of liquidity consumption actually obtained by investors in the quantities traded. It can therefore be seen as the impact of the specific transaction on the prices available in the market. Importantly, the effective spread can be decomposed into the realized spread (the realized returns to market makers) and price impact (the adverse selection costs associated with an individual trade). Figure 2 shows the effects of the different tax regimes on these spreads for the stock market. Introducing a stock tax in the setting decreases the proportion of informed trading in the stock market, positively affecting its liquidity. Consequently, informed trading migrates to the options market, which in turn increases adverse selection and reduces liquidity. This can be seen both for quoted and effective spreads. Furthermore, it is clear from the two bottom graphs of Figure 2 that this effect is purely driven by the alleviation of the adverse selection in the market. Further, introducing a tax in the options market has the opposite effect. Informed traders migrate from the options to the stock market, and liquidity improves in the options and worsens in the stock market.

From a welfare perspective, it’s crucial to note that the magnitudes of welfare changes brought about by an option’s tax are significantly less than those resulting from a stock tax. Consequently, implementing a tax on both stocks and options delivers a positive net effect on economic welfare. I calculate the welfare loss as the trading volume in both markets multiplied by the change in the effective spread in each market (see section 3.4 for the empirical calibration of the welfare loss). According to my model, with an options-to-stock trading volume ratio of 1:20, the introduction of an FTT is predicted to improve the effective spread by 0.89% (89 bps) due to a reduction in adverse selection in the stock market. This suggests an average trading cost saving of 89 Euros for a stock market trading volume of 10,000. In equilibrium, the higher share of informed trading in the options market increases the adverse selection component of the effective spread. The model predicts a subsequent increase in trading costs by 0.1% (10 bps) in the options market. This suggests an average trading cost increase of 0.50 Euros. The improvement of market liquidity is greater in the stock than the decline in the options market, as shown by the relative effective spread and in Euro terms. Consequently, conditional on the stock market volume being greater than the options market volume, the model predicts a welfare improvement from the introduction of the FTT in the stock and options market.

In the last step, I simulate my model under imperfect competition (see Figure 3).\footnote{14}{The options-to-stock trading volume ratio of 1:20 corresponds to my empirical findings in the sample period.} \footnote{15}{All three financial transaction tax designs in practice, as shown in section 2.1, include exemptions for}
Due to the FTT introduction, market makers reduce their liquidity-providing activity as a response to the higher costs and, in the limit, are driven out of the market entirely. Figure 3 shows that decreasing competition levels adversely affect the markets’ spreads. The top two graphs of Figure 3 show that both the quoted spread and the effective spread increase relative to the benchmark as the proportion of active market markers in the stock market decreases. This result is driven by two effects. First, the realized spread, representing the compensation market-makers obtain for providing liquidity, rises as the diminished competition among them enables them to exercise their market power, leading them to market makers. Practitioners confirmed that these exemptions vary across countries and can effectively include significant bureaucratic burdens for market makers in order to provide proof of market-making activity. Thus, even in the presence of exemptions, financial taxes can lead to significant indirect additional costs for market makers. Moreover, practitioners confirmed that the actual tax burden is often uncertain. This is observable by contrasting the high forecasting error of the estimated tax revenues in Italy at the end of the year relative to the actually confirmed tax revenues. The projected tax revenues are up to three times greater compared to the actual tax income reported a year later (MEF, 2014 - 2023).
impose a positive premium on each trade (bottom left panel in Figure 3). Second, the price impact, the proxy for adverse selection in the market, also increases as reduced competition exacerbates the exposure of each market maker to informed traders (bottom right panel in Figure 3). In fact, due to the lower competition levels, both the rise in the realized spread and the price impact elevates the effective spread above the non-tax benchmark levels. The model suggests an exemption of a tax on financial transactions by market makers can mitigate the issue of imperfect competition.

In summary, the model predicts that introducing the same tax rate in both stock and its options markets leads to an asymmetric effect of taxation across markets. Taxing the stock market significantly reduces volume, which is both an effect of decreased trading quantities and lower trading frequencies. Liquidity, as measured by four different spread measures, is affected positively in the taxed market. This result arises because of the alleviation of the adverse selection problem as informed trading moves to the untaxed market. The welfare improvements are discussed. With a lower level of liquidity provision due to the FTT and imperfect competition, the realized spread and, consequently, the effective spread increases to levels higher than the no-tax benchmark. Therefore, the model suggests a lenient market maker exemption. In the next section, I empirically test these hypotheses explicitly by leveraging the recent FTT introductions in Italy, France, and Spain.

2 Tax design, identification strategy, and data

This section explains the exogenous variation I leverage to estimate the causal effects of the FTT, the data, sample selection procedures, and variable measurement methods.

2.1 Tax designs

In the aftermath of the 2007/08 financial crisis, there were numerous initiatives to implement a pan-European FTT. However, only France, Italy, and Spain ultimately introduced their distinct versions of an FTT. In this section, I examine the three FTT designs, emphasizing the commonalities and relevant differences. Table 1 summarizes some of the main features of the FTTs introduced in the three countries studied in this article. All three countries have in common that the tax base is constituted by the daily net position changes, i.e. the FTT focuses on the transfer of ownership. As a consequence, pure intraday trading is practically exempted. While France and Italy introduced FTTs shortly after the first EU proposal was rejected, Spain only implemented the tax in 2021. Despite these differences
in timing, the French and Spanish FTT share similarities across all main features of the tax, while Italy’s tax design includes some important differences. Firstly, the threshold for the introduction of the tax - which in all cases is defined by the market capitalization of the stock - was set to be €1bln for France and Spain and €500mln for Italy. The FTT rate introduced on regulated and OTC markets for France and Spain was 0.2%, whereas Italy implemented a 0.1% tax rate on exchange and a 0.2% on OTC markets.

Further, Italy is the only country that extended the FTT to derivative markets. The scope of the tax on the derivatives included all products that have as underlying a taxed stock. The tax rate for derivative transactions in Italy varies and depends on the type of derivative and the total notional value of the contract. Equity options and futures are taxed on a sliding scale, starting with 0.125% for a notional value of the contract over 2,500 Euros and up to 1% for a notional value over 1,000,000 Euros.

While market makers are exempt in all three tax designs, in practice, Italy enforced the exemptions more strictly compared to France and Spain. Italy follows the narrow European ESMA legislation for the definition of ”market-making activity”. France and Spain use an ad-hoc, looser definition of market-making that can incorporate investors that perform a market-making role effectively but without being officially designated as market makers. The result is stricter enforcement of the market-making exemptions in Italy, with a significantly higher burden of proof of market-making activities compared to France and Spain.

2.2 Identification strategy and data

I leverage the natural experiment provided by the introductions of financial transaction taxes for stocks and derivatives to test the model’s predictions. I adopt a difference-in-differences (diff-in-diff) estimation to identify the different tax impacts on trading activity and market liquidity for the three different countries that have recently introduced FTTs.
France, Italy, and Spain. For this purpose, I compare the treated group, stocks whose trading is now taxed, to an untreated control group, stocks that are not taxed but that are otherwise as similar as possible.

Specifically for each country treated with a tax change, the diff-in-diff analysis asks for a control group that is, in the absence of treatment, as similar as possible. In my case, this applies particularly to the market structure environment, traders, market participants, and sharing similar macroeconomic shocks over the observation period. For France, I use the Netherlands as the control group (see Colliard and Hoffmann (2017) for an in-depth discussion). The Netherlands is a natural candidate as it shares a common border with France and is part of the European Union. Both countries are exposed to similar shocks, and the stock markets are of similar size and equally integrated and developed. The exchange venues are both parts of Euronext and therefore utilize to the same market structure. Traders in Amsterdam and Paris face identical trading protocols, tick size regimes, and fee structures. For Italy and Spain, I follow Coelho (2016) and pair them with each other. Both share similar macroeconomic shocks, sectoral distributions, and market sizes. They do not share an identical market environment, as in the Euronext case, but there was no major change in the trading environment in either country countries during the period of analysis. The diff-in-diff approach accounts for this non-observable heterogeneity through the company fixed effect.

For the analysis of the derivatives market, I use stock options and futures, which have either the treatment or control stocks as the underlying asset. My sample of stocks consists of all companies above the country-specific size threshold as explained in Table 1 throughout my sample period. Table 2 shows the number of treatment and control stocks, options, and futures in detail, and Table 7 and 8 shows the mean and the standard deviation of the constructed financial market variables. The stock options samples are constructed as follows. I define an event window of 6 months before and after each FTT introduction. I collect all open options during the event window with a stock in the treatment or control group as the underlying. For example, in the case of France, this gives me 2,435 stock options on 42 stocks with a market capitalization above one billion Euros. The futures sample is constructed in the same manner. I compile all futures that trade during the event window with a stock in the treated or control group as the underlying. Table (8) shows the pre-event stock market summary statistics for trading activity and market liquidity.

In my identification strategy in equation (R.1), I compare all trading activity and market quality measures for stocks and derivatives affected by the tax to the untreated stocks in
Table 2: Number of treated and control stocks and derivatives

<table>
<thead>
<tr>
<th>Treated group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>French tax introduction in 2012</strong></td>
<td></td>
</tr>
<tr>
<td>81 French stocks above 1 billion EUR</td>
<td>25 Dutch stocks above 1 billion EUR</td>
</tr>
<tr>
<td>2,435 stock options on 42 French stocks</td>
<td>3,119 stock options on 19 Dutch stocks</td>
</tr>
<tr>
<td>303 futures on 38 French stocks</td>
<td>131 futures on 16 Dutch stocks</td>
</tr>
<tr>
<td><strong>Italian tax introduction 2013</strong></td>
<td></td>
</tr>
<tr>
<td>50 Italian stocks above 500 million EUR</td>
<td>51 Spanish stocks above 500 million EUR</td>
</tr>
<tr>
<td>7,764 stock options on 20 Italian stocks</td>
<td>9,692 stock options on 18 Spanish stocks</td>
</tr>
<tr>
<td>688 futures on 39 Italian stocks</td>
<td>349 futures on 33 Spanish stocks</td>
</tr>
<tr>
<td><strong>Spanish tax introduction 2021</strong></td>
<td></td>
</tr>
<tr>
<td>81 Spanish stocks above 1 billion EUR</td>
<td>80 Italian stocks above 1 billion EUR</td>
</tr>
<tr>
<td>9,642 stock options on 25 Spanish stocks</td>
<td>16,374 stock options on 24 Italian stocks</td>
</tr>
<tr>
<td>205 futures on 29 Spanish stocks</td>
<td>1,208 futures on 53 Italian stocks</td>
</tr>
</tbody>
</table>

the control country. Equation (R.1) shows the formal definition.\textsuperscript{16} Formally, the model described satisfies for each stock/derivative $i$ and date $t$ the following equation

$$
\mathbb{E}(y_{i,t}) = \alpha_i + \gamma_t + \beta D_{i,t} \tag{R.1}
$$

where $D_{i,t}$ is the dummy variable that takes the value of one for treated stocks in the months after the tax introduction and is zero otherwise. The terms $\alpha_i$ capture the security’s time-invariant fixed effects and $\gamma_t$ its time-fixed effects. Standard errors are clustered by security and time following Thompson (2011). The regression model specification (R.1), like all diff-in-diffs, relies on the untestable but crucial common trend assumption. It says in the absence of the treatment, the treated and control groups would have co-moved closely. It became customary in the diff-in-diff literature to use visual inspection to check for commonality in the control group (see figure 4) and to run placebo diff-in-diff estimations. Placebo diff-in-diff is a replication of equation (R.1) on random event days. In the absence of the treatment, regression results should not be statistically different from zero.\textsuperscript{17} The

\textsuperscript{16}The case of France, I follow Colliard and Hoffmann (2017) and adopt a flexible diff-in-diff to account for this strong seasonality that otherwise significantly biases the impact evaluation of the tax introduction. The flexible diff-in-diff allows the treatment in the first month after the tax introduction to be potentially different from the other months after the event. The seasonality stems from country-wide summer holidays (see Foley, Meling, and Ødegaard (2023)) and, based on anecdotal evidence, from legal uncertainty among market participants on whether they will be taxed.

\textsuperscript{17}The robustness tests of the common trend are presented in Table 9 and Figure 9 in Appendix B.
tests confirm the validity of my control groups. All empirical tests and results are based on security-day level panels. I use millisecond-stamped intraday trade and quote data from Thomson Reuters Refinitiv.

### 2.3 Measures of trading activity and market liquidity

In this section, based on the theoretical model of two markets, I derive the empirical financial market variables necessary to test the model predictions. I focus on trading activity and market liquidity measures.

As the model in 1.1 describes, an exogenous increase in trading costs (or, more directly, a tax on trading financial securities) changes the propensity to trade the treated security on that exchange. As such, I first assess the trading activity of stocks and their derivatives by estimating changes in trading volume and the frequency of taxed securities. Secondly, I assess the market depth and decompose the standard bid-ask spread into liquidity supplying and demanding trading costs.

*Log volume* is a trading activity measure calculated as the natural logarithm of the sum of EUR values traded on day $t$ and for stock/derivative $i$.

*Log depth* is the natural logarithm of the mean of the available liquidity at the inside spread of bid and ask sides.

As the model in 1.1 describes, adverse selection affects spreads and provided liquidity. The standard measure of the cost of a small round-trip transaction is quantified as the difference between the best ask and bid quote normalized by the mid-price. This can be expressed in percentage points or basis points (bps), contingent on its magnitude. The richness and abundance of Reuters’ millisecond financial market data enable a detailed dissection of this spread into four refined spread measures, along with its quoted depth. Following Foucault, Pagano, and Röell (2013), I decompose the bid-ask spread into the quoted spread, the effective spread, the price impact, and the realized spread.

*The quoted spread* is the weighted average bid-ask spread from the quotes posted on day $t$ for security $i$. The quoted spread is defined as

$$\text{quoted spread} = \frac{(a_\tau - b_\tau)(q_\tau / q_{i,t})}{m},$$

where $(a_\tau - b_\tau)(q_\tau / q_{i,t})$ is the weighted average bid-ask spread divided by the mid-price $(m)$.

---

18The standard bid-ask spread is only a good measure of trading costs for orders that are small enough to be entirely filled at the best quotes.
The effective spread calculates trading costs using the prices actually obtained by investors and measures the slippage incurred. It is defined as the difference between the price at which a market order executes \( p_\tau \) and the mid-quote \( \text{mid}_\tau \) on the market the instant right before the trade happens. The effective spread is likely to increase with the size of transactions. The effective spread for trade \( \tau \) for a given security is then given as

\[
effective\ \text{spread} = q_\tau \frac{p_\tau - \text{mid}_\tau}{\text{mid}_\tau},
\]

where \( q_\tau \) is a buy-sell indicator taking the value of 1 (-1) for buys (sells). Trades are signed using the algorithm proposed by Lee and Ready (1991).

The effective spread is comprised of the realized spread and the price impact. The realized spread can be interpreted as the compensation liquidity providers receive after accounting for trades with informed traders. It is a proxy for revenues of liquidity provision. The price impact can be interpreted as a measure of adverse selection.

The realized spread implicitly adopts the viewpoint of liquidity suppliers and is calculated as the difference between the transaction price and the mid-price five minutes after the transaction. The underlying assumption is that the interval should be long enough to ensure that market quotes have adjusted to reflect the price impact of the transaction.

\[
\text{realized\ spread} = q_\tau \frac{p_\tau - \text{mid}_{\tau+5\min}}{\text{mid}_\tau},
\]

where \( \text{mid}_{\tau+5\min} \) is the mid-quote five minutes after the transaction.

The price impact is defined as follows and measures transaction costs that are based on the extent to which an order generates an adverse reaction in the market price.

\[
\text{price\ impact} = q_\tau \frac{\text{mid}_{\tau+5\min} - \text{mid}_\tau}{\text{mid}_\tau},
\]
Figure 4 presents the difference-in-difference estimates of the causal effects of the three distinct FTT designs on trading volumes, both on-exchange and OTC. These plots display the cross-sectional average for treated (black) stocks and control (light gray) stocks, adjusted by their respective pre-event averages. The time series have been smoothed using a five-day moving average. The dashed lines indicate the averages for the treated and the control group. By construction, they are zero and the same before the event. After the event, the difference serves as a visual representation of the difference-in-difference estimates, aligning with the regression results found in Tables 3, 4, 5, and 6.
3 The causal FTT effects on market quality

This section presents the estimated causal impacts of the FTT on various market quality measures. The results are divided into three sections. The first section explores the effects of Italy’s FTT introduction, which taxes both stock and derivative transactions. This is followed by analyses of the French and Spanish scenarios, where the tax is applied solely to stock transactions.

3.1 Results for Italy

The causal estimation results for the Italian FTT introduction on stock transactions indicate that the tax did not impact trading volume but contributed to a significant decline in market liquidity, causing both quoted and effective spreads in the stock market to increase. The results are presented in Table 3 and Figure (4). Column (1) in Table 3 shows the effect on volume and market liquidity for stocks traded on regulated markets.

For trading volume, while the estimate is negative, a decrease in trading activity of the taxed group relative to the control group, the effect is statistically insignificant. In contrast, I observe a substantial decline in trading volume for Italian stocks traded in the higher taxed OTC markets, column (4). This finding is consistent with my model in Section 1.1, which anticipates a migration of trading volume from the taxed to the untaxed market. In this instance, it refers to the migration of trading activity from the higher taxed OTC market (0.20% tax rate) to the comparatively lower taxed on-exchange market (0.10% tax rate).

The deterioration in market liquidity, both quoted and effective spreads, seems to be primarily driven by a 15 bps increase in the realized spread - the rewards required by liquidity providers. An FTT introduction of 0.10% (10 bps) on stock transactions causes the effective spread to increase by 0.21% (21 bps) and the quoted spread by 0.48% (48 bps). In Section 1.1, the model predicts that the introduction of an FTT reduces competition among market makers which allows them to exercise market power and subsequently increase their reward for providing liquidity. This is consistent with compensation for paying national FTTs in Italy, where the exemptions for liquidity providers are strict. The finding is

19 For all of my results on stocks traded on regulated markets, I use data for the national exchanges, e.g. Borsa Italia (Italy), Euronext Paris (France), and the Bolsa de Madrid (Spain). The choice is based on the fact that these national markets account for the vast majority of the liquidity for stocks issued in these respective countries.

20 This result is further supported by the quarterly aggregated year-to-year changes in OTC volumes for Italian markets reported by Italian Companies and Exchange Commission (CONSOB) and Cappelletti, Guazzarotti, and Tommasino (2017)
Table 3: Causal Effect of the Italian FTT on Stocks

This table presents the estimates for the coefficient $\beta$ from equation $E(y_{i,t}) = \alpha_i + \gamma_t + \beta D_{i,t}$, where the dependent variable corresponds to proxies for trading activity and market liquidity described in section 2.3. Volume and depth are presented as percentages, while spread measures are denoted in basis points (bps). The regression is applied to the introduction of the tax on Italian stocks with a market capitalization above €500 million, and the event date is, therefore, 01.03.2013. Due to OTC data constraints, determining liquidity measures for OTC markets is not feasible. Standard errors (in parenthesis) are clustered by stock and time, and as usual, ***, **, * denote statistical significance at the 1%, 5%, and 10% level.

<table>
<thead>
<tr>
<th></th>
<th>Stocks</th>
<th>Options</th>
<th>Futures</th>
<th>OTC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trading activity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>volume</td>
<td>-0.057</td>
<td>0.201</td>
<td>0.131</td>
<td>-0.610***</td>
</tr>
<tr>
<td>(0.082)</td>
<td>(0.138)</td>
<td>(0.144)</td>
<td>(0.219)</td>
<td></td>
</tr>
<tr>
<td><strong>Market liquidity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>depth</td>
<td>-0.040</td>
<td>-0.066</td>
<td>0.107</td>
<td></td>
</tr>
<tr>
<td>(0.039)</td>
<td>(0.137)</td>
<td>(0.245)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>quoted spread</td>
<td>0.484**</td>
<td>0.099</td>
<td>-0.080</td>
<td></td>
</tr>
<tr>
<td>(0.199)</td>
<td>(0.372)</td>
<td>(0.098)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>effective spread</td>
<td>0.214***</td>
<td>-0.390</td>
<td>0.419</td>
<td></td>
</tr>
<tr>
<td>(0.081)</td>
<td>(0.286)</td>
<td>(0.735)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>realized spread</td>
<td>0.153**</td>
<td>0.517</td>
<td>0.151</td>
<td></td>
</tr>
<tr>
<td>(0.061)</td>
<td>(0.438)</td>
<td>(0.113)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>price impact</td>
<td>0.034*</td>
<td>-0.175</td>
<td>-0.200</td>
<td></td>
</tr>
<tr>
<td>(0.020)</td>
<td>(0.254)</td>
<td>(0.151)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| # treated | 51 | 1148 | 223 | 65 |
| # control | 50 | 2213 | 125 | 37 |
| # observations | 8200 | 19345 | 5205 | 5305 |

supported by Malinova and Park (2015), who find that higher explicit trading costs are passed on and translate into increased spreads. Further, I also observe increases in price impacts, consistent with an increase in the adverse selection component of the spread. It is economically small and weakly significant at the 10%-significance level. This is in line with my model of FTTs with imperfect competition (Section 1.1 and Figure 3), where reduced competition exacerbates the exposure of each market maker to informed traders, which increases the price impact.\(^\text{21}\)

Columns (2) and (3) report the results for options and futures written on Italian stocks traded in regulated markets.\(^\text{22}\). Overall, the results for options and futures show no sta-

\(^{21}\)Comerton-Forde, Hendershott, Jones, Moulton, and Seasholes (2010) show empirically that market-maker balance sheets explain time variation in liquidity. A decrease in the number of market makers providing liquidity can lead to the same economic effect as a constant number of market makers reducing their balance sheet capacity (Grossman and Miller, 1988). This holds true if the balance sheet capacity of the market maker remains unchanged post-FTT introduction.

\(^{22}\)Specifically, I report measures for the aggregation of derivatives traded on the Borsa Italiana and
Table 4: Causal Effect of the Italian FTT on Derivatives

This table presents the estimates for the coefficient $\beta$ from equation $E(y_{i,t}) = \alpha_i + \gamma_t + \beta D_{i,t}$, where the dependent variable corresponds to proxies for trading activity and market liquidity described in section 2.3. The regression is applied to the introduction of the tax on derivatives written on Italian stocks, with an event date of 01.09.2013. Volume and depth are presented as percentages, while spread measures are denoted in basis points (bps). Due to OTC data constraints, determining liquidity measures for OTC markets is not feasible. Standard errors (in parenthesis) are clustered by stock and time, and as usual, $$**, *$$ denote statistical significance at the 1%, 5%, and 10% level.

<table>
<thead>
<tr>
<th></th>
<th>Stocks</th>
<th>Options</th>
<th>Futures</th>
<th>OTC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trading activity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log volume</td>
<td>-0.005</td>
<td>-0.051</td>
<td>-0.119</td>
<td>-0.0157</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.097)</td>
<td>(0.339)</td>
<td>(0.216)</td>
</tr>
<tr>
<td><strong>Market liquidity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log depth</td>
<td>0.040***</td>
<td>-0.075</td>
<td>-0.003</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.183)</td>
<td>(0.141)</td>
<td></td>
</tr>
<tr>
<td>quoted spread</td>
<td>0.036</td>
<td>-0.123</td>
<td>-0.184</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.170)</td>
<td>(0.141)</td>
<td></td>
</tr>
<tr>
<td>effective spread</td>
<td>0.155</td>
<td>-0.125</td>
<td>0.173</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.096)</td>
<td>(0.282)</td>
<td>(0.136)</td>
<td></td>
</tr>
<tr>
<td>realized spread</td>
<td>0.123</td>
<td>-0.228</td>
<td>0.188</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.079)</td>
<td>(0.274)</td>
<td>(0.340)</td>
<td></td>
</tr>
<tr>
<td>price impact</td>
<td>0.019</td>
<td>0.809</td>
<td>-0.225</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.079)</td>
<td>(0.984)</td>
<td>(0.199)</td>
<td></td>
</tr>
</tbody>
</table>

# treated | 51 | 1213 | 84 | 65
# control | 52 | 2273 | 148 | 37
# observations | 8858 | 19570 | 2095 | 5854

Table 4 shows the results for the introduction of the FTT on derivatives in Italy, which was introduced six months after the stock tax — September 1st, 2013. I do not find any significant changes in either volume or liquidity. The model predicts a weaker relative response of the market to a tax on stock options relative to stocks. Relative to the stock market, trading volume is low in the options market. A small tax on derivatives seems to have a very mild effect on the markets. Alternatively, market participants have learned from the FTT introduction on stocks six months before and preemptively adjusted their behavior in anticipation of its effects.

Statistically significant effects on trading volume or market liquidity. In line with my model predictions for trading migration of informed traders, I find evidence consistent with a 20% increase in trading volume in the options market, although it is not found to be statistically significant.

EUREX, which combined account for the major share of on-exchange derivatives trading for the products considered.
Table 5: Causal Effect of the French FTT

This table presents the estimates for the coefficient $\beta$ from equation $E(y_{i,t}) = \alpha_i + \gamma_t + \beta D_{i,t}$, where the dependent variable corresponds to proxies for trading activity and market liquidity described in section 2.3. Note that for France, I use the flexible model to account for seasonality. Due to OTC data constraints, determining liquidity measures for OTC markets is not feasible. Volume and depth are presented as percentages, while spread measures are denoted in basis points (bps). The regression is applied to the introduction of the tax on French stocks with a market capitalization above €1 billion, and the event date is 01.08.2012. Standard errors (in parentheses) are clustered by stock and time, and as usual, ***, **, * denote statistical significance at the 1%, 5%, and 10% level.

<table>
<thead>
<tr>
<th></th>
<th>Stocks</th>
<th>Options</th>
<th>Futures</th>
<th>OTC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trading activity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log volume</td>
<td>-0.093**</td>
<td>-0.117</td>
<td>-0.259</td>
<td>-0.019</td>
</tr>
<tr>
<td>(0.057)</td>
<td>(0.114)</td>
<td>(0.194)</td>
<td>(0.278)</td>
<td></td>
</tr>
<tr>
<td><strong>Market liquidity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log depth</td>
<td>-0.007</td>
<td>-0.132</td>
<td>0.164***</td>
<td></td>
</tr>
<tr>
<td>(0.037)</td>
<td>(0.160)</td>
<td>(0.037)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>quoted spread</td>
<td>-0.091</td>
<td>0.296***</td>
<td>-0.059</td>
<td></td>
</tr>
<tr>
<td>(0.585)</td>
<td>(0.216)</td>
<td>(0.042)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>effective spread</td>
<td>0.221</td>
<td>0.566**</td>
<td>0.422</td>
<td></td>
</tr>
<tr>
<td>(0.156)</td>
<td>(0.258)</td>
<td>(0.522)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>realized spread</td>
<td>0.002</td>
<td>0.715***</td>
<td>0.352</td>
<td></td>
</tr>
<tr>
<td>(0.085)</td>
<td>(0.212)</td>
<td>(0.451)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>price impact</td>
<td>0.124</td>
<td>0.134***</td>
<td>0.222</td>
<td></td>
</tr>
<tr>
<td>(0.098)</td>
<td>(0.301)</td>
<td>(0.970)</td>
<td></td>
<td></td>
</tr>
<tr>
<td># treated</td>
<td>81</td>
<td>1036</td>
<td>93</td>
<td>275</td>
</tr>
<tr>
<td># control</td>
<td>25</td>
<td>1260</td>
<td>43</td>
<td>111</td>
</tr>
<tr>
<td># observations</td>
<td>11818</td>
<td>34113</td>
<td>3213</td>
<td>12127</td>
</tr>
</tbody>
</table>

3.2 Results for France

The overall result of the FTT introduction in France shows a decrease in stock market volume, though its market liquidity remains unaffected. In the options market, trading volume remains unaffected, but market liquidity deteriorates, aligning with my model’s predictions of migration of informed traders as detailed in Section 1.1 and Figure 2.

In line with my model’s predictions, stock volume decreases by around 10% after the introduction of the FTT as trading frequency and quantities are reduced, and trading migrates away from the taxed market. Market liquidity stays unaffected in the aggregate (column (1)). This is in line with Colliard and Hoffmann (2017).

For options, I find evidence of trading migration by informed traders from the taxed stock to the untaxed options market. The model in section 1.1 predicts that spreads increase.

23See Colliard and Hoffmann (2017) for a detailed discussion of the impact of the FTT on stock liquidity.
in the options markets after taxation of the stock market due to the amplification of adverse selection in the untaxed market. This result in the model stems from the trading migration of informed traders to the untaxed market. A higher share of informed traders in the options market forces market makers to increase spreads to compensate for losses against better-informed insiders. My empirical findings support these theoretical predictions. The observed increase in the quoted and effective spread are both economically and statistically significant. Consistent with my model, I observe increases in price impact, representing an increase in adverse selection, and higher realized spreads, resulting in increased rewards to liquidity providers. The findings suggest that the tax in the stock market leads to a higher share of informed trading in the options market, which increases both adverse selection and quoted spreads. This is captured by an increase in the price impact of 14 bps, which represents the adverse selection cost of the effective spread. The findings also suggest that the FTT in the stock market increases the revenue of liquidity provision in the options market by around 72 bps. The options trading volume stays unaffected by the tax.

In the futures market, the market depth increases by around 16%, whereas volume and spread measures of futures stay unaffected by the tax in the stock market. The empirical results suggest that futures are not utilized to avoid paying the FTT, nor do they represent a viable trading alternative for informed traders. For France, where on- and off-exchange trading of stocks are taxed at the same rate, I do not observe a trading migration from OTC to lit markets.

### 3.3 Results for Spain

The overall results for the causal impact of the Spanish FTT on the market are the following: a significant decrease in trading volume in the stock market and an otherwise weak effect in all other respects of market quality. The results are presented in Table 6 and Figure (4).

Following the introduction of the FTT, stock market volume decreased significantly by 22%. As we can see in figure (4), Spanish and Italian stocks share a strong common trend before the FTT introduction, validating the parallel trends assumption. In the months after the introduction, the two markets diverge visibly. Stock market volume grew significantly in Italy in the month after the introduction, while volume in Spain decreased during the same period. The aggregate stock market liquidity is unaffected by the FTT introduction.

Overall, the measures for trading volume and liquidity in the options market are statistically insignificant. The effective spread increases by 35 bps, equally distributed between realized spread (22 bps) and price impact (26) bps. Consistent with the idea of informed trading migration from the taxed stock to the untaxed options market, I observe increases
Table 6: Causal Effect of the Spanish FTT

This table presents the estimates for the coefficient $\beta$ from equation $E(y_{i,t}) = \alpha_i + \gamma_t + \beta D_{i,t}$, where the dependent variable corresponds to proxies for trading activity and market liquidity described in section 2.3. Due to OTC data constraints, determining liquidity measures for OTC markets is not feasible. Volume and depth are presented as percentages, while spread measures are denoted in basis points (bps). The regression is applied to the introduction of the tax on Spanish stocks with a market capitalization above €1 billion on the event day 16.01.2021. Standard errors (in parenthesis) are clustered by stock and time, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% level.

<table>
<thead>
<tr>
<th></th>
<th>Stocks</th>
<th>Options</th>
<th>Futures</th>
<th>OTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trading activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log volume</td>
<td>-0.216***</td>
<td>-0.135</td>
<td>-0.049</td>
<td>0.199</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.108)</td>
<td>0.566</td>
<td>(0.202)</td>
</tr>
<tr>
<td>Market liquidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log depth</td>
<td>0.007</td>
<td>-0.137</td>
<td>0.107</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.089)</td>
<td>(0.144)</td>
<td></td>
</tr>
<tr>
<td>quoted spread</td>
<td>0.034</td>
<td>0.098</td>
<td>-0.080</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.070)</td>
<td>(0.135)</td>
<td>(0.1976)</td>
<td></td>
</tr>
<tr>
<td>effective spread</td>
<td>0.004</td>
<td>0.359</td>
<td>0.419</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
<td>(0.288)</td>
<td>(0.735)</td>
<td></td>
</tr>
<tr>
<td>realized spread</td>
<td>0.011</td>
<td>0.221</td>
<td>0.151</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.246)</td>
<td>(0.113)</td>
<td></td>
</tr>
<tr>
<td>price impact</td>
<td>0.001</td>
<td>0.260</td>
<td>-0.282*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.239)</td>
<td>0.151</td>
<td></td>
</tr>
<tr>
<td># treated</td>
<td>52</td>
<td>1220</td>
<td>138</td>
<td>74</td>
</tr>
<tr>
<td># control</td>
<td>81</td>
<td>3515</td>
<td>119</td>
<td>86</td>
</tr>
<tr>
<td># observations</td>
<td>12339</td>
<td>16122</td>
<td>1282</td>
<td>14247</td>
</tr>
</tbody>
</table>

in the effective spread and price impact. While economically significant, the results are not statistically significant in my sample period.

The results for futures are similar to those of France and Italy. The futures market does not react to an FTT introduction in the stock market, and the empirical results suggest that they are not utilized to avoid the FTT. The OTC markets do not exhibit a statistically significant reaction to the FTT introduction. In Spain, OTC and on-exchange trading are subject to the same tax rate of 0.20%.

### 3.4 FTT revenues

This section presents a country-specific analysis, contrasting the FTT’s revenues with its potential welfare losses. Using tax income data from respective national finance ministries and tax authorities, I investigate the economic effects of FTTs by comparing tax revenue against estimated welfare losses due to increased effective spreads post-FTT introduction.
My results underscore the significance of the tax design for economic welfare and suggest that FTTs with lenient market maker exemptions can lead to scenarios where the tax revenues from FTTs surpass the associated welfare losses. For tax designs with strict market maker exemptions, the estimated welfare loss is approximately twice as big as the tax revenues.

**Italy:** Figure 5 compares Italy’s FTT revenue and my estimates for the associated welfare loss. The FTT revenues and welfare loss are represented in millions of Euros. Monthly FTT income data is obtained from the Italian finance ministry (MEF, 2014 - 2023). The tax revenue remains relatively stable, averaging almost 40 million Euros per month. The calculation of the estimated welfare loss associated with the FTT proceeds as follows. I first estimate the monthly trading volume of stocks subject to the FTT. Subsequently, I adopt the stringent assumption that the 21 bps estimated increase in the effective spread from Table 3 represents the causal costs incurred for trading the affected stocks throughout the entire 2014-2023 sample. The average monthly welfare loss amounts to approximately 85 million Euros, which is about twice the collected taxes. Due to limited data availability, I have to limit my calculation of welfare loss only to Italian stock volume despite the tax also applying to derivatives. In my sample, the stock market volume accounts for over 95% of the total volume relative to derivative volume. The derivative data for the entire 2014-2023 period is unavailable to us.

**France:** Figure 6 shows the French FTT revenue relative to a potential welfare loss. The French tax authorities provide FTT revenues aggregated at a yearly frequency. The
welfare loss is calculated as in the Italian case. In France, I do not find a statistically significant increase in the effective spread. However, the point forecast in Table 5 indicates a statistically insignificant increase of 20 bps for France following the FTT introduction, which is of the same economic magnitude as in Italy. The resulting yearly welfare loss varies from 0 (assuming the point forecast to be insignificant) up to 1960 million Euros (assuming the increase of the effective spread equals 20 bps). The average yearly FTT revenue is approximately 1040 million Euros. In recent years, France’s FTT revenue has been increasing, suggesting a decline in tax-exempt transactions relative to the overall trading volume. This trend may be attributed to the growth of retail trading, driven by factors such as lower retail trading costs, gamification of online broker trading apps, and the prevalence of working from home during the COVID lock-downs (Aramian and Comerton-Forde, 2023).

Spain: In the case of Spain, I only observe confirmed yearly FTT revenues in 2021 amounting to 342 million Euros and a preliminary estimate of 2022 at 351 million Euros (ATE, 2022). The estimated effective spread increase in Spain is 0.004 bps and is statistically insignificant (see Table 6). This results in a yearly average FTT revenue of 348 million, with a corresponding average welfare loss of 9.96 million Euros.
4 Synopsis and policy relevance

The results of the FTTs’ impact on financial markets and tax revenues presented in the previous sections carry four implications for the optimal tax design. The subsequent section compares differences in FTT taxation across countries and formulates the implications and their consequences on the optimal financial transaction tax policy.

First, in my cross-country analysis, OTC and on-exchange transactions are subject to heterogeneous tax treatments. According to my model, a higher tax rate leads to a migration of trading volume towards the lower-taxed market. Empirically, I observe a significant reduction in OTC trading volume when it is treated with higher taxes, with trading migrating to the lit on-exchange market. When OTC and on-exchange trading activities are taxed at the same rate, I observe no difference in trading volumes or trading migrations. From a policy standpoint concerning the optimal FTT design, my findings suggest that it is prudent to maintain the same tax rate for both markets, on-exchange and OTC, to avoid distorting venue preferences. However, if the objective is to incentivize the transition from relatively more opaque OTC trading to lit exchanges, implementing a relatively higher tax rate in the OTC market proves to be an effective strategy.

Second, an FTT can apply to stocks only or additionally to its derivatives. Italy includes equity derivatives in the tax base. However, the average FTT revenue in Italy relative to GDP (0.25%) does not exceed those of France (0.4%) and Spain (0.26%), which exclude derivatives. This implies that, due to the comparatively much lower turnover of equity derivatives in relation to stock turnover, the inclusion of equity derivatives in the tax base does not considerably increase overall tax income. Nonetheless, a tax on derivatives may be beneficial as it reduces the incentive for tax avoidance and distorting venue preferences. Closing this tax avoidance strategy comes at a low cost. The empirical and theoretical evidence suggests that a derivative FTT exerts negligible adverse effects on the market.

Third, the Italian FTT design on stock and derivative transactions allows for the empirical test of the model’s predictions with respect to tax avoidance. This is particularly important because there has always been a concern that FTTs could be avoided using the derivatives market. The IMF writes in the assessment of the desirability of FTTs “Taxing only the spot market will drive trading into untaxed derivatives markets, lowering the capitalized discount of the tax in the spot market. In the extreme [...] all trading would take place in derivatives markets; the capitalized discount of the FTT would be zero; and the tax would collect no revenue.” (Matheson, 2011). I reject this common conception that the synthetic replication of stocks is a practiced alternative to avoid the FTT. This is
true for both stock options and equity futures.\textsuperscript{24} My findings demonstrate that, regardless of the tax design, this tax avoidance channel remains unused in all three countries under examination.

Fourth, the stringency of market maker exemptions has significant implications for both market quality and overall welfare. In a strict market maker regime, obtaining FTT tax-exempt status is cumbersome and expensive, and only designated market makers benefit from it. In the imperfect competition segment of Section 1, I theoretically examine this scenario by subjecting market-makers to the FTT, which reduces liquidity provision and, in extreme cases, causes market exit. The model suggests that, under imperfect competition, introducing an FTT results in wider realized spreads in the stock market as market-makers pass on the higher trading costs (Malinova and Park, 2015).

In my empirical analysis of the FTT’s impact with strict market maker exemption, I observe this increase in realized spread.\textsuperscript{25} I argue that the increase is due to the more restrictive market-maker exemption. Yet, as I only observe the aggregate effect, an alternative interpretation of the increase in realized spreads could be inventory risk resulting from the shift in trading volume from OTC to on-exchange markets (Stoll, 1978). While both effects are not mutually exclusive, I argue that the result is dominated by the strict market maker exemption for two reasons. First, there was no increase in the trading volume that market makers needed to manage in their inventory. The results in Table 3 report a statistically insignificant volume reduction of -5.7% for the market treated with the FTT. Second, the price impact, measuring the adverse selection component of the effective spread, increases in the case of strict market maker exemption, as suggested by the imperfect competition model. However, trading migration from OTC markets, generally perceived as uninformed (Ang, Shtauber, and Tetlock, 2013; Lee and Wang, 2022), is not expected to amplify the adverse selection portion of the spread.

In the cross-country analysis in the cases with more lenient market maker exemptions, I do not observe a statistically significant increase in the effective spread, my proxy for trading costs, following the introduction of the FTT. This suggests that offering lenient tax exemptions to market-makers can prevent distortive effects on the market. However, the lenient approach comes with a cost. The tax exemptions reduce the overall taxable base, thereby diminishing the tax revenues generated by the FTT. In Italy, with a strict

\textsuperscript{24}According to the French Financial Market Authority, there is no evidence of trading migration to untaxed OTC investment instruments, such as Contracts for Difference (CFDs) (AMF, 2017).

\textsuperscript{25}My findings on market quality differ from the conclusions drawn in previous research on the Italian FTT, such as the studies conducted by Cappelletti, Guazzarotti, and Tommasino (2017) and Hvozdyk and Rustanov (2016). With only daily data, both studies find no significant effects on liquidity.
market maker regime, FTT revenue amounts to 480 million Euros annually (0.25% of 2022 GDP). It is the only country in my analysis where a statistically significant increase in the effective spread, my proxy for trading costs, is observed. The welfare loss due to the FTT is approximately 1 billion Euros annually, which is twice the FTT revenues. In contrast, France does not show a statistically significant increase in trading costs but generates substantial annual tax revenue, amounting to 1,040 million Euros (0.4% of 2022 GDP). Between 2019 and 2021, the average yearly revenue increased to 1,628 million Euros (0.62% of 2022 GDP). Spain collected 342 million Euros in tax revenue in 2022 (0.26% of GDP) with an estimated negligible welfare loss of 10 million Euros.

My theoretical framework suggests that, under full market-maker exemptions, market liquidity increases in the taxed market, resulting in an overall improvement in welfare. Simultaneously, it predicts a decrease in liquidity in the untaxed market due to higher adverse selection, contributing to a reduction in welfare. In both my model and my empirical findings, the majority of trading activity takes place in the stock market. Therefore, the overall welfare effect remains strictly positive in the scenario where the stock market is taxed. Remarkably, this outcome persists even when the same tax rate is applied to both markets. This is because the transaction price in the options market is typically lower, resulting in a lower tax burden when the same ad valorem tax rate is applied compared to the stock market.

When I extend the FTT benchmark model to the imperfect competition scenario, the realized spread in the stock market increases, and the price impact decreases, see Section 1.1 and Figure 3. In equilibrium, the combination of strict market maker exemption and the FTT results in an effective spread higher than both its no-tax benchmark and the level of FTT with market maker exemption. Simultaneously, there is an improvement in liquidity and associated welfare coming from the options market. However, the net impact on overall welfare from an FTT without market-maker exemptions is negative, as the reduction in welfare in the stock market dominates the improvement in the options market. In summary, both my theoretical and empirical findings suggest that lenient exemptions are more favorable for countries seeking to raise tax revenues without compromising market quality and the associated welfare loss.

5 Conclusions

This paper sheds light on the impact of FTTs in a setting where alternative untaxed trading venues and products are available, and traders can choose to be active in taxed or untaxed
markets. Additionally, I discuss the desirability of specific FTT designs for a country’s tax composition and the overall welfare relative to the raised tax income. The analysis is conducted both theoretically, through a sequential trade model, and empirically with a difference-in-difference analysis to estimate the FTT’s causal effects.

The theoretical model provides four insights. It shows an asymmetric impact of taxes on stocks compared to options due to the leverage of options. The model also predicts a significant reduction in trading volume in the stock market when a tax is introduced, resulting from decreased traded quantities and trading frequencies. Furthermore, the model suggests increased market liquidity in the taxed market due to the alleviation of adverse selection. However, if the FTT reduces market maker competition, market liquidity suffers, and aggregate welfare is reduced.

Empirically, I find that FTTs introduced only on stocks with lenient market maker exemptions significantly affect trading activity but do not substantially influence aggregate liquidity in stock markets. The FTT design that reduces market maker competition impairs market liquidity. My findings also reveal trading migration from OTC equity to on-exchange markets when differential tax rates are implemented. On-exchange derivative trading activity is not significantly affected, challenging the common conception that the synthetic construction of stock payouts is a utilized alternative to avoid the FTT.

These empirical results confirmed three of the model’s predictions: the asymmetric effect of a tax on stocks relative to their derivatives, a significant decrease in stock volume while option volume remains relatively unaffected, and the migration of informed trading to the untaxed market. However, I find no empirical evidence supporting the theoretical prediction of improved market liquidity due to the alleviation of adverse selection problems in the taxed market.

This study highlights the critical role of market-maker exemptions in FTT design and its impact on the functioning of financial markets and tax income. I find that stringent market-maker exemptions display potential drawbacks, such as increased trading costs and welfare reductions surpassing the respective tax revenues. Conversely, an FTT with lenient market maker exemptions hardly weighs on financial markets whilst generating substantial tax revenues. The inclusion of equity derivatives in the tax base does not considerably increase overall tax income. Nonetheless, a tax on derivatives may be beneficial as it reduces the incentive for tax avoidance and distorting venue preferences. Closing this tax avoidance strategy comes at a low cost. My empirical and theoretical evidence suggests that a derivative FTT exerts negligible adverse effects on the market.

In light of these findings, policymakers must carefully consider the design of FTTs. The
choice of the optimal FTT design depends on the goal the tax is intended to achieve. My results demonstrate that if well designed, an FTT can deliver significant tax revenue to the government without imposing significant additional costs on participants in the stock markets. My findings also suggest that FTTs can inadvertently increase adverse selection in untaxed markets. Policymakers should consider these cross-market effects when designing a financial transaction tax.

References

AMF, 2017, The financial transaction tax: A really good idea, Capelle-Blancard Presentation to the Scientific Advisory Board of the AMF on September 14, 2015 The Scientific Advisory Board Review.


Aramian, Fatemeh, and Carole Comerton-Forde, 2023, Retail trading in European equity markets, Available at SSRN.

ATE, 2022, El nuevo impuesto sobre transacciones financieras, Nota informative 3, Agencia Tributaria.


Coelho, Maria, 2016, Dodging robin hood: Responses to France and Italy’s financial transaction taxes, Available at SSRN 2389166.


Directive, Council, 2019, Council directive implementing enhanced cooperation in the area of financial transaction tax, German delegation to the council of the European union, Explanatory Memorandum.


Ekeland, Ivar, Jean-Charles Rochet, and Vincent Wolff, 2021, Modernizing the tax system, unpublished working paper.


MEF, 2014 - 2023, APPENDICI STATISTICHE AL BOLLETTINO 225, Ministero dell Economia e delle Finanze.


A Mathematical Appendix

First, section A.1 introduces the static trade model of asymmetric information and financial transaction tax with its equilibrium strategies and prices. Second, section A.2 outlines the competition among market makers for order flow. Third, Section A.3 outlines the sequential trading model, allowing for a comprehensive characterization of the full-time series of quotes, prices, and traded volumes.

A.1 The benchmark model

At the beginning of each trading day, an information event happens with probability $\eta$. Conditional on an information event happening, the final value of the asset is either $S_0u$ or $S_0d$ with probabilities $\mu$ and $(1 - \mu)$, respectively, where $S_0$ is the value of the stock at the beginning of the trading day. Absent an information event, the final value of the asset is $S_0m$, with $u \geq m \geq d$. I will refer to the three states of the world as the "$u$-state" (up-state), "$m$-state" (middle-state) and "$d$-state" (down-state). For the derivative contracts, I restrict our attention to two options, a (European) call or put option with expiration at the end of the period and strike prices $K_c$ and $K_p$, respectively. The orders placed by the traders are market orders. Market makers set their prices after observing the order either from an insider or from a liquidity trader. Furthermore, it is assumed that the market makers in both the options and stock markets have access to the same information set.

The market is populated by a unit measure of traders, a fraction $\delta$ of which are informed insiders, and the remaining fraction $(1 - \delta)$ are liquidity traders. Insiders are risk-neutral and strategic and do not face any borrowing or short-selling constraints. The liquidity traders do not anticipate the impact of their orders on market prices. They choose their trades to maximize the utility of their terminal wealth, with a utility function given by $U(W) = W - \gamma W^2$, where $\gamma$ determines the risk aversion of the liquidity traders. The liquidity traders have state-contingent shocks, which cause them to trade in the stock or options markets to hedge their idiosyncratic risk exposure. There exist two types of liquidity traders: $LT_1$ is exposed to a liquidity shock equal to $-L$ in the $u$-state, $-l$ in the $m$-state, and 0 in the $d$-state; $LT_2$ is exposed to state-contingent shocks equal to 0, $-l$ and $-L$ for states $u$, $m$ and $d$ respectively. Finally, liquidity traders will trade in the stock market with probability $\omega$ or in the options market with probability $(1 - \omega)$. This results in four different types of liquidity traders, depending on the type of shock they experience and the market they use to hedge their risk ($\{LT_1^S, LT_2^S, LT_1^O, LT_2^O\}$).

I denote the probability of trading in the stock market as $\{\alpha_u, \alpha_d\}$ and the probability

Electronic copy available at: https://ssrn.com/abstract=4612809
Figure 7: The tree diagram summarizes the probabilistic structure of the model described in this section. At the LTS nodes the game develops as in the case where no information event happens. \( LT^S \), \( LT^C \) and \( LT^P \) refer to the liquidity traders that trade stocks, call options or put options respectively. \( LT_1 \) and \( LT_2 \) refer to the type of liquidity shocks experienced by the liquidity traders.
that the informed traders choose calls if they trade in the options market \( \{\beta_u, \beta_d\} \).

The profits available to an informed trader if \( S = S_0u \) are as follows:

\[
\Pi_{up} = \begin{cases} 
Q_s(S_0u - A_s) & \text{if buy stock} \\
Q_c((S_0u - K_c)\theta - A_c) & \text{if buy call} \\
Q_p B_p & \text{if sell put.}
\end{cases}
\]

(1)

and similarly, the payoffs for the down-state are:

\[
\Pi_{down} = \begin{cases} 
Q_s(B_s - S_0d) & \text{if sell stock} \\
Q_c B_c & \text{if sell call} \\
Q_p((K_p - S_0d)\theta - A_p) & \text{if buy put,}
\end{cases}
\]

(2)

where \( \{A_s, B_s, A_c, B_c, A_p, B_p\} \) are respectively the bid and ask prices for stock, call and put, \( \{Q^*_s, Q^*_c, Q^*_p\} \) are the trading strategies available to the informed trader and \( \theta \) is the number of stocks controlled by an option contract.

**Equilibrium strategies and prices**

The equilibrium in the economy described above is a standard rational expectation equilibrium, characterized by a set of prices and trading strategies such that the liquidity traders choose market orders to maximize their expected utility, the insiders choose their market orders to maximize their profits, and the market makers set prices equal to their conditional expectations.

The objective functions for the liquidity traders who trade in the stock market are:

\[
Q_s^{1s} = \arg \max_{\{Q_s\}} \mathbb{E}[U(Q_s)] = \max_{\{Q_s\}} \left[ \eta U[-L + (S_0u - A_s)Q_s] + (1 - \eta) U[-l + (S_0m - A_s)Q_s] + \eta(1 - \mu) U[(S_0d - A_s)Q_s] \right],
\]

(3)

\[
Q_s^{2s} = \arg \max_{\{Q_s\}} \mathbb{E}[U(Q_s)] = \max_{\{Q_s\}} \left[ \eta U[-L + (S_0u - A_s)Q_s] + (1 - \eta) U[-l + (S_0m - A_s)Q_s] + \eta(1 - \mu) U[(S_0d - A_s)Q_s] \right]
\]

(4)

For the liquidity traders in the options market, the objective functions are found by
substituting the relevant option payoffs for every possible state. The optimal strategies \( \{Q_s^*, Q_c^*, Q_p^*\} \) are derived by maximizing these functions.

The insiders anticipate the impact of their strategies on prices. Excessive trading by insiders in one asset informs the risk-neutral market maker of their type. The market maker has rational expectations and perfectly anticipates the strategies of both trader types. Deviations from the optimal quantities chosen by the liquidity trader \( (Q_s^{1*}, Q_c^{1*} \text{ or } Q_p^{1*}) \), the market maker infer that she is trading with an informed trader and sets the price equal to the expected value in the respective state of the world. To exploit private information while avoiding full revelation, the insider mimics the stock and option liquidity trades.

The market makers set equilibrium prices such that their expected profit is zero. The ask and bid prices represent the conditional value of the asset, contingent upon the market maker encountering either a buy or a sell order. In the stock market, I have the following bid and ask prices:

\[
A_s = E[S \mid Q_s > 0] = S_0uPr[u \mid Q_s > 0] + S_0mPr[m \mid Q_s > 0] + S_0dPr[d \mid Q_s > 0] \tag{5}
= \frac{S_0((m - m\eta + d(-1 + \delta)\eta(-1 + \mu))\omega + u\eta\mu(2\alpha_u\delta + \omega - \delta\omega))}{2\alpha_u\delta\eta\mu + \omega - \delta\eta\omega}
\]

\[
B_s = E[S \mid Q_s < 0] = S_0uPr[u \mid Q_s < 0] + S_0mPr[m \mid Q_s < 0] + S_0dPr[d \mid Q_s < 0] \tag{6}
= \frac{S_0(m(-1 + \eta)\omega + u(-1 + \delta)\eta\mu\omega + d\eta(-1 + \mu)(2\alpha_d\delta + \omega - \delta\omega))}{2\alpha_d\delta\eta(-1 + \mu) + (-1 + \delta\eta)\omega}
\]

In the options market, the bid and ask prices for puts and calls are defined accordingly. To illustrate, I present the bid price of a call option:

\[
B_c = E[\text{Call} \mid Q_c > 0] \tag{7}
= (K_p - S_0u)^+\theta Pr[u \mid Q_p < 0] + (K_p - S_0m)^+\theta Pr[m \mid Q_p < 0] + (K_p - S_0d)^+\theta Pr[d \mid Q_p < 0]
= \frac{\theta(K_c(1 - \eta - (\delta - 1)\eta\mu) - S_0(m - m\eta - u(-1 + \delta)\eta\mu))(1 + \delta)}{1 - \omega + \delta\eta(-1 + 4(-1 + \alpha_d)\beta_d(-1 + \mu) + \omega)}.
\]
Probability of informed trading

The model allows for two mutually exclusive equilibria: first, informed traders choose to trade only in either the stock or the options market ($\alpha_u, \alpha_d$ are at their boundaries). Second, informed traders are indifferent between trading in the two markets (e.g. $\alpha_u, \alpha_d$ are inside their boundaries). I will call the former a separating equilibrium and the latter a pooling equilibrium. I provide calculations for the case where the trader is informed that we are currently in an up-state. The conditions for a pooling equilibrium in the down-state are then found accordingly.

The profit of buying a stock, given that $\alpha_u = 1$, is

$$\Pi(BS) = \frac{(1 - \delta)(1 - \mu)\omega(\delta - L\gamma\omega + L\gamma\delta\omega)}{\gamma(2\delta\omega(\omega - 2\mu) - \omega^2 + \delta^2(4\mu(\omega - 1) - \omega^2))},$$

and the expected profit from buying the call or selling the put is

$$\Pi(BC) = \Pi(SP) = L(1 - \mu).$$

The conditions for a pooling equilibrium in the up-state is therefore

$$L(1 - \mu) > \frac{(1 - \delta)(1 - \mu)\omega(\delta - L\gamma\omega + L\gamma\delta\omega)}{\gamma(2\delta\omega(\omega - 2\mu) - \omega^2 + \delta^2(4\mu(\omega - 1) - \omega^2))},$$

Proposition 1 For the market structure described above, we have a pooling equilibrium if and only if

$$\frac{\delta(1 - \mu)(4L\gamma\mu(\delta(-1 + \omega) - \omega) + (-1 + \delta)\omega)}{\gamma(-\omega^2 + 2\delta + \omega(-2\mu + \omega) + \delta^2(4\mu(-1 + \omega) - \omega^2))} > 0$$

and

$$\frac{\mu((1 - \delta)\delta\omega - L(-1 + \gamma(-1 + \delta)^2\omega^2))}{\gamma(\delta^2((-2 + \omega)^2 + 4\mu(-1 + \omega)) + \omega^2 - 2\delta\omega(-2 + 2\mu + \omega))} > 0,$$

and the equilibrium $\{\alpha_u, \alpha_d\}$ and $\{\beta_u, \beta_d\}$ are then given by

$$\alpha_u^* = \alpha_d^* = \omega \quad \text{and} \quad \beta_u^* = \beta_d^* = \frac{1}{2}$$

\footnote{For the remainder of this section I assume $\eta = 1$, $m = 1$, $K_c = S_d$, $K_p = S_u$ and $S_0 = 1$ in order to facilitate the exposition of the results.}
The equilibrium trading strategies are

\[ Q_s^1 = \frac{L\gamma(-1 + \delta) + \delta(1 + \delta(-1 + 2\mu))}{(d - u)\gamma(1 + \delta^2 + \delta(-2 + 4\mu))}, \quad (14) \]

\[ Q_c^1 = Q_p^1 = \frac{L\gamma(-1 + \delta) + \delta(1 + \delta(-1 + 2\mu))}{(d - u)\gamma\theta(1 + \delta^2 + \delta(-2 + 4\mu))}, \quad (15) \]

\[ Q_s^2 = \frac{L\gamma(-1 + \delta) + \delta(-1 + \delta(-1 + 2\mu))}{(u - d)\gamma(1 + \delta^2 + \delta(2 + 4\mu))}, \quad (16) \]

\[ Q_c^2 = Q_p^2 = \frac{L\gamma(-1 + \delta) + \delta(-1 + \delta(-1 + 2\mu))}{(u - d)\gamma\theta(1 + \delta^2 + \delta(2 + 4\mu))}, \quad (17) \]

and the equilibrium prices are

\[ A_s = \frac{d(-1 + \delta)(-1 + \mu) + u(1 + \delta)\mu}{1 + \delta(-1 + 2\mu)}, \quad B_s = \frac{\delta(1 + \delta)(\mu - 1) + u(\delta - 1)\mu}{\delta(2\mu - 1) - 1}, \quad (18) \]

\[ A_c = \frac{(u - d)(1 + \delta)\theta\mu}{1 + \delta(2\mu - 1)}, \quad B_c = \frac{(u - d)(\delta - 1)\theta\mu}{\delta(2\mu - 1) - 1}, \quad (19) \]

\[ A_p = \frac{(u - d)(1 + \delta)\theta(\mu - 1)}{\delta(2\mu - 1) - 1}, \quad B_c = \frac{(u - d)(\delta - 1)\theta(\mu - 1)}{1 + \delta(2\mu - 1)}. \quad (20) \]

**Financial transaction taxes**

In line with the transaction taxes introduced in the last decade, I limit ourselves to studying two tax scenarios – a tax on stocks and a tax on stocks and options. The FTT is introduced as a percentage of the transaction value. For instance, when buying a stock, the agent pays \( A_s(1 + t) \), where \( A_s \) is the ask price and \( t \) the transaction tax, or when selling a stock, the agent receives \( (B_s(1 - t)) \).

**A.2 Imperfect competition**

In this section, dealers compete for the order flow by providing a quote schedule.\(^{27}\) A quote schedule is a set of quantities market makers are willing to trade at any designated price.\(^{27}\)

\(^{27}\)In the benchmark case in section A.1, market makers, when chosen to trade, are allotted the full order flow. This mechanism leads to market makers slightly undercutting each other’s quotes until prices equal their conditional expectations and expected profits are zero.
At every trading round, an auctioneer will then parcel out the full order flow amongst all the market makers at the market clearing price.

I consider a fixed number of market makers $M$, a proportion $m_s$ of which provide liquidity in the stock market, and $(1-m_s)$ provide liquidity in the options market. I then define $Q_s^m(p_s)$ and $Q_o^m(p_o)$ to be the total number of shares or options that a dealer is willing to sell (or offer to buy if $Q < 0$) at price $p$. The total market supply for the two markets at price $p$ is then $\sum^M Q_s^m(p_s)m_s$ and $\sum^M Q_o^m(p_o)(1-m_s)$. We seek a rational expectation equilibrium such that the set of schedules set by market markers $\{Q_m(p)\}_{m=1}^M$ and the resultant price mapping $p^*(q)$ is such that it maximizes their profits, they correctly anticipate the clearing price and forms expectations accordingly, the markets clear, e.g. $\sum^M m_sQ_s^m(p_s) = Q_s$ and $\sum^M (1-m_s)Q_o^m(p_o) = Q_o$.

**Proposition 2** Market makers in the stock market will post the following quantity and price schedules:

\[
Q_s^m(p) = \begin{cases} 
\phi_s p & \text{if } p = A_s \\
\frac{1}{\phi_s} p & \text{if } p = B_s 
\end{cases} \quad \text{with} \quad \phi_s = \frac{(M-2)}{(M-1)(Mm_s - m_s - M)\alpha_s}, \tag{21}
\]

\[
p_s(Q_s) = \begin{cases} 
\lambda_s Q_s & \text{if } Q_s > 0 \\
\frac{1}{\lambda_s} Q_s & \text{if } Q_s < 0 
\end{cases} \quad \text{with} \quad \lambda_s = \frac{(M-1)(1-m_s + Mm_s)\alpha_s}{M(M-2)m_s}, \tag{22}
\]

and the market makers in the options market will post the following schedules:

\[
Q_o^m(p) = \begin{cases} 
\phi_o p & \text{if } p = A_o \\
\frac{1}{\phi_o} p & \text{if } p = B_o 
\end{cases} \quad \text{with} \quad \phi_o = \frac{(M-2)}{((M-1)(M(1-m_s) + m_s)\alpha_o}, \tag{23}
\]

\[
p_o(Q_o) = \begin{cases} 
\lambda_o Q_o & \text{if } Q_o > 0 \\
\frac{1}{\lambda_o} Q_o & \text{if } Q_o < 0 
\end{cases} \quad \text{with} \quad \lambda_o = \frac{(M-1)(M(1-m_s) + m_s)\alpha_o}{M(M-2)(1-m_s)} \tag{24}
\]

As market makers face less competition in liquidity provision, they will be able to use their market power to increase their rents by increasing spreads. The magnitude of the effect of imperfect competition on the posted quantities and respective prices depends both on...
$M$, the total number of market makers in the market, and $m_s$, the relative presence of market makers in the stock versus the options market.

### A.3 Sequential model

The static model can be extended to a sequential trading model by updating the market makers’ beliefs, the probabilities informed trading, and quotes and prices. The advantages of the sequential model are the characterization of the full-time series of quotes, prices, and volume, which are used to explicitly derive the standard liquidity measures that can be empirically calculated with readily available TAQ data.

As in the benchmark scenario of section A.1, at the beginning of a trading day, an information event happens with probability $\eta$. Conditional on the information event happening, we are either in a high or low state of the world. During the day, the market maker will update her probabilities that an information event happened at the start of the day and her probability of the state of the world based on the incoming trades. For example, a stock purchase will increase the market maker’s belief that we are currently in an up-state.

The sequential model can be represented by the following set of equations, which provide a time series of trades, quantities, and prices.

$$
\mu_j(\text{Buy Stock}; \mu_{j-1}) = \frac{\mu_{j-1}(2\alpha_u\delta + \omega - \delta\omega)}{2\alpha_u\delta\mu_{j-1} + \omega - \delta\omega}
$$

$$
\mu_j(\text{Buy Call}; \mu_{j-1}) = \frac{\mu_{j-1}(\delta - 1 + 4(\alpha_u - 1)\beta_u\delta + \omega - \delta\omega)}{\delta - 1 + 4(\alpha_u - 1)\beta_u\delta + \omega - \delta\omega}
$$

$$
\mu_j(\text{Sell Put}; \mu_{j-1}) = \frac{\mu_{j-1}(1 - \omega + \delta(3 + 4\alpha_u(\beta_u - 1) - 4\beta_u + \omega))}{1 - \omega + \delta(4(\alpha_u - 1)(\beta_u - 1)\mu_{j-1} - 1 + \omega)}
$$

$$
\eta_j(\text{Buy Stock}; \eta_{j-1}; \mu_{j-1}) = \frac{\eta_{j-1}(2\alpha_u\delta\mu_{j-1} + \omega - \delta\omega)}{2\alpha_u\delta\eta_{j-1}\mu_{j-1} + \omega - \delta\eta_{j-1}\omega}
$$

$$
\eta_j(\text{Buy Call}; \eta_{j-1}; \mu_{j-1}) = \frac{\eta_{j-1}(\delta - 1 + 4(\alpha_u - 1)\beta_u\delta\mu_{j-1} + \omega - \delta\omega)}{\delta\eta_{j-1}(1 + 4(\alpha_u - 1)\beta_u\mu_{j-1} - \omega) + \omega - 1}
$$

$$
\eta_j(\text{Sell Put}; \eta_{j-1}; \mu_{j-1}) = \frac{\eta_{j-1}(1 - \omega + \delta(4(\alpha_u - 1)(\beta_u - 1)\mu_{j-1} + \omega - 1))}{1 - \omega + \delta(4(\alpha_u - 1)(\beta_u - 1)\mu_{j-1} + \omega - 1)}
$$

In order to determine the option prices in the sequential model, I exploit the trinomial structure of stock prices implied by the probability tree. In fact, the model above implies
that the stock prices are determined by the following trinomial tree:

\[
S_{t+1} = \begin{cases} 
S_t u & \text{with probability } p_u = \eta \times \mu \\
S_t m & \text{with probability } p_m = 1 - \eta \\
S_t d & \text{with probability } p_d = \eta \times (1 - \mu)
\end{cases}
\]

Note that this structure of stock prices can be seen as the discretized version of stock prices derived from a (hypothetical) geometric Brownian motion. In order to determine the risk-neutral probabilities \(p_{RN}^u, p_{RN}^d, p_{RN}^m\) and the appropriate jump sizes \(\{u, m, d\}\), I construct conditions that match the parameters of the trinomial tree with the first two moments of the distribution of the (hypothetical) geometric Brownian motion, while also imposing that the probabilities are specified so that the growth rate of the stock matches the risk-free rate.

\[
\mathbb{E}[S_{t+1} \mid S_t] = e^{r\Delta t} S_t \quad (25)
\]
\[
\text{Var}[S_{t+1} \mid S_t] = \Delta t S_t^2 \sigma^2 \quad (26)
\]

Additionally, I impose the two following constraints on the jumps sizes

\[
ud = 1 \quad \text{and} \quad m = 1 \quad (27)
\]

These constraints imply that the upward jump is the reciprocal of the downward jump, which leads to a recombining tree, where the number of nodes in the tree grow linearly with the number of steps. Then, if we additionally impose \(p_{RN}^m = 1 - p_{RN}^u - p_{RN}^d\), we end up with three constraints on four parameters \(\{u, d, p_{RN}^u, p_{RN}^d\}\). We have discretion over the choice of the jump sizes, and, following the literature, I set:

\[
u = e^{\beta \sigma \sqrt{\Delta t}}, \quad d = e^{-\beta \sigma \sqrt{\Delta t}}
\]

where \(\beta > 1\) is chosen such that a risk-neutral measure exists (and such that \(p_{RN}^u + p_{RN}^d < 1\)).
The risk-neutral probabilities are then given by

\[ p_{RN}^{u} = \frac{1 - e^{r \Delta t} - e^{r \Delta t + \sqrt{\Delta t} \beta \sigma} + e^{2r \Delta t + \sqrt{\Delta t} \beta \sigma} + \Delta t e^{\sqrt{\Delta t} \beta \sigma} \sigma^2}{(e^{\sqrt{\Delta t} \beta \sigma} - 1)^2 (1 + e^{\sqrt{\Delta t} \beta \sigma})} \]

\[ p_{RN}^{d} = \frac{e^{2 \sqrt{\Delta t} \beta \sigma} (e^{r \Delta t} - e^{2^{r \Delta t}} - e^{\sqrt{\Delta t} \beta \sigma} + e^{r \Delta t + \sqrt{\Delta t} \beta \sigma} - \Delta t \sigma^2)}{(e^{\sqrt{\Delta t} \beta \sigma} - 1)^2 (1 + e^{\sqrt{\Delta t} \beta \sigma})} \]

\[ p_{RN}^{m} = 1 - p_{RN}^{u} - p_{RN}^{d} \]

In order to find the option prices, we have to determine the option payoffs at maturity T:

\[ C^c(S, T) = max(S - K_c, 0) \]
\[ C^p(S, T) = max(K_p - S, 0) \]

The remaining prices can then be determined by the following backward induction formula:

\[ C_{n,t}^{c,p} = e^{-r \Delta t} [p_u^{RN} C_{n+1,t+1}^{c,p} + p_m^{RN} C_{n,t+1}^{c,p} + p_u^{RN} C_{n-1,t+1}^{c,p}] \] (28)

where \{n, t\} determine the node and time step of the trinomial tree. In order to make the option pricing coherent with the trading structure, I assume that the step sizes of the trinomial tree (t) represent days. This implies that the option pricing outlined in this section provides daily option prices for every possible path of the probability tree, which in turn is determined by the set of two probabilities \{\eta, \mu\}. The intraday option ask and bid prices can then be determined in the following way:

\[ Ask_{k,t}^c = C_{n+1,t+1}^c Pr_{k,t}[u \mid Buy] + C_{n,t+1}^c Pr_{k,t}[m \mid Buy] + C_{n-1,t+1}^c Pr_{k,t}[d \mid Buy] \]
\[ Bid_{k,t}^c = C_{n+1,t+1}^c Pr_{k,t}[u \mid Sell] + C_{n,t+1}^c Pr_{k,t}[m \mid Sell] + C_{n-1,t+1}^c Pr_{k,t}[d \mid Sell] \]

where k defines the trading round during trading day t. The ask and bid prices for the put option are found similarly.
Figure 8: The change in trading frequency in the sequential model

The Figure shows the histogram of daily trading frequencies with and without FTT. The dark bins show the frequency when the tax is in place, and the light bins show the frequency without taxation.
### B Empirical appendix

Table 7: Summary statistics of stock market variables

<table>
<thead>
<tr>
<th>Stock trading activity</th>
<th>France</th>
<th>Netherlands</th>
<th>Italy</th>
<th>Spain</th>
<th>Spain</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td>log volume</td>
<td>16.32</td>
<td>16.68</td>
<td>15.53</td>
<td>15.48</td>
<td>15.51</td>
<td>15.61</td>
</tr>
<tr>
<td></td>
<td>1.45</td>
<td>1.16</td>
<td>2.02</td>
<td>2.31</td>
<td>1.84</td>
<td>1.71</td>
</tr>
<tr>
<td>Stock liquidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log depth</td>
<td>3.68</td>
<td>4.13</td>
<td>3.81</td>
<td>3.47</td>
<td>3.26</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>0.90</td>
<td>0.74</td>
<td>1.23</td>
<td>0.86</td>
<td>0.66</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>9.30</td>
<td>5.48</td>
<td>20.09</td>
<td>27.26</td>
<td>35.86</td>
<td>15.56</td>
</tr>
<tr>
<td>effective spread</td>
<td>4.27</td>
<td>3.60</td>
<td>9.03</td>
<td>11.07</td>
<td>9.63</td>
<td>5.17</td>
</tr>
<tr>
<td></td>
<td>2.60</td>
<td>1.61</td>
<td>7.42</td>
<td>11.28</td>
<td>14.12</td>
<td>5.38</td>
</tr>
<tr>
<td>realized spread</td>
<td>1.83</td>
<td>0.72</td>
<td>4.26</td>
<td>6.11</td>
<td>4.86</td>
<td>3.86</td>
</tr>
<tr>
<td></td>
<td>1.42</td>
<td>0.92</td>
<td>5.23</td>
<td>7.94</td>
<td>10.01</td>
<td>4.63</td>
</tr>
<tr>
<td>price impact</td>
<td>2.00</td>
<td>1.58</td>
<td>2.85</td>
<td>2.83</td>
<td>1.64</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>1.47</td>
<td>1.14</td>
<td>2.47</td>
<td>2.94</td>
<td>3.13</td>
<td>2</td>
</tr>
<tr>
<td># stocks / derivatives</td>
<td>81</td>
<td>25</td>
<td>50</td>
<td>51</td>
<td>81</td>
<td>80</td>
</tr>
<tr>
<td># observations</td>
<td>3321</td>
<td>1025</td>
<td>2050</td>
<td>2550</td>
<td>4212</td>
<td>3280</td>
</tr>
</tbody>
</table>

OTC Stock trading activity

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Netherlands</th>
<th>Italy</th>
<th>Spain</th>
<th>Spain</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td>log volume</td>
<td>11.15</td>
<td>10.77</td>
<td>10.87</td>
<td>9.16</td>
<td>10.47</td>
<td>9.61</td>
</tr>
<tr>
<td></td>
<td>2.25</td>
<td>2.14</td>
<td>2.17</td>
<td>1.84</td>
<td>3.12</td>
<td>2.75</td>
</tr>
<tr>
<td># stocks</td>
<td>117</td>
<td>37</td>
<td>59</td>
<td>28</td>
<td>62</td>
<td>76</td>
</tr>
<tr>
<td># observations</td>
<td>6682</td>
<td>2125</td>
<td>2301</td>
<td>1092</td>
<td>3936</td>
<td>4669</td>
</tr>
</tbody>
</table>

Electronic copy available at: https://ssrn.com/abstract=4612809
Table 8: Summary statistics of equity derivative market variables

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Netherlands</th>
<th>Italy</th>
<th>Spain</th>
<th>Spain</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option trading activity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log volume</td>
<td>3.88</td>
<td>3.12</td>
<td>3.20</td>
<td>3.45</td>
<td>2.78</td>
<td>2.27</td>
</tr>
<tr>
<td>(1.73)</td>
<td>(2.17)</td>
<td>(2.65)</td>
<td>(1.96)</td>
<td>(1.99)</td>
<td>(1.81)</td>
<td></td>
</tr>
<tr>
<td>Options liquidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log depth</td>
<td>9.83</td>
<td>10.58</td>
<td>9.54</td>
<td>9.54</td>
<td>9.60</td>
<td>9.29</td>
</tr>
<tr>
<td>(1.80)</td>
<td>(2.36)</td>
<td>(2.13)</td>
<td>(2.13)</td>
<td>(2.84)</td>
<td>(2.78)</td>
<td></td>
</tr>
<tr>
<td>quoted spread</td>
<td>1.90</td>
<td>1.43</td>
<td>2.48</td>
<td>3.57</td>
<td>3.17</td>
<td>4.49</td>
</tr>
<tr>
<td>(1.52)</td>
<td>(1.49)</td>
<td>(2.79)</td>
<td>(3.62)</td>
<td>(3.11)</td>
<td>(4.68)</td>
<td></td>
</tr>
<tr>
<td># options</td>
<td>661</td>
<td>844</td>
<td>2190</td>
<td>3106</td>
<td>4198</td>
<td>2899</td>
</tr>
<tr>
<td># observations</td>
<td>8083</td>
<td>11865</td>
<td>34658</td>
<td>50995</td>
<td>74229</td>
<td>60796</td>
</tr>
<tr>
<td><strong>Futures trading activity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log volume</td>
<td>1.27</td>
<td>0.29</td>
<td>3.68</td>
<td>5.84</td>
<td>5.17</td>
<td>7.56</td>
</tr>
<tr>
<td>(2.97)</td>
<td>(1.47)</td>
<td>(2.26)</td>
<td>(2.17)</td>
<td>(2.34)</td>
<td>(3.55)</td>
<td></td>
</tr>
<tr>
<td>Stock liquidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log depth</td>
<td>12.43</td>
<td>12.94</td>
<td>10.92</td>
<td>12.43</td>
<td>10.91</td>
<td>12.37</td>
</tr>
<tr>
<td>(2.91)</td>
<td>(4.33)</td>
<td>(2.66)</td>
<td>(4.27)</td>
<td>(4.17)</td>
<td>(3.08)</td>
<td></td>
</tr>
<tr>
<td>quoted spread</td>
<td>1.21</td>
<td>1.07</td>
<td>1.91</td>
<td>1.31</td>
<td>1.27</td>
<td>1.40</td>
</tr>
<tr>
<td>(1.41)</td>
<td>(1.26)</td>
<td>(2.68)</td>
<td>(1.64)</td>
<td>(1.63)</td>
<td>(1.10)</td>
<td></td>
</tr>
<tr>
<td># futures</td>
<td>112</td>
<td>43</td>
<td>154</td>
<td>70</td>
<td>76</td>
<td>271</td>
</tr>
<tr>
<td># observations</td>
<td>2111</td>
<td>928</td>
<td>2780</td>
<td>1143</td>
<td>924</td>
<td>3448</td>
</tr>
</tbody>
</table>
Table 9: Robustness Test for the Diff-in-Diff Common Trend Assumption

This table presents robustness tests for the FTT introduction dates but all in 2018. For example, on 01.08.2012, France introduced the FTT on stock markets. This table presents the diff-in-diff analysis for 01.08.2018. In the absence of the FTT introduction, the point forecast of the diff-in-diff should be close to zero and statistically not different from zero.

This table presents the estimates for the coefficient \( \beta \) from equation \( \mathbb{E}(y_{i,t}) = \alpha_i + \gamma_t + \beta D_{i,t} \), where the dependent variable corresponds to proxies for volume and liquidity in the stock market described in section 2.3. Note that for France, I use the flexible model to account for seasonality. Volume and depth are presented as percentages, while spread measures are denoted in basis points (bps). Standard errors (in parentheses) are clustered by stock and time, and as usual, ***, **, * denote statistical significance at the 1%, 5%, and 10% level.

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Italy</th>
<th>Italy</th>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>01.08.2018</td>
<td>01.03.2018</td>
<td>01.09.2018</td>
<td>16.01.2018</td>
</tr>
<tr>
<td>Trading activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log volume</td>
<td>-0.027</td>
<td>0.010</td>
<td>0.004</td>
<td>-0.082</td>
</tr>
<tr>
<td></td>
<td>(0.050)</td>
<td>(0.069)</td>
<td>(0.004)</td>
<td>(0.058)</td>
</tr>
<tr>
<td>Liquidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log depth</td>
<td>-0.0032</td>
<td>-0.1311***</td>
<td>0.0083</td>
<td>0.0458</td>
</tr>
<tr>
<td></td>
<td>(0.0517)</td>
<td>(0.0534)</td>
<td>(0.0121)</td>
<td>(0.0784)</td>
</tr>
<tr>
<td>quoted spread</td>
<td>0.0397</td>
<td>0.0988</td>
<td>0.0412</td>
<td>-0.0693</td>
</tr>
<tr>
<td></td>
<td>(0.0527)</td>
<td>(0.0876)</td>
<td>(0.0431)</td>
<td>(0.0674)</td>
</tr>
<tr>
<td>effective spread</td>
<td>0.0187</td>
<td>0.0042</td>
<td>0.0557</td>
<td>-0.0014</td>
</tr>
<tr>
<td></td>
<td>(0.0186)</td>
<td>(0.2939)</td>
<td>(0.1691)</td>
<td>(0.0316)</td>
</tr>
<tr>
<td>realized spread</td>
<td>0.0268</td>
<td>-0.0244</td>
<td>0.0128</td>
<td>-0.0141</td>
</tr>
<tr>
<td></td>
<td>(0.0210)</td>
<td>(0.0264)</td>
<td>(0.0148)</td>
<td>(0.0244)</td>
</tr>
<tr>
<td>price impact</td>
<td>0.0123*</td>
<td>0.0366</td>
<td>0.0093</td>
<td>-0.0048</td>
</tr>
<tr>
<td></td>
<td>(0.0074)</td>
<td>(0.0209)</td>
<td>(0.0953)</td>
<td>(0.0103)</td>
</tr>
<tr>
<td># treated</td>
<td>82</td>
<td>74</td>
<td>74</td>
<td>50</td>
</tr>
<tr>
<td># control</td>
<td>29</td>
<td>50</td>
<td>50</td>
<td>74</td>
</tr>
<tr>
<td># observations</td>
<td>12054</td>
<td>10166</td>
<td>10166</td>
<td>10291</td>
</tr>
</tbody>
</table>

Electronic copy available at: https://ssrn.com/abstract=4612809
Figure 9 illustrate the placebo difference-in-difference estimates for the causal impact of the FTT on trading volume on-exchange for the four FTT introduction dates but all in 2018. The plots show the cross-sectional average for treated (black) and control (light gray) stocks minus the respective pre-event averages. The time series are smoothed with a five-day moving average. The dashed lines indicate the averages for the treated and the control group. By construction, they are zero and the same before the event. After the event, the difference reflects the diff-in-diff estimate of the regression result in table (3). In the absence of the FTT introduction, the point forecast of the diff-in-diff should be close to and statistically not different from zero. The differences correspond to the insignificant point forecasts in Table 9 for log volume.